INTERNATIONAL CONFERENCE ON
Solid Waste 2023

Waste Management in Circular Economy and Climate Resilience

31 May – 3 June 2023
Hong Kong

Abstract Book

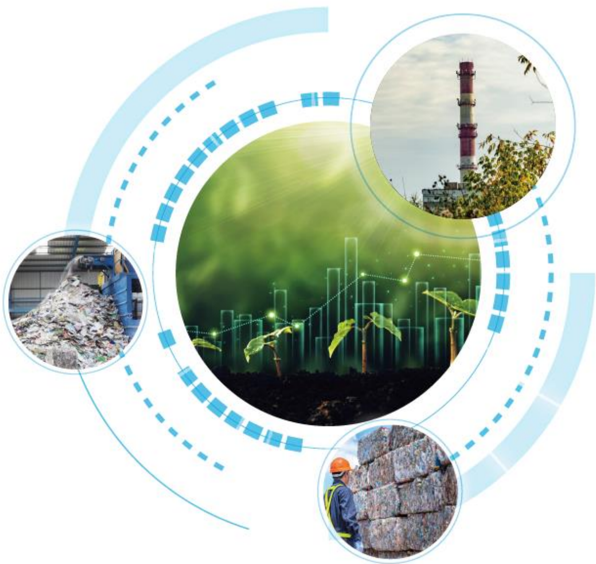
Main Organizer

香港浸會大學
HONG KONG BAPTIST UNIVERSITY

浙江大學
ZHEJIANG UNIVERSITY

IBA 生物資源與農業研究所
INSTITUTE OF BIORESOURCE AND AGRICULTURE

APASWM
Asia-Pacific Association for Sustainable Waste Management



Supporting Organizations

HKIE The Hong Kong Institution of Engineers
hkpc
HKWMA Hong Kong Waste Management Association 香港廢物管理學會
CityU
The Hong Kong Polytechnic University 香港理工大學
東莞理工學院 Dongguan University of Technology
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University of Florida
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Universität Rostock Traditio et Innovatio
The University of Nottingham

International Conference on
Solid Waste 2023:

Waste Management in Circular Economy and Climate Resilience

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Hong Kong

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International Conference on Solid Waste 2023:
Waste Management in Circular Economy and Climate Resilience

Organized by

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The Hong Kong Institution of Engineers (HKIE)
The Hong Kong Polytechnic University
Tongji University, P.R. China
University of Boras, Sweden
University of Florida, USA
University of Nottingham, Malaysia
University of Queensland, Australia
University of Rostock, Germany
University of Shanghai for Science and Technology, P.R. China

WELCOME MESSAGE

It is my great privilege and pleasure to welcome you all, new and old friends, to the "International Conference on Solid Waste 2023: Waste Management in Circular Economy and Climate Resilience (ICSWHK2023)" here in the beautiful city of Hong Kong. I would like to take this opportunity to express my sincere thanks for your support for the last five International Conferences, ICSWHK2011, ICSWHK2013, ICSWHK2015, BioWCHK2016, and SBM2021; and 'YOU' made the events grand successful. Similar to the previous conferences, we have received overwhelming response from all over the world to participate in the ICSWHK2023 conference. Leveraging internationally renowned researchers and practitioners, the event has attracted nearly 400 abstracts from over 40 countries in the various disciplines of the conference themes. Several stakeholders working in waste management such as academicians, researchers, policy makers and companies have submitted their abstracts to showcase the innovative waste management practices around the world. We are expecting around 500 participants, including local and international members seating together and sharing experiences. Further, we are encouraging local postgraduate students to participate in the conference by providing free registration to catalyze networking opportunities for young researchers to exchange ideas and interact with eminent scientists working in waste management and circular economy around the world.

Adaption of circular and green economy in waste management sector is the key factor to curb the environmental pollution along with effective mitigation of climate change. However, the present global economy is only 8.6% circular as per Circularity Gap Report 2021 indicating a huge potential for promoting the circular economy across the world. The recent outbreak of the Covid-19 pandemic has further hindered sustainable waste management practices and resulted in elevated waste generation. Hence, green recovery and circular economy could be the cornerstone for future waste management practices to achieve United Nations Sustainability Development Goals. Focusing with these themes, ICSWHK2023 includes 10 keynote speeches, 32 plenary lectures, 24 invited letures, 158 oral and 120 poster presentations. Further, two pre-conference workshops titled "Enhanced Landfill Mining: Technologies, Products, and Costs" and "Biochar for Sustainable Management of Urban Biomass Waste" and technical field trips to the state-of-the-art treatment facilities in Hong Kong, Y-Park, T-Park, Eco-Park and O-Park are also arranged.

ICSWHK2023 will definitely provide you a great opportunity and platform to exchange your views, visions, and experiences on waste treatment technology, sustainable waste management and environmental issues among scientists, academics, practitioners and policy makers from all over the world. We also wish this conference can be a turning point for companies involved in waste and environment issues to build up a network. In order to remove the monetary barrier to attend the Conferences, we have provided complete or partial sponsorship to some participants from developing countries. Thanks to our generous sponsors who make us meet at least certain demands of the participants. I do hope that with the limited available resources we can encourage more young researchers, especially those coming from development countries can join this conference to meet renowned waste management experts from all over the world.

We strongly believe this conference will offer you ample chance to gain new insights about the latest environmental technology. This is a unique opportunity for the young scientists and researchers who are specialized in waste management. Outstanding papers will be published in a special issue of SCI journals such as Bioresource Technology and Environmental Technology after review. Best Poster Award, and Young Researcher Award are also waiting to acknowledge and embrace your knowledge and potential.

Finally, we are here today to actively share experiences, learn the developments and seek for collaborations on various issues of sustainable waste management. Your presence and contributions are vital in making this conference a truly international platform for sharing ideas and experiences. I am certain that along with having an enriching experience at the conference you will also enjoy the most pleasurable experience in visiting one of the most dynamic and vibrant cities in the world. It will be a memorable event for colleagues and friends from all over the world to establish friendship to promote academic exchanges at an international level and to contribute to the development of new approach for solid waste management. We hope our participants will have a fruitful conference and find time to explore Hong Kong, a dynamic metropolis steeped in unique blends of East and West.

HEARTY WELCOME TO HONG KONG!

Conference Chair
Prof. Jonathan W.C. Wong, PhD, BBS, MH, JP
Sino-Forest Applied Research Centre for Pearl River Delta Environment and
Department of Biology
Hong Kong Baptist University
Hong Kong

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International Conference on

Solid Waste 2023:

Waste Management in Circular Economy

and Climate Resilience

Conference Programme

Conference Theme

1. Circular and green economy in waste management
2. Green recovery practices in sustainable waste management
3. Low carbon, carbon neutral and climate friendly solid waste management practices
4. Life cycle assessment and End-of-life scenarios in waste management
5. Environmental and health impact in circular economy
6. Emerging blue and green technologies in circular economy to mitigate climate change
7. Waste collection, segregation and characterization towards circular economy
8. Innovative strategies for waste separation, recycling and recovery
9. Sustainable solid waste management practices—Countries perspective
10. Sustainable waste utilization & recycling methods
11. Carbon negative technologies
12. Bioenergy and bioproducts from waste (anaerobic digestion, biofuels, etc)
13. Biomass production from waste & carbon sequestration (composting, biochar, etc)
14. Advanced thermal technologies for waste treatment – Trend & development
15. Landfill management & leachate treatment
16. Hazardous, industrial and special waste management
17. Electronic waste management, treatment and pollution abatement
18. Waste management industry - Market potential
19. Economic instruments and financing methods for waste management
20. Environmental education for waste management industries and community
21. Artificial intelligence, machine learning and deep learning in waste management
22. Covid-19 pandemic: Challenges, strategies, and policies
23. Microplastics and Bioplastics

Conference Venue

The Conference will be held at the Hong Kong Convention and Exhibition Centre (HKCEC) from 31 May to 03 June 2023. The Hong Kong Convention and Exhibition Center abbreviated as HKCEC, is one of a kind, Hong Kong's large-scale conference and exhibition venue. Every year, it is known to host the largest exhibitions and concerts in Asia and also around the world. HKCEC has been honored as the Best Convention and Exhibition Center in Asia multiple times. The Conference will take place on the 4/F of HKCEC and the conference office will be located in room S422. A floor map showing the venue for the parallel and poster sessions, registration desk and other offices are shown below. In addition, a map of the Wanchai area with the locations of bus stops, MTR stations and Hotels nearby is also given below.

Address: Hong Kong Convention and Exhibition Centre (HKCEC),1 Expo Drive, Wanchai, Hong Kong

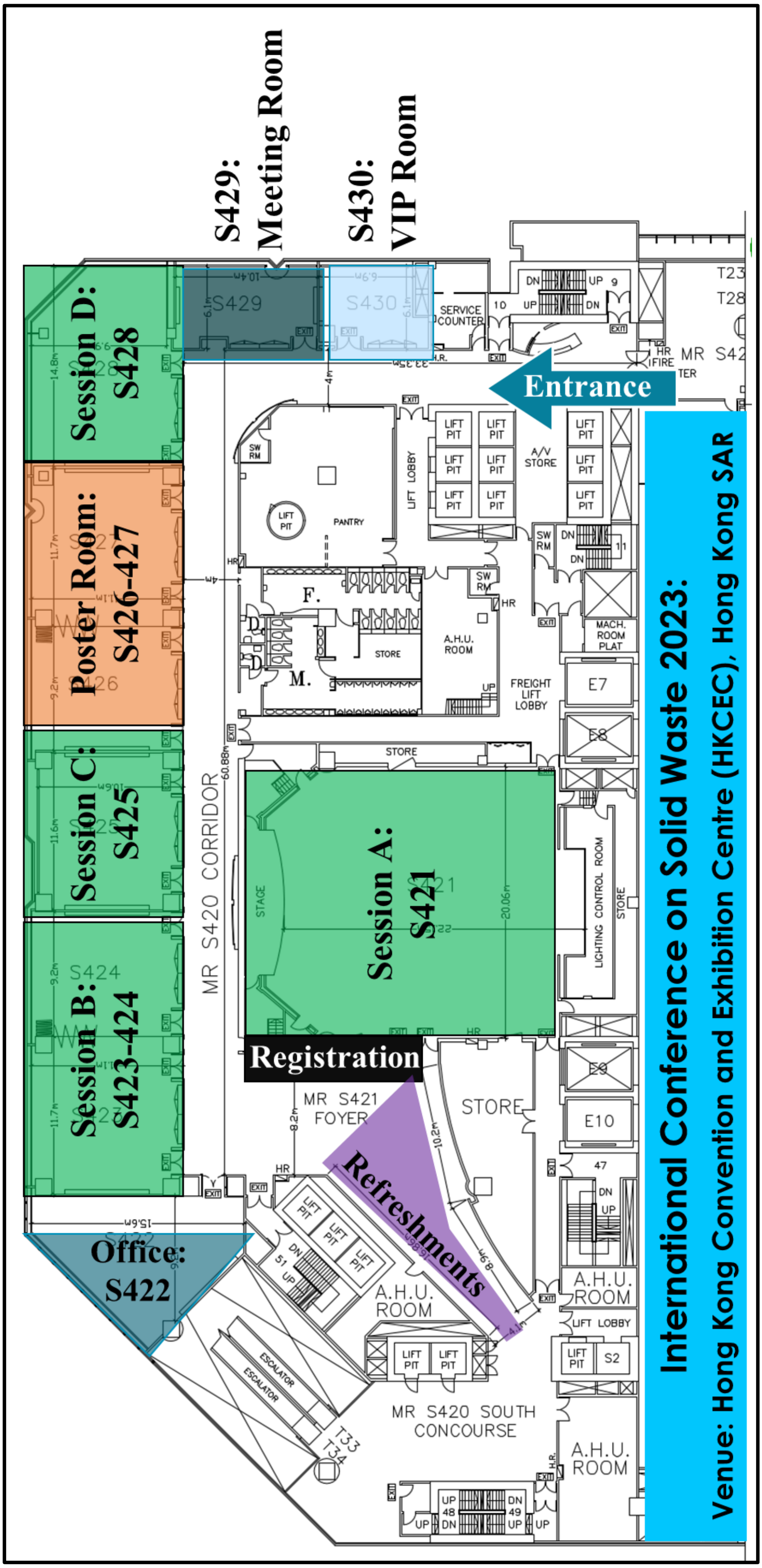
Local Transportation

From Hong Kong International Airport:

By Bus: Route no. A11 or E11 to Wanchai and change to route no. 40M to the HKCEC (Estimated time: 80 mins; Estimated cost: HK$40-$45)

By Train: Airport Station to Hong Kong Station (by Airport Express) and switch to Wanchai Station (by MTR Metro) (Estimated time: 40 mins; Estimated cost: HK$100-$120)

By Taxi: All are metered, relatively cheap, air-conditioned and clean (Estimated time: 30 mins; Estimated cost: HK$360-$430)


S429: Meeting Room
S430: VIP Room
Session D: S428
Poster Room: S426-427
Session C: S425
Session B: S423-424
Session A: S421
Office: S422
Registration
Refreshments
Entrance
MR S420 CORRIDOR
MR S421 FOYER
MR S420 SOUTH CONCOURSE
International Conference on Solid Waste 2023:
Venue: Hong Kong Convention and Exhibition Centre (HKCEC), Hong Kong SAR


酒店 Hotels
1 港島香格里拉酒店 Island Shangri-La, Hong Kong
2 港麗酒店 Conrad Hong Kong
3 香港萬豪酒店 JW Marriot Hong Kong
4 衛蘭軒 The Wesley Hotel
5 港島皇悅酒店 Hong Kong Empire Hotel
6 灣仔維景酒店 Metropark Hotel Wanchai
7 華美粵海酒店 Wharney Guang Dong Hotel
8 六國酒店 Luk Kwok Hotel
9 香港灣景國際 The Harbour View
10 香港君悅酒店 Grand Hyatt Hong Kong
11 萬麗海景酒店 Renaissance Harbour View Hotel Hong Kong
12 芬名酒店 The Fleming Hong Kong Hotel
13 世紀香港酒店 Novotel Century Hong Kong Hotel
14 利景酒店 The Charterhouse
15 南洋酒店 South Pacific
港鐵出入口 MTR Entrance
警署 Police Station
主要大廈 Major Buildings
灣仔渡海碼頭 Wanchai Ferry Pier
的士站 Taxi Stand
機場快綫香港站 免費穿梭巴士上落客處 Pick up and drop off point for free shuttle to Airport Express Hong Kong Station
行人天橋 Pedestrian Footbridge
來往會展中心及灣仔港鐵站之行人天橋 Pedestrian Footbridge between HKCEC and Wanchai MTR Station
主要交通工具 Major Public Transport
B1 巴士站 (金紫荊廣場) Bus Stops at Golden Bauhinia Square
B2 巴士站 (灣仔碼頭) Bus Stops near Wanchai Ferry Pier
B3 巴士站 (告士打道) Bus Stops at Gloucester Road
B4 巴士站 (港灣道 瑞安中心) Bus Stops at Shui On Centre, Harbour Road
B5 巴士站 (會議道) Bus Stops at Convention Avenue
灣仔渡海碼頭 (往尖沙咀及紅磡) Wanchai Ferry Pier (to Tsim Sha Tsui & Hung Hom)
灣仔港鐵站 Wanchai MTR Station
維多利亞港 Victoria Harbour
香港會議展覽中心 Hong Kong Convention and Exhibition Centre
博覽道入口 Expo Drive Entrance
港灣道入口 Harbour Road Entrance
金紫荊廣場 Golden Bauhinia Square
往中環 To Central
往銅鑼灣 To Causeway Bay
Harcourt Road
Gloucester Road
Hennessy Road
Lockhart Road
Jaffe Road
Fleming Road
O'Brien Road
Luard Road
Fenwick Street
Arsenal Street
Fenwick Pier St.
Convention Avenue
Expo Drive
Expo Drive East
Harbour Road
Tonnochy Road
Marsh Road
Stewart Road
Queensway
Queen's Road East
Justice Drive
Johnston Road
Wanchai Road
Thomson Road
Lung Wui Road
Tim Mei Ave
Tim Wa Ave
Admiralty
Wanchai Station
Wanchai Sport Ground
Harcourt Garden

Conference Structure

The Conference includes:

- **Pre-conference workshops** on 30th May 2023 held in the Harbourview Hotel, Wan Chai, Hong Kong
  Workshop 1: Enhanced Landfill Mining: Technologies, Products, and Costs
  Workshop 2: Biochar for Sustainable Management of Urban Biomass Waste
- **Main Conference**: From 31st May to 2nd June 2023 in Hong Kong Convention and Exhibition Centre (HKCEC), includes,
  - ✧ Keynote sessions
  - ✧ Parallel oral sessions
  - ✧ Poster presentation and viewing sessions
- **Technical field trips (half-day)** on 3rd June 2023
  Filed trip 1: Y-PARK (Promotes recycling of yard waste into useful materials) and T-PARK (Transformation Park-Converting waste to energy)
  Field trip 2: Eco-PARK (Hong Kong's first recycling Business Park) and O-PARK (Organic Resources Centre-renewable energy generation plant)
- **Conference Banquet for the speakers and registered participants at Choi Fook Royal Banquet (iSquare), 26/F iSQUARE, 63 Nathan Road, Tsim Sha Tsui.**

Parallel Oral Sessions

The conference is structured into 4 parallel oral sessions: Session A (Room: S421), Session B (Room: S423-424), Session C (Room: S425) and Session D (Room: S428). Each parallel oral session includes plenary and invited talks followed by oral and short-oral presentations from the participants.

Instructions for Oral Presentations

Platform Schedule

The oral sessions will be conducted from the 31st May morning through the 2nd June afternoon. The program states the session to which your paper has been assigned and the day the session is scheduled.

Guidelines for Oral Presentation (in person mode)

a. Preparation of PowerPoint Presentation

- All authors presenting their work in an oral session are advised to use Microsoft PowerPoint for making the presentation with the slide size: 16:9 (widescreen) preferably.
- The presentation should be saved as "**Abstract Number_Name [eg. A001_XX XX]**".
- Please refer to the abstract number in the attached draft of the program.

b. Uploading your PowerPoint Presentation

- Please bring your presentation file to the speakers' viewing room, the day before your presentation (for the morning session for the next day), or during the lunch break (for the afternoon session).
- Please bring your presentation file on a USB flash memory stick.

c. Oral presentation

- The duration of presentation is as follows:

- Keynote Speech: 30 minutes
- Plenary Lecture: 25 minutes
- Invited Lecture: 20 minutes
- Oral Presentation: 15 minutes (**12 minutes for presentation and 3 minutes for Q&A)**
- Short-oral Presentation: 10 minutes (**8 minutes for presentation and 2 min for Q&A)**

- Presenters should be present in the session room 10 minutes earlier to meet the session Chair and check their presentations on the computer.
- **Each room is equipped with a PC (Window OS), a video projector, and a laser pointer.**
- All authors are required to follow a strict schedule, to allow participants to move between the sessions.

Guidelines for Oral Presentation (online mode)

- The authors are required to follow the same format for the preparation of the presentation as stated above.
- Online oral presenters can attend the conference via Zoom link provided at https://icswhk.hkbu.edu.hk/.
- All authors are required to send a video recording of their presentation to the Secretariat at icswhk2023@gmail.com no later than **20th May**. The file should be named as "**Vid_oral_Abstract number_Name" (eg. Vid_oral_A001_XX XX).**
- The oral presenters also need to specify by **20th May** if they would like us to broadcast the recorded video or make an online presentation during the conference.
- The recording should not be more than 12 minutes for an oral presentation and 8 minutes for a short-oral presentation to facilitate questions and discussion in the remaining time.
- The authors are required to join their session 10 minutes before through a Zoom link that will be uploaded to the Conference website (https://icswhk.hkbu.edu.hk/).

Poster Presentation and Viewing Sessions

A continuous poster presentation will take place in room S426-427 on day 1 (31 May) and day 2 (1 June) of the conference. Special poster viewing sessions are dedicated on day 1 (31 May: 1300-1400 & 1800-1900), day 2 (1 June: 0800-0900; 1300-1400 & 1745-1830) and day 3 (2 June: 0800-0900 & 1300-1400). The poster presenters are expected to be available in front of their posters during the viewing sessions as the other participants are invited to view the posters and exchange their ideas with the authors. Furthermore, the posters will be judged by a panel of international experts during the viewing sessions.

TEN 'Best Poster Award' with a cash prize of HKD 1000 each and a certificate of recognition will be awarded during the closing ceremony of the conference on day 3 (2nd June).

Participants should prepare and bring hard copy of their own posters to Hong Kong and the organizers are not responsible for poster printing.

Instructions for Poster Presentations

Guidelines for Poster Presentation (in person mode)

a. Preparation of Posters

- Posters to be presented should be prepared in an "A0 portrait" (width = 841 mm x height = 1189 mm) format with 25 mm margins around.
- Authors can choose their design for the poster.
- Participants should prepare and bring along a hard copy of own poster for presentation to Hong Kong. The conference committee will NOT be responsible for printing the poster.

b. Setting-up of Posters

- Posters can be set up from 31 May at 0900 onwards.
- All the necessary stationery will be provided for setting up the poster at the venue.
- All posters should be dismantled by 1900 pm on 2 June. The organizer has no responsibility for any damage or disposal the posters that left after the dismantling deadline.

c. Poster Presentation and Viewing Sessions

- Poster presentation will take place on the first two days of the conference.
- Special poster viewing sessions are dedicated as follows:
    - 31 May: 1300-1400 & 1810-1900
    - 1 June: 0800-0900, 1300-1400 & 1745-1830
    - 2 June: 0800-0900 & 1300-1400
- A panel of judges will review the posters followed by a Q &A session for poster presenters.
- Participants are invited to view posters and exchange views and ideas with the authors who are suggested to be available in front of their posters during the judging and poster viewing sessions.

Guidelines for Poster Presentation (online mode)

- The posters should be prepared on a 758 px (length) x 417 px (width) template.
- The file name of the poster should be **"Poster_Abstract Number_Name" (eg. Poster_A001_XX XX)**.
- All online poster presenters are required to send their posters by 20th May to the Secretariat at icswhk23@hkbu.edu.hk.
- Online presenters can join the conference via a Zoom link provided on the conference website (International Conference on Solid Wastes 2023 | (hkbu.edu.hk).
- There is no Q & A session for the online poster presenters.
- The posters will be displayed on a 43" digital display panel.

Coffee, Lunch and Conference Dinner

Coffee, tea, and light refreshments will be served at the venue during breaks to all speakers and paid registered participants. Lunches are NOT included; there are plenty of choices for restaurants and fast-food shops near the conference venue.

The **Conference Banquet dinner** for all speakers and registered participants will be held on 1st June at Choi Fook Royal Banquet (iSquare), 26/F iSQUARE, 63 Nathan Road, Tsim Sha Tsui.

Social Event

In addition to our excellent academic programme, we are also organizing an unforgettable social event on the evening of 1 June (day 2) **(Invited speakers and paid registered participants ONLY)**.

"The Banquet Dinner at Choi Fook Royal Banquet (iSquare) in Tsim Sha Tsui (Time: 1900 to 2200)"

The banquet dinner presents an excellent opportunity to network with your peers while indulging in a sumptuous meal amidst the stunning backdrop of Victoria Harbour. Along with the delicious food, traditional Chinese performances like Lion dance and Face-changing has been organized for an entertaining evening. This event is open to all invited speakers and paid registered participants. The transportation will be arranged from the venue. For those who would like to purchase the banquet dinner coupon, please contact the secretariat. Transportation will be arranged to depart from the conference venue at 1830 sharp.

Technical Field Trips

After the main conference, on 3 June, two half-day field trips for our delegates are organized for the speakers and participants visiting from various countries. Each field trip will involve visits to two of the state-of-the-art treatment facilities in Hong Kong as follows:

1. Field Trip A: (Time: 0830 to 1300)

Y-PARK (Facility for recycling of yard waste into useful materials) and **T-PARK** (Transformation park-Converting waste to energy)

Y-PARK aims to promote the recycling of yard waste into useful materials, reducing disposal at landfills and relevant carbon emissions, realizing "zero landfill" and facilitating carbon neutrality in the long run. Y·PARK is equipped with various installations, including wood shredders, wood cutting machine, drying and sterilization unit etc., which can transform suitable yard waste into various useful materials such as wood boards, wood beams, wood chips and sawdust etc.

T-PARK signifies the continuous drive to shape Hong Kong's "waste-to-energy" ambitions for the good of the community. In this plant, sewage sludge is used as fuel and the heat energy produced from the sludge incineration process is recovered and converted into electricity. T-PARK is more than just a plant, but a place to learn and engage in Hong Kong's green force through its recreational and educational facilities.

Itinerary for field trip A:

Time	Activity
0830	**Depart from Harbourview Hotel**
0930 - 1030	**Y-Park**
1100 - 1230	**T-Park**
1230	**Depart to Harbourview Hotel**

2. Field Trip B: (Time: 0830 to 1300)

Eco-PARK (Hong Kong's first recycling Business Park) and **O-PARK** (Organic Resources Centre-renewable energy generation plant)

Eco-PARK, Hong Kong's first recycling-business park, is a facility of the Environmental Protection Department specially constructed for the recycling industry. In operation since 2007, Eco-PARK provides long-term land at affordable costs and a whole package of amenities for use by the recycling and environmental industry with a view to alleviating the expenditure of recyclers on infrastructure, thereby encouraging their investment in advanced technologies and recycling processes. Currently, Eco-PARK has 10 tenants, engaging in recycling business of waste cooking oil, waste metals, waste wood, waste electrical and electronic equipment (WEEE), waste plastics, waste batteries, construction and demolition waste, waste glass, waste rubber tyres and waste paper.

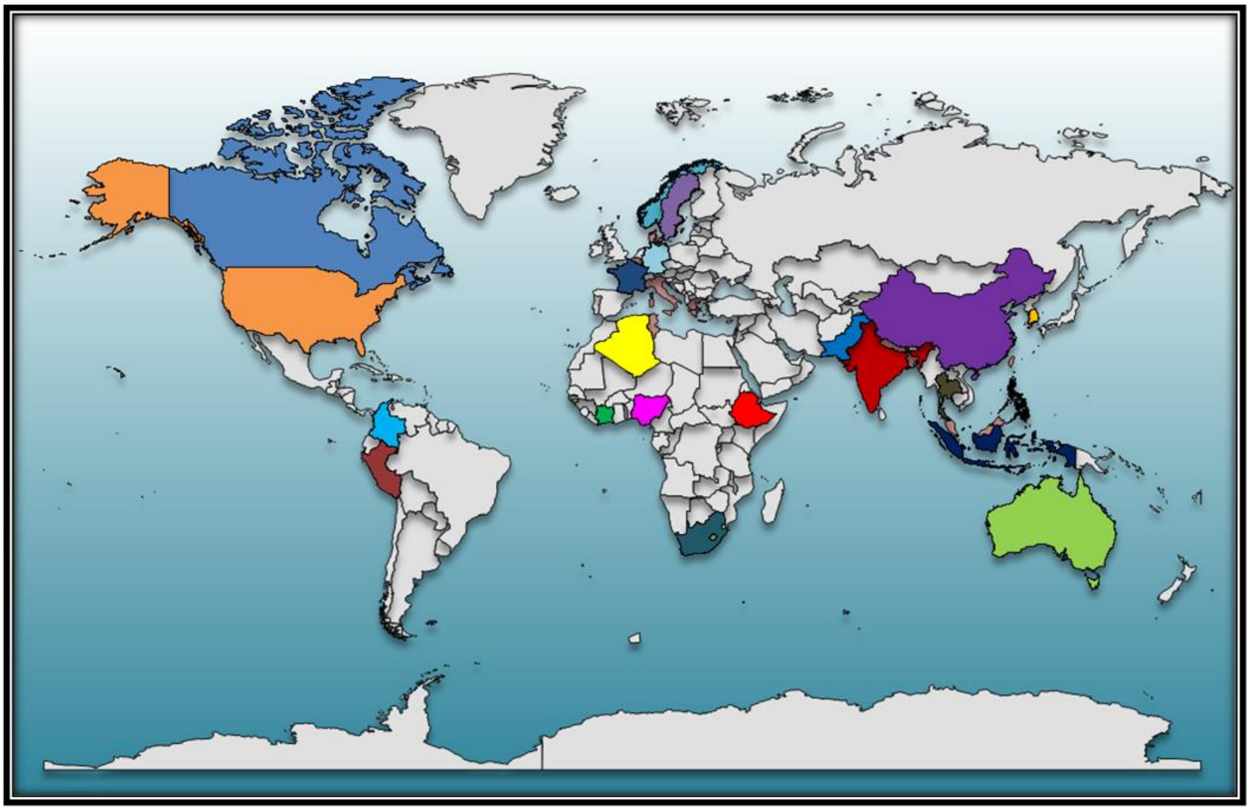
O-PARK, the first organic resources recovery centre, adopts anaerobic digestion technology to convert food waste into biogas (a source of renewable energy similar to natural gas) for electricity generation whilst the residues from the process is produced as compost for landscaping and agriculture use. O-PARK is capable of handling 200 tonnes of food waste per day. The biogas generated from the anaerobic digestion process is turned into heat and electricity that can support the needs of the facility. When running in full capacity, about 14 million kWh of electricity can be exported to the grid per year, which is equivalent to the power consumption by some 3,000 households. After the anaerobic digestion process, digestate will be converted into compost. The facility can generate about 20 tonnes of compost per day as a by-product, where it can be used for landscaping and agriculture applications

Itinerary for field trip B:

Time	Activity
0830	**Depart from Harbourview Hotel**
0900 - 1030	**Eco-Park**
1100 - 1230	**O-Park**
1230	**Depart to Harbourview Hotel**

Participation Statistics

We have received overwhelming response from all over the world to participate in the ICSWHK2023 conference. Leveraging internationally renowned researchers and practitioners, the event has attracted nearly 400 abstracts from over 40 countries in the various disciplines of the conference themes. Several stakeholders working in waste management such as academicians, researchers, policy makers and companies have submitted their abstracts to showcase the innovative waste management practices around the world. We are expecting around 500 participants, including local and international members seating together and sharing experiences. Further, we are encouraging local postgraduate students to participate in the conference by providing free registration to catalyze networking opportunities for young researchers to exchange ideas and interact with eminent scientists working in waste management and circular economy around the world.



Abstract received from around 40 different countries

Main Conference Programme

Conference Program (As on 23/05/2023)

30 May 2023 (Venue: The Harbourview Hotel)	
	Pre-Conference Workshops
0900-1230	**Workshop 1: Enhanced landfill mining: Technologies, products, and costs**
1400-1730	**Workshop 2: Biochar for sustainable management of urban biomass waste**

Day 1: 31 May 2023 (Venue: The Hong Kong Convention and Exhibition Center (HKCEC))	
0800- 0900	**Registration**
0900-1000	**Opening Ceremony (Room: S421)**
0900-0905	**Opening Address: Chair - Prof. Jonathan Wong, Hong Kong Baptist University, Hong Kong SAR**
0905-0910	**Welcome Speech: Prof. Alex Wei, President, Hong Kong Baptist University, Hong Kong SAR**
0910-0930	**Opening Keynote Speech: Mr. Kenneth Cheng, Assistant Director, Hong Kong Environmental Protection Department, Hong Kong SAR “Waste management status of Hong Kong”**

0930-1000	**Opening Keynote Speech: A753/ Prof. Shen Qirong, Academician, Nanjing Agricultural University, P.R. China "Manufacture of organic-based fertilizers to ensure development of sustainable agriculture"**							
1000-1015	**Photo session**							
1015-1045	**Coffee Break**							
1045-1215	**Keynote Session: Chair – Prof. Chettiyappan Visvanathan; Room: S421**							
1045-1115	**Keynote Speech 1: A750/ Prof. Michael Nelles/ Germany/ The role of biogenic waste and residues in the bioeconomy & energy system – Strategic, technical, ecological & economical aspects**							
1115-1145	**Keynote Speech 2: A754/ Prof. Jianhua Yan/ China/ Sustainable treatment and utilization of MSWI fly ash**							
1145-1215	**Keynote Speech 3: A248/ Prof. Ashok Pandey/ India/ Microplastics and nanoplastics pollution and their sustainable management/ Online**							
1215-1400	**Lunch (1215-1300) and Poster Viewing (1300-1400) (Room: S426)**							
1400-1500	**Keynote Session: Chair – Prof. Michael Nelles; Room: S421**							
1400-1430	**Keynote Speech 4: A749/ Prof. Klaus Fricke/ Germany/ Enhanced landfill mining – Technologies, products, and costs**							
1430-1500	**Keynote Speech 6: A751/ Prof. R. D. Tyagi/ Canada/ Valorization of wastes to bioplastics: Challenges and opportunities**							
	Session A – Room: S421		**Session B – Room: S423**		**Session C – Room: S425**		**Session D: Room: S428**	
1505-1600	**A1: Anaerobic Digestion**		**B1: Composting**		**C1: Sustainable Waste Management**		**D1: Thermal Treatment (Pyrolysis, Gasification & Incineration)**	
	Chair: Prof. Michael Nelles		**Chair: Dr. Venkata Mohan**		**Chair: Prof. Katia Lasaridi**		**Chair: Prof. Roger Ruan**	
	Co-Chair: Dr. Parthiba Karthikeyan Obulisamy		**Co-Chair: Dr. Ravindran Balasubramani**		**Co-Chair: Dr. Soh Kheang Loh**		**Co-Chair: Prof. Murugesan Kumarasamy**	
1505-1530	P1	Plenary Lecture: A957/ Prof. Hélène Carrere/ France/ Pretreatments of organic substrates and their indigenous bacteria for dark fermentation	P2	Plenary Lecture: A946/ Prof. Ji Li/ China/ Composting microbes: Past, present and future	P3	Plenary Lecture: A947/ Prof. Chettiyappan Visvanathan/ Thailand/ Moving plastic waste management from liner to circular economy: Role of dumpsite plastic mining	P4	Plenary Lecture: A250/ Prof. Duu-Jong Lee/ Hong Kong/ Gasification of municipal solid waste as a disposal route for circular economy
1530-1545	O1	A365/ Prof. Pratap Pullammanappallil/ USA/ Factors that limit decomposition of organic fraction of non-recyclable municipal solid waste in a high-solids, leach-bed anaerobic digestion process	O2	A682/ Prof. Yun Cao/ China/ Lignite effects active nitrogen gas emission during poultry wastes composting: Insights into the microbial mechanism	O3	A273/ Prof. Qi-Tang Wu/ China/ Comprehensive recycling of fresh municipal sewage sludge to safely fertilize plants and achieve low carbon emission	O4	A776/ Prof. Hua Li/ China/ Co-pyrolysis of food waste and agricultural waste: Mechanism and process optimization study
1545-1600	O5	A056/ Prof. Liu Jing/ Sweden/ Biodegradability evaluation of plastics in organic solid waste	O6	A301/ Dr. Wang Xuan/ China/ Synergistic abatement of NH_3 and N_2O emission from	O7	A229/ Dr. Sridhar Pilli/ India/ Energy economics of the municipal solid waste process	O8	A571/ Prof. Xuebin Wang/ China/ Study on pyrolysis of ultra-high grade oil shale and

		using a novel volumetric respirometer		composting process				characteristics of three-phase products
1600-1620	**Coffee Break**							
1620-1810		**A2: Anaerobic Digestion**		**B2: Composting**		**C2: Sustainable Waste Management**		**D2: Thermal Treatment (Pyrolysis, Gasification & Incineration)**
		Chair: Prof. Hélène Carrere		**Chair: Prof. Ji Li**		**Chair: Prof. R. D. Tyagi**		**Chair: Prof. Jianhua Yan**
		Co-Chair: Prof. Jing Liu		**Co-Chair: Dr. Xuan Wang**		**Co-Chair: Prof. Qi-Tang Wu**		**Co-Chair: Prof. Hua Li**
1620-1645	P5	Plenary Lecture: A948/ Dr. Venkata Mohan/ India/ Metabolic insights of carboxydotrophics in syngas fermentation for low-carbon chemicals/fuels	P6	Plenary Lecture: A74/ Prof. Zengqiang Zhang/ China/ Nitrogen transformation during pig manure composting with diatomite addition	P7	Plenary Lecture: A356/ Prof. Katia Lasaridi/ Greece/ Assessing the baseline of food waste generation in Greek households	P8	Plenary Lecture: A11/ Prof. Roger Ruan/ USA/ Catalytic microwave-assisted pyrolysis of organic solid waste for fuels, chemicals, and materials production
1645-1705	I1	Invited Lecture: A950/ Dr. Parthiba Karthikeyan Obulisamy/ USA/ Pretreatment of food waste for high-rate hydrogen production	I2	Invited Lecture: A62/ Dr. Ravindran Balasubramani/ South Korea/ Dynamics of nutrients and gaseous emissions during co-composting of food waste and poultry manure with different amendments	I3	Invited Lecture: A938/ Dr. Soh Kheang Loh/ Oil palm biomass - Waste to wealth circular approach	I4	Invited Lecture: A92/ Prof. Murugesan Kumarasamy/ India/ Conversion of waste face mask into carbonized functional materials for environmental applications
1705-1720	O9	A051/ Dr. Jibao Liu/ China/ Deciphering molecular transformation behavior and potential molecular markers in advanced anaerobic digestion of sludge by FT-ICR MS nontarget metabolomic analysis	O10	A207/ Prof. Vinod Kumar Garg/ India/ Nutrient recovery and treatment of organic waste by vermitechnology	O11	A256/ Prof. Lan Xiang/ China/ Separation of low-grade phosphate ores by novel semi-through hydraulic barrier hydrocyclone	O12	A198/ Dr. Lei Wang/ China/ Synthesis gas production from co-pyrolysis of straw biomass and polyethylene agricultural film
1720-1735	O13	A077/ Dr. Nirakar Pradhan/ Hong Kong/ Effect of micro-nano zero-valent iron on the metabolic profiles of fermentative bacteria	O14	A060/ Dr. Guoying Wang/ China/ Responds of physiological inheritance mechanism on seed germination under phytotoxicity during chicken manure composting	O15	A144/ Prof. Lei Wang/ China/ Designing low-carbon cements for stabilization/solidification of MSWI fly ash	O16	A212/ Dr. Jian Zhang/ China/ Ash fusion characteristics of sewage sludge and its inhibitors to avoid slagging during incineration
1735-1750	O17	A007/ Dr. Liwen Luo/ Hong Kong/	O18	A163/ Ms. Ruonan Ma/ China/	O19	A009/ Dr. Muthu Kumar	O20	A567/ Dr. Yili Zhang/ China/

		Regulation of acidogenic fermentation through exogenous additives for promoting carbon conversion of food waste in two-phase anaerobic system		Deciphering the dynamics of antibiotic resistance genes and the driving mechanisms during pig manure, kitchen waste, sewage sludge composting		Sampath/ India/ Process optimization for the pretreatment of *Lantana Camara* using combined acid and deep eutectic solvent for sugar production		Emission and distribution of dioxin in a coal-fired power plant coupled with garbage and biomass
1750-1800	SO1	A072/ Mr. Chuenchart Wachiranon/ USA/ Effect of microaeration on anaerobic co-digestion of food waste and sewage sludge	SO2	A043/ Ms. Xu Zhao/ China/ Effects of reflux of mature compost during perishable waste composting	SO3	A156/ Ms. Komal Saini/ India/ Effective utilisations of discarded reverse osmosis post-carbon for dye adsorption	SO4	A041/ Mr. Jianzun Lu/ China/ Fabrication of hydrophobic composite material using residues derived from incineration of textile waste
1780-1810	SO5	A242/ Ms. Hemapriya S/ India/ Precise pH control of food waste biomethanation using granulated activated carbon	SO6	A042/ Ms. Akansha Choubey/ India/ Examination of feasibility and effectiveness of earthworm in degradation of kitchen refuse	SO7	A297/ Ms. Adjoavi Colette Djassou/ Ivory Coast/ Enhancing compressive strength of rubberised concrete with sodium hydroxide coupled with microwave devulcanization treatment	SO8	A568/ Ms. Shin Ying Foong/ Malaysia/ Production of a novel catalyst from oil palm waste and chitosan for application in catalytic microwave pyrolysis of algae
1800-1900	**Poster Viewing (Room: S426)**							

	Day 2: 01 June 2023 (Venue: The Hong Kong Convention and Exhibition Center (HKCEC))			
0800-0900	**Poster Viewing (Room: S426)**			
0900-1000	**Keynote Session: Chair – Prof. Qunxing Huang**			
0900-0930	**Keynote Speech 5: A747/ Prof Hailong Wang/ China/ Pristine and modified biochar derived from urban green waste for remediation of contaminated environments**			
0930-1000	**Keynote Speech 7: A39/ Prof. Pinjing He/ China/ Influences of waste segregation policy on the climate change impact of waste management systems/ Online**			
1000-1020	**Coffee Break**			
1020-1205	**A3: Anaerobic Fermentation**	**B3: Composting**	**C3: Waste Management Practices: Countries Perspective**	**D3: Thermal Treatment (Pyrolysis, Gasification & Incineration)**
	Chair: Prof. Agamuthu Pariathamby	**Chair: Prof. Guanyu Zheng**	**Chair: Prof. Su Shiung Lam**	**Chair: Prof. Dong-Jin Kim**
	Co-Chair: Prof. Jun Zhou	**Co-Chair: Prof. Qiyong Xu**	**Co-Chair: Prof. Anthony Lau**	**Co-Chair: Prof. Gina Villegas-**

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1020-1045	P9	Plenary Lecture: A939/ Prof. Lixiang Zhou/ China/ A novel approach for purifying anaerobic food waste digestate through bio-conditioning and dewatering followed by activated sludge process: A case study	P10	Plenary Lecture: A940/ Prof. Lin Ma/ China/ Challenges and strategies for improving manure management system in China	P11	Plenary Lecture: A756/ Prof. Weixiang Wu/ China/ Technological barriers of MSW classification, reduction and resource utilization in China	P12	Plenary Lecture: A313/ Prof. Qunxing Huang/ China/ Novel step pyrolysis technology for recovery valuable products from waste tires
1045-1105	I5	Invited Lecture: A61/ Dr. Suyun Xu/ China/ CO_2 enrichment regulates acid production and methane yield from anaerobic digestion of food waste	I6	Invited Lecture: A941/ Dr. Ammaiyappan Selvam/ India/ Decentralized municipal solid waste composting in Tamil Nadu, India – A case study	I7	Invited Lecture: A758/ Prof. Konstadinos Abeliotis/ Greece/ Food waste generation in the grocery retail sector	I8	Invited Lecture: A33/ Dr. Suchithra T. Gopakumar/ Malaysia/ Catalytic co-pyrolysis of sweet sorghum stalk and polypropylene: Simultaneous waste reduction and biofuel production
1105-1120	O21	A068/ Dr. Rajnikant Rajagopal/ Canada/ Co-digestion of swine-manure and carcass at low temperature: A long term operation and stability monitoring	O22	A117/ Ms. Dongyi Li/ Hong Kong/ The role of different types of biochar in food waste digestate composting	O23	A012/ Dr. Dhundhi Raj Pathak/ Nepal/ The Impact of COVID-19 on quantification and characterization of solid waste in the Bagmati river corridor of Kathmandu Valley, Nepal	O24	A176/ Dr. Yaqi Peng/ China/ Utilization of mechanochemically pretreated municipal solid waste incineration fly ash for supplementary cementitious material
1120-1135	O25	A107/ Mr. Subbarao Shamsundar/ India/ Design and implementation of a pilot carbon capture technology to obtain compressed biogas (green fuel) & compressed CO_2 from biogas plant at NIE-CREST, Mysuru, India	O26	A341/ Ms. Yue Wang/ China/ Different composting technologies and raw materials induced microbial dynamics and core microbiomes	O27	A202/ Dr. Steuer Benjamin/ Hong Kong/ Evaluating circular economy applications for plastic waste management in Hong Kong	O28	A338/ Dr. Anurita Selvarajoo/ Malaysia/ Improving biochar properties by pyrolysis of palm biomass for use as cement based materials

1135-1145	SO9	A151/ Mr. Xunan Li/ China/ Effect of biogas residue biochar on anaerobic digestion of food waste with different organic loading	SO10	A055/ Ms. Lingxiao Wang/ China/ Mature compost promotes biodegradable plastic degradation and reduces greenhouse gas emissions during kitchen waste composting	SO11	A015/ Prof. Bashir J K Mohammad/ Malaysia/ Sustainable bioenergy, economic, and environmental impacts of resource recovery from organic fraction municipal solid waste in Penang, Malaysia/ Online	SO12	A368/ Mr. Wei-Jhu Wang/ Taiwan/ A study on the effects of waste glass sand on the properties of bricks contained with incinerator bottom ash
1145-1155	SO13	A255/ Mr. Haixiao Guo/ China/ Enhanced anaerobic digestion of waste activated sludge with periodate-based pretreatment/ Online	SO14	A096/ Mr. Arun Kumar M/ India/ Effect of mature compost as additive during municipal solid waste composting	SO15	A352/ Dr. Yatim Puan/ Malaysia/ Transition towards circular economy: Policy insights from a developing country/ Online	SO16	A014/ Mr. Xin Guo/ China/ Migration and transformation characteristics of molten heavy metals from MSWI fly ash under different additives/ Online
1155-1205	SO17	A266/ Ms. Yufen Wang/ China/ Enhancement strategies and mechanisms of high-value medium-chain fatty acids production from waste activated sludge through anaerobic fermentation/ Online	SO18	A738/ Mr. Jufei Wang/ China/ Controllability improvement of food waste composting quality: A comparative study of control strategies	SO19	A241/ Ms. Trinh Lina/ Vietnam/ Understanding, consensus, and willingness to implement solid waste management policy of citizens in municipalities of Vietnam/ Online	SO20	A158/ Mr. Yifan Xiang/ China/ The application of laser ionization-time-of-flight mass spectrometry online detecting system for dioxins in a municipal solid waste incineration plant/ Online
1205-1400	**Lunch (1205-1300) & Poster Viewing (1300-1400) (Room: S426)**							
1400-1600	**A4: Anaerobic Digestion: Bioenergy & Bioproducts**		**B4: Composting**		**C4: Waste Utilization & Recycling**		**D4: Biochar & its Applications**	
	Chair: Dr. Venkata Mohan		**Chair: Dr. Sunita Varjani**		**Chair: Prof. Lin Luo**		**Chair: Prof. Qunxing Huang**	
	Co-Chair: Dr. Suyun Xu		**Co-Chair: Dr. M.K. Manu**		**Co-Chair: Dr. Dhundi Raj Pathak**		**Co-Chair: Dr. Jun Zhao**	
1400-1425	P13	Plenary Lecture: A249/ Prof. Agamuthu Pariathamby/ Malaysia/ Biomass to green energy: an Asian perspective	P14	Plenary Lecture: A363/ Prof. Guanyu Zheng/ China/ Spatial distribution of fecal pollution indicators in sewage sludge flocs and their removal and inactivation during sludge conditioning processes	P15	A761/ Prof. Su Shiung Lam/ Malaysia/ Microwave processing of waste for circular waste management	P16	Plenary Lecture: A289/ Prof. Dong-Jin Kim/ South Korea/ Phosphate adsorption of Mg and Ca-biochar and its P bioavailability
1425-1445	I9	Invited Lecture:	I10	Invited Lecture:	I11	Invited Lecture:	I12	Invited Lecture:

		A940/ Prof. Jun Zhou/ China/ Biogas Production from Agro-waste in Nanjing Tech University: Research and Practice		A770/ Prof. Qiyong Xu/ China/ Evaluation of digestate-derived biochar on humification and in-situ odor reduction during food waste digestate composting		A942/ Prof. Anthony Lau/ Canada/ Combined steam explosion and water leaching pretreatments to upgrade the fuel properties of wheat straw		A958/ Mr. Tom Miles/ USA/ Biochar products, systems and processes in North America
1445-1500	O29	A395/ Dr. Xiaodong Xin/ China/ Sludge source-redox mediators obtainment and availability for enhancing bioelectrogenesis and acidogenesis: Deciphering characteristics and mechanisms	O30	A349/ Dr. Yung-song Chen/ Taiwan/ Study of the three common vermicomposting species on cyclical utilization of swine manure in organic farmland	O31	A280/ Dr. Chun Ho Lam/ Hong Kong/ Electrocatalytic upgrading of furfural, a platform chemical from hemicellulose-rich feedstocks	O32	A700/ Prof. Gina Villegas-Pangga/ Philippines/ Enrichment of biochar for improved soil conditions and crop productivity
1500-1515	O33	A122/ Dr. Xiaolei Zhang/ China/ Direct carbon recovery from raw wastewater for bioenergy production by anaerobic digestion	O34	A329/ Mr. Barun Kanoo/ India/ Preliminary risk assessment of decentralized composting systems for source separated biodegradable wet waste from households	O35	A701/ Dr. R. Ramesh/ India/ Three-dimensional activated carbon derived from Luffa fiber biomass for capacitive energy storage application	O36	A713/ Dr. Chunxue Yu/ China/ Nitrogen-doped biochar induced efficient activation of ferrate (VI) for degradation of organic pollutants: Effect of nitrogen species and surface promoted mechanism
1515-1530	O37	A168/ Dr. Jialin Liang/ China/ Iron-rich digestate biochar toward sustainable peroxymonosulfate activation for efficient anaerobic digestate dewaterability	O38	A084/ Ms. Yuwen Zhou/ China/ Patterns of heavy metal resistant bacterial community succession influenced by biochar amendment during poultry manure composting	O39	A376/ Dr. Jianbo Liao/ China/ Efficient recovery of phosphate from aqueous solution by calcium peroxide decorated iron-rich sludge carbon: Adsorption performance and mechanism	O40	A278/ Dr. Remya Neelancherry/ India/ Applicability of commingled food waste biochar as a potential fertilizer
1530-1540	SO21	A054/ Ms. Lijun Luo/ Hong Kong/ Impact of salinity on hydrogen production and acidogenic bacteria for food waste fermentation	SO22	A019/ Ms. Jiaqi Liu/ China/ Effects of fungal pathogen and assistant materials on composting process of infected vegetable wastes	SO23	Dr. Qiuxiang Xu/ China/ Hydrochar prepared from digestate improves anaerobic co-digestion of sewage sludge and food waste	SO24	A120/ Ms. Peixin Wang/ Hong Kong/ Investigation on the synthesis strategy of MgO-biochar catalysts for glucose isomerization to fructose
1540-1550	SO25	A088/ Mr. Neeraj Raja Ram/	SO26	A048/ Ms. Anqi Wang/	SO27	A951/ Ms. Geng Yiqi/ Hong	SO28	A082/ Ms. Qiaozhi Zhang/

		India/ Investigation of microbial-substrate interaction using mixed microbial consortia for enhancement of biogas production from food waste		China/ Bacterial dynamics and functions driven by fermentation material backflow to reduce environmental burden during food waste composting		Kong/ Efficient catalytic hydrogen production from FA over Pd nanoparticles loaded on chitosan biochar at room temperature		Hong Kong/ Synthesizing yard waste-derived biochar for microwave-assisted degradation of PPCPs: performance of various oxidants
1550-1600	SO29	A257/ Dr. Zhang Le/ China/ Cascading fermentation of oleaginous yeast using organic waste for lipid production/ Online	SO30	A165/ Ms. Yan Liu/ China/ Effects of Biochar, superphosphate and magnesium sulfate as additives on gaseous emissions during chicken manure composting/ Online	SO31	A415/ Mr. Zhenwei Yi/ China/ Evaluation of carbon emission and economy of carbon dioxide mineralization for building materials technology	SO32	A057/ Dr. Chaoren Sun/ China/ Straw and straw biochar differently affect microorganisms and soil organic carbon pools in farmland soil under different water regimes/ Online
1600-1620	**Coffee Break**							
1620-1750	**A5: Bioenergy & Bioproducts**		**B5: Biowaste Volarisation**		**C5: Waste Utilization & Recycling**		**D5: Biochar & its Applications**	
	Chair: Prof. Binghua Yan		**Chair: Prof. Lin Ma**		**Chair: Prof. Konstadinos Abeliotis**		**Chair: Dr. Suchithra T. Gopakumar**	
	Co-Chair: Dr. Xiaolei Zhang		**Co-Chair: Dr. Ammaiyappan Selvam**		**Co-Chair: Prof. Weixiang Wu**		**Co-Chair: Mr. Tom Miles**	
1620-1645	P17	Plenary Lecture: A959/ Prof. Solange I Mussatto/ Denmark/ Sustainable strategies to overcome inhibition of biomass hydrolysates and get more value from lignocellulosic biomass/ Online	P18	Plenary Lecture: A169/ Dr. Sunita Varjani/ Hong Kong/ Green processing of cottonseed oil soap-stock for sustainable waste management	P19	Plenary Lecture: A943/ Prof. Lin Luo/ China/ Soil remediation and resource utilization of red mud/ Online	P20	Plenary Lecture: A960/ Prof. Dan Tsang/ Hong Kong/ Green technology with biochar for waste recycling and carbon reduction
1645-1700	O41	A311/ Dr. Mathava Kumar/ India/ Bio-hydrogen generation from food waste: Effects of microwave pre-treatment and inoculum source	O42	A071/ Dr. Surendra KC/ USA/ Insect-based biorefinery for organic wastes valorization	O43	A723/ Dr. Fanghua Li/ /China/ Sustainable production of jet-fuel range hydrocarbons and carbonaceous materials from biowaste catalytic co-pyrolysis	O44	A962/ Dr. P. Maadeswaran/ India/ Synthesis of ternary CeO_2/Fe_2O_3/R-GO nanocomposite loaded biochar for photocatalytic degradation of organic pollutants

1700-1715	O45	A336/ Mr. Harishankar Kopperi/ India/ Solid waste biorefinery: Integrated process development via hydrothermal liquefaction and dark fermentation	O46	A330/ Dr. Kaari Manigundan/ India/ Integrated genomic and field level evaluation of agricultural waste enriched potential *Streptomyces* UP1A-1 for plant growth promotion and disease control	O47	A350/ Dr. Nallapaneni Manoj Kumar/ Hong Kong/ Blockchain-based artificial intelligence of things nutrient-rich food waste selection framework for food waste-derived medical textiles	O48	A650/Dr. Manman Xu/ China/ Melaleuca bark-based biochar for triclosan adsorption and energy storage applications
1715-1730	O49	A172/ Mr. To Ming Ho/ Hong Kong/ Elucidate biorefinery inhibition effect on commercially collected food waste and greener pre-treatment for sophorolipids production	O50	A290/ Mr. Krishna Chaitanya Maturi/ India/ Investigation of morphological characteristics of *Abelmschus esculentus* during terrestrial weed compost amendment in soil	O51	A265/ Mrs. Meilan Zhang/ China/ Optimization of wet waste pre-treatment process and the removal of inert fine particles/ Online	O52	A173/ Dr. Min Pan/ Hong Kong/ Co-application of sewage sludge-Chinese medicinal herbal residues-biochar to antibiotics and antibiotic resistance genes in soil-plant system
1730-1740	SO33	A206/ Ms. Youli Yang/ China/ High solid anaerobic fermentation of vegetable wastes for propionic acid recovery	SO34	A037/ Ms. Yujing Wang/ China/ Odor characterization and health risk assessment of food waste bioconversion by housefly (*Musca domestica* L.) larvae	SO35	A186/ Mr. Kartik Popat/ India/ Employing aspen plus for process modeling of syngas production from municipal solid waste/ Online	SO36	A231/ Mr. Hongxian Li/ China/ Molecular simulation combined with DFT calculation to guide the directional design of heteroatom-doped biochar for efficient CO_2 capture
1740-1750	SO37	A179/ Dr. Bharthiraja B./ India/ Biodiesel production from rice straw using ascomycetous yeast *Yarrowia lipolytica*/ Online	SO38	A322/ Prof. Sihem Arris/ Algeria/ Bio-waste valorisation as sorbent for removal of methylene blue from aqueous solutions/ Online	SO39	A267/ Mr. Adedeji Jacob Adedayo/ South Africa/ Performance evaluation of interlocking paving bricks incorporating waste plastic as alternative aggregates/ Online	SO40	A064/ Ms. Si Tian/ China/ Study on water retention of biochar prepared from coffee by-products/ Online
1750-1830	**Poster Viewing (Room: S426)**							
1900-2200	**Banquet Dinner: Choi Fook Royal Banquet (iSquare), Tsim Sha Tsui**							

Day 3: 02 June 2023 (Venue: The Hong Kong Convention and Exhibition Center (HKCEC))												
0800-0900	**Poster Viewing (Room: S426)**											
0900-1000	**Keynote Session: Chair – Prof. Tian Zhang**											
0900-0930	**Keynote Speech 8: A752/ Prof. Jonathan Wong/ Hong Kong/ Sustainable biowaste management: Opportunities and Challenges in Circular Economy**											
0930-1000	**Keynote Speech 9: A748/ Prof. Chi Sun Poon/ Hong Kong/ Total recycling of concrete waste using accelerated carbonation**											
1000-1020	**Coffee Break**											
1020-1220	**A6: Bioenergy & Bioproducts**			**B6: Biowaste Valorisation**			**C6: Waste Utilization & Recycling**			**D6: Catalytic Conversion Technologies**		
	Chair: Prof. Yanling Cheng			**Chair: Prof. Sandhya Babel**			**Chair: Prof. Samir Khanal**			**Chair: Prof. Patrick Drogui**		
	Co-Chair: Dr. Liwen Luo			**Co-Chair: Prof. Shiyong Sun**			**Co-Chair: Prof. Kaimin Shih**			**Co-Chair: Prof. Haowen Guo**		
1020-1045	P21	Plenary Lecture: A760/ Prof. Anurag Garg/ India/ Approaches for valorisation of biodegradable organic fraction of domestic solid waste		P22	Plenary Lecture: A307/ Prof. Tian Zhang/ USA/ Green recovery from and sustainable management of solid waste generated in electrolytic manganese production		P23	Plenary Lecture: A038/ Prof. Fan Lu/ China/ Odours and other airborne contaminants of emerging concerns relating to MSW storage and transportation		P24	Plenary Lecture: A963/ Dr. Zhao Jun/ Hong Kong/ Conversion of biomass to 5-hydroxymethylfurfural-derived chemicals using carbon-based catalysts	
1045-1105	I13	Invited Lecture: A964/ Prof. Binghua Yan/ China/ Highly selective butyric acid production by coupled acidogenesis and ion substitution electrodialysis		I14	Invited Lecture: A762/ Dr. Carol S.K. Lin/ Hong Kong/ Technological advancement and development of circular waste-based biorefinery for sustainable production of chemicals, materials and fuels		I15	Invited Lecture: A767/ Prof. Kouassi Benjamin Yao/ Ivory Coast/ Valorisation of cocoa pod husks in cellulose triacetate and lactic acid		I16	Invited Lecture: A763/Prof. Yaoyu Zhou/ China/ Magnetic ball-milled red mud@peanut seedling straw biochar as hydrogen peroxide activator for degradation of tetracycline/ Online	
1105-1125	I17	Invited Lecture: A766/ Prof. Hojae Shim/ Macau/ Biodiesel production from optimal food waste hydrolysis by yeast *Rhodosporidium toruloides*		I18	Invited Lecture: A083/ Dr. Mukesh Kumar Awasthi/ China/ Microbial biotechnology approaches for conversion of fruit processing waste in to emerging source of healthy food for sustainable environment		I19	Invited Lecture: A298/ Dr. Ka Yu Cheng/ Australia/ Biotechnical processes for extraction and recovery of metals value from electronic wastes		I20	Invited Lecture: A764/ Prof. Patrick Drogui/ Canada/ Degradation of emerging recalcitrant contaminants in wastes and wastewater using electro-technology	

1125-1140	O53	A286/ Mr. Leygnima Yaya Ouattara/ Ivory Coast/ Cocoa pod husk valorization: Acid-Alkaline pretreatment for microbial lactic acid production	O54	A663/ Prof. Wenjing Lu/ China/ Potential of bio-risks in MSW management system	O55	A296/ Dr. Jian-lin Chen/ Hong Kong/ Monitoring of beach litter in waters of Hong Kong using aerial drone	O56	A116/ Dr. Reeti Kumar/ Hong Kong/ Nitrogen-doped carbon as efficient catalysts for metal-free conversion of 5-hydroxymethylfurfural to 2,5-furandicarboxylic acid
1140-1155	O57	A008/ Ms. Anuradha/ India/ Deep eutectic solvents for the pretreatment of lignocellulosic biomass to enhance the sugar recovery	O58	A369/ Mr. Arsenio Jr Bulfa/ Philippines/ Ecological effects of organic fertilizers produced from agrowastes with different carbon-nitrogen (C/N) ratios on corn growth, soil chemical properties and earthworm behavior	O59	A259/ Dr. Qi Zhao/ Hong Kong/ Choline chloride-dicarboxylic acid based deep eutectic solvents for the valuable metal recovery of waste printed circuit boards	O60	A110/ Dr. Johnravindar Davidraj/ Hong Kong/ Synthesis of Pd-CNT based hybrid and its application in hydrogen production from formic acid at ambient temperature
1155-1210	O61	A320/ Dr. Venugopal Gopikrishnan/ India/ Exploration of organic waste for its bioactive pigments/ Online	O62	A714/ Dr. Wencong Yue/ China/ Carbon emissions in treating food loss and waste in China based on life cycle assessment	O63	A177/ Dr. Dharmar Manimaran/ India/ Effect of 7, 8 dihydroxycoumarin protects environment toxicity of cadmium induced in Zebrafish (Danio rerio) embryos	O64	A194/ Dr. Wang Qiulin/ China/ Insight into PCDD/Fs catalytic decomposition mechanism using two model objects: Experiment and DFT calculation
1210-1220	SO41	A309/ Mr. Jianyu Guan/ Hong Kong/ Construction of a multi-parameter-based model to simulate lignin fractionation kinetics in biorefinery processes for urban waste valorization/ Online	SO42	A310/ Ms. Yahui Miao/ Hong Kong/ Environmental evaluation of emerging bakery waste oil-derived sophorolipids production by applying dynamic life cycle assessment (*dLCA*)	SO43	A013/ Dr. Yue Zhu/ China/ Generation and utilization of garden waste in Shanghai: Status quo, challenges and countermeasures analysis/ Online	SO44	A184/ Ms. Chenxi Zhu/ China/ Solar-driven reforming of waste polyester plastics for hydrogen evolution over CdS/NiS
1220-1400	**Lunch (1220-1300) & Poster Viewing (1300-1400) (Room: S426)**							
1400-1600	**A7: Bioenergy & Bioproducts**		**B7: Bioplastics & Microplastics**		**C7: Innovative Waste Management Practices**		**D7: Landfill, Construction & Demolition Waste Management**	
	Chair: Prof. Pratap Pullammanappallil		**Chair: Dr. Carol S.K. Lin**		**Chair: Prof. Fan Lu**		**Chair: Prof. Yaoyu Zhou**	
	Co-Chair: Prof. Hojae Shim TBC		**Co-Chair: Dr. Mukesh Kumar Awasthi**		**Co-Chair: Dr. Ka Yu Cheng**		**Co-Chair: Dr. Reeti Kumar**	

1400-1425	P25	Plenary Lecture: A965/ Prof. Jishuang Chen/ China/ Material utilization of straw biomass as a kind agricultural by-products, the acquirement and practice	P26	Plenary Lecture: A966/ Prof. William Clarke/ Australia/ Measuring the extent of biodegradation of plastics	P27	Plenary Lecture: A967/ Prof. Samir Khanal/ USA/ Nanobubble technology applications in environmental remediation and controlled environment agriculture	P28	Plenary Lecture: A755/ Prof. Rainer Stegmann/ Germany/ Landfill in-situ aeration and improvement of landfill gas extraction systems- Ways to pollution control and climate protection
1425-1445	I21	Invited Lecture: A968/ Prof. Yanling Cheng/ China/ Fermentation of food waste for the production of clean energy and biofertilizer	I22	Invited Lecture: A359/ Prof. Shiyong Sun/ China/ Enzyme immobilization onto clay surface for waste conversion	I23	Invited Lecture: A101/ Dr. Deepak Pant/ Belgium/ Technological advances in bio/electrochemical carbon dioxide capture & utilization (CCU)/ Online	I24	Invited Lecture: A768/ Dr. Hubert Baier/ Germany/ Pre- and co-processing of tailor-made alternative fuel
1445-1500	O65	A332/ Dr. Singanan Malairajan/ India/ The role of novel biocarbon on the treatment of industrial wastewater – A green concept	O66	A111/ Dr. Manu M.K./ Hong Kong/ Microplastics pollution in food waste biological treatment	O67	A308/ Prof. Bing Xie/ China/ Toxic metal transformation characteristics of fly ash from different cooling zones after municipal solid waste incinerator	O68	A276/ Prof. Haowen Guo/ Hong Kong/ A novel sustainable landfill cover system using recycled construction waste aggregates
1500-1515	O69	A017/ Dr. Ruixue Chang/ China/ Study on the effect and potential mechanism of suppression on Cucumber Fusarium wilt from different biogas slurry	O70	A412/ Dr. Yuquan Wei/ China/ Deciphering the mechanism shaping bacterial community in plastisphere and kitchen waste composting with PLA/PBAT blends	O71	A145/ Dr. Rajamani Sengoda Gounder/ India/ Remediation & reuse of mercury contaminated site by unique two stage process of waterwash and retord	O72	A166/ Prof. Akinbile O. Christopher/ Nigeria/ Assessing the effectiveness of iron oxide activated carbon nanocomposite and iron oxide nanoparticles in landfill leachate treatment
1515-1530	O73	A157/ Mr. Johnny Lo/ Hong Kong/ Fabrication of food waste-derived biodegradable medical textiles via electrospinning and electrospraying for healthcare apparel and personal protective	O74	A006/ Mr. Rajat Kumar/ Hong Kong/ Bioprocess robustness of newer polyhydroxyalkanoate producers as sustainable and persistent industrial strains	O75	A073/ Ms. Siu Ka Yi/ Hong Kong/ Performance of food waste pre-treatment system with the aid of solar-heated water	O76	A628/ Dr. Sook Fun Wong/ Singapore/ Binder testing of mixed plastics-polymer modified bitumen for asphaltic wearing course

		equipment						
1530-1540	SO45	A076/ Ms. Xiaoyun Liu/ China/ Separation and purification of glabridin from deep eutectic solvents (DES) extract of *Glycyrrhiza glabra* residue by macroporous resin	SO46	A090/ Mr. Yi Zheng/ China/ Untargeted metabolomics elucidated biosynthesis of polyhydroxyalkanoate by mixed microbial cultures from waste activated sludge under different pH values	SO47	A036/ Ms. Xinyue Kang/ China/ Evaluation of bioaerosol risk during insect-protein-production of biowaste	SO48	A314/ Dr. Kwok-Pan Ho/ Hong Kong/ Laboratory-scale and pilot-scale study on chemical co-precipitation treatment of old-age landfill leachate
1540-1550	SO49	A326/ Ms. Rabia Jalil Khan/ Hong Kong/ One-pot fractionation of endocarp waste for sustainable high value-added products/ Online	SO50	A180/ Ms. Sima Jingyuan/ China/ Identification and removal of microplastic pollutants in soil-like materials from landfills	SO51	A277/ Ms. Pawena Limpiteeprakan/ Thailand/ Development of cushioning materials from water hyacinth fibers and bagasse/ Online	SO52	A047/ Mr. Udo Eduard Lange/ Germany/ Improvement of upstream SWM supporting the start up operation of four new sanitary landfills in Indonesia
1550-1600	SO53	A086/ Ms. A. Umapathi/ India/ Conversion of Food waste into lipid by oleaginous fungi/ Online	SO54	A325/ Dr. Sonam Paliya/ India/ Aerobic degradation of deca-brominated diphenyl ethers (Deca-BDE): Novel indigenous microbes, mineralization, dehalogenation, metabolites and degradation pathway/ Online	SO55	A374/ Mr. Salvo Salvacion/ Philippines/ Utilization of corn wastes as biochar in amending acidic soil grown with corn	SO56	A018/ Mr. Yuan Liang/ Hong Kong/ Prediction of illegal dumping by using Geographically weighted regression
1600-1615	**Coffee Break**							
1615-1730	**A8: Bioenergy & Bioproducts**		**B8: Bioplastics & Microplastics**		**C8: Hazardous & Industrial Waste Management**		**D8: Landfill, Construction & Demolition Waste Management**	
	Chair: Prof. Anurag Garg		**Chair: Prof. William Clarke**		**Chair: Prof. Kouassi Benjamin Yao**		**Chair: Prof. Rainer Stegmann**	
	Co-Chair: Dr. Qiuxiang Xu		**Co-Chair: Mr. Rajat Kumar**		**Co-Chair: Dr. Sook Fun Wong**		**Co-Chair: Dr. Johnravindar Davidraj**	
1615-1640	P29	Plenary Lecture: A364/ Prof. Pratap Pullammanappallil/ USA/ Thermo-mechanical treatment of nonrecyclable municipal solid waste to enhance organics recovery and biochemical processing	P30	Plenary Lecture: A759/ Prof. Sandhya Babel/ Thailand/ Microplastics contamination in compost produced from solid waste	P31	Plenary Lecture: A757/ Prof. Kaimin Shih/ Hong Kong/ Emerging pollutants in wastewater sludge: lessons learned from perfluorochemicals	P32	Plenary Lecture: A969/ Prof. Wilson Lu/ Hong Kong/ Sharing construction waste materials across different jurisdictions: Prospects and challenges for a smarter and greener

								Greater Bay Area/ Online
1640-1655	O77	A315/ Prof. Arun Alagarsamy/ India/ Development of low-cost proton exchange membrane (PEM) for microbial fuel cells (MFC)	O78	A044/ Mr. Huihuang Zou/ China/ Near-infrared spectroscopy based method for rapid detection of microplastics in complex environment	O79	A306/ Dr. Prasanta Dhak/ India/ Remediation of toxic effects of *Parthenium hysterophorus* through circular economy by using it for the removal of As, Sb, Cd, Cr, U, F and other heavy metals from wastewater	O80	A010/ Dr. Syeda Azeem Unnisa/ India/ Jawaharnagar municipal landill leachate treatment, Hyderabad, Telangana state
1655-1710	O81	A651/ Dr. Jiayu Zhang/ China/ Deciphering chloramphenicol biotransformation mechanisms and microbial interactions via integrated multi-omics and cultivation-dependent approaches	O82	A085/ Dr. Bhoomika Yadav/ Canada/ Concomitant production of value-added co-products during polyhydroxyalkanoate (PHA) production: Approaches for building circular bioeconomy in PHA process/ Online	O83	A160/ Ms. Jiang Wenqian/ China/ Emission characteristics and QSAR model interpretation of PCDD/Fs in a large-scale hazardous waste incinerator under different operation conditions	O84	A360/ Mrs. Ishita De/ India/ Construction & demolition waste challenges – An analysis using the analytical hierarchy process/ Online
1710-1720	SO57	A283/ Mrs. Belhadri Mazouri/ Algeria/ Characterization and valorization of marine sediment/ Online	SO58	A106/ Ms. Tossou Ayoko/ Canada/ Production of PHA from pineapple residues by *Cupriavidus Necator*/ Online	SO59	A443/ Ms. Hayat El Amri/ Canada/ Electrooxidation treatment and dewatering of septic tank sludge/ Online	SO60	A203/ Ms. Anusha Atmakuri/ Canada/ Landfill leachate treatment using a combination of biological and electrochemical methods/ Online
1720-1730	SO61	A366/ Dr. Soulwene Kouki/ Tunisia/ Valorization of biowastes from wastewater phytoremediation process: A model for constructed wetlands integrated management in a South-Mediterranean region/ Online	SO62	A067/ Mrs. Chavan Shraddha/ USA/ Production of polyhydroxyalkanoate (PHA) biopolyesters by thermophilic bacteria using waste substrates/ Online	SO63	A174/ Dr. Kazeem Aderemi Bello/ Nigeria/ Toward the adoption of circular economy in Africa: Prospects and challenges/ Online	SO64	A661/ Ms. Benguit Alae/ Canada/ Tertiary treatment of a mixture of composting and landfill leachates using electrochemical processes/ Online
1730-1800	**Closing Session and Award Presentation**							

Notations: P: Plenary; **I:** Invited; **O:** Oral; **SO:** Short-oral

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03 June 2023	
Technical Fieldtrips	
0830-1300	**Field Trip A: Y-PARK (Facility for recycling of yard waste into useful materials) and T-PARK (Transformation park-Converting waste to energy)**
0830-1300	**Field Trip B: Eco-PARK (Hong Kong's first recycling business park) and O-PARK (Hong Kong's first food waste treatment plant)**

Poster Programme

Poster Viewing Time	
31 May 2023	1300-1400 **(Judging by panel and Viewing for participants)** 1800-1900 **(Viewing for participants)**
1 June 2023	0800-0900 **(Viewing for participants)** 1300-1400 **(Judging by panel and Viewing for participants)** 1745-1830 **(Viewing for participants)**
2 June 2023	0800-0900 **(Viewing for participants)** 1300-1400 **(Viewing for participants)**

Anaerobic Digestion		
A054	Ms. Lijun Luo/ Hong Kong	Impact of salinity on hydrogen production and acidogenic bacteria for food waste fermentation
A088	Mr. Neeraj Raja Ram/ India	Investigation of microbial-substrate interaction using mixed microbial consortia for enhancement of biogas production from food waste
A095	Ms. Aarti Raj/ India	Molecular docking studies of selective bioactive compounds of food waste with key enzymes that affect anaerobic digestion
A243	Ms. Roshni Raj/ India	Physicochemical and biological pretreatment of municipal wastewater against antimicrobial resistance for enhanced anaerobic digestion
A245	Ms. Puja Das/ India	Production of value-added products from anaerobic digestion of brewery spent grain: Roles of pretreatment, co-digestion and trace elements
A436	Mr. Yuk Kit Yuen/ Hong Kong	Evaluation of substrate competition for *Thermotoga neapolitana* fermentation
A689	Dr. Qiuxiang Xu/ China	Rhamnolipid pre-treatment of primary sludge effectively improves short-chain fatty acids production from anaerobic fermentation
A716	Mr. Hyeok Kim/ Korea	Role of quorum sensing and quenching in anaerobic digestion: A mini review
A619	Dr. Johnravindar Davidraj/ India	Effects of hydrothermal pretreatment and the activated sludge on anaerobic digestion of food waste
A718	Mr. MitProhim You/ Korea	Enhancing bio-hydrogen production in anaerobic reactor through exogenous addition of quorum sensing signals
A118	Dr. Jiwan Singh/ India	Anaerobic digestion of invasive noxious aquatic weed *Alternanthera philoxeroides* for production of biogas: Optimization of food to microbe ratio and kinetic study/ Online
A201	Ms. Yannan Ruan/ China	Biochar mediated methanogenesis from acetic acid and ethanol and its correlation with the electron exchange capacity/ Online

Composting		
A097	Mr. M Arun Kumar/India	Influence of different bulking agents on municipal solid waste composting
A098	Ms. Haorong Zhang/ China	Control of nitrogen and odor emission during chicken manure composting with a carbon-based microbial agent inoculation and biotrickling filter

A341	Ms. Yue Wang/ China	Different Composting Technologies and Raw Materials Induced Microbial Dynamics and Core Microbiomes
A674	Dr. Dengmiao Cheng/ China	Dynamics of oxytetracycline, sulfamerazine, and ciprofloxacin and related antibiotic resistance genes during sewage sludge composting
A053	Mrs. T. Anishla/ India	Co-composting of food waste with organic materials: Impact of C/N ratio/ Online
A075	Ms. Fei Li/ China	Nitrogen retention and emissions during kitchen waste and fallen leaves aerobic composting covered with a semi-permeable membrane/ Online
A089	Mrs. KP Ilamathi/ India	Chicken manure composting: Effect of initial carbon / nitrogen ratio/ Online
A340	Dr. Noor Zalina Mahmood/Malaysia	Potential of carbon emissions avoidance from food waste composting in Higher Education Institution (HEI)/ Online

Biowaste Valorisation		
A215	Ms. Masse Bamba/ Ivory Coast	Preparation and characterization of cellulose triacetate from cocoa pod husk (CPH)
A291	Mr. Leygnima Yaya Ouattara/ Ivory Coast	Valorization of cocoa pod husk in high value added-products
A323	Dr. Elda Cicala/ Italy	Extremophile extracts from microalgae and vegetales for the food industry
A331	Mr. Tharak Athmakuri/ India	Metabolic insights of carboxydotrophics in syngas fermentation for low-carbon chemicals/fuels
A746	Dr. Godan TK/ Hong Kong	Biotransformation of sorghum syrup derived HMF to FDCA using novel *Rhodococcus qingshengii* C27
A355	Ms. Anjali Mishra/ India	Spent mushroom substrate and fruit waste bioconversion by Black soldier fly larvae (*Hermetia illucens*): Effect of cow dung biochar addition/ Online

Bioplastics & Microplastics		
A150	Ms. Rui Ma/ China	Dissolved oxygen impact on PHA production with kitchen waste as carbon source
A704	Mr. Xiao Dong Wang/ China	Polyhydroxyalkanoates production by mixed cultures acclimated from wastewater sludge with food waste as carbon source in continuous fermentation
A1121	Dr. Abhishek Srivastav/ India	Fate and impacts of bioplastics during food waste anaerobic digestion
A192	Ms. Shweta Yavagal/ India	Bioplastics: An emerging blue technology contributing to green economy/ Online

Waste Management Practices: Countries Perspective		
A149	Ms. Peixiu Chen/ Hong Kong	"The challenge of plastic beverage container recycling in Hong Kong-Perspectives and performances of local recyclers"
A175	Ms. May Soe Oo/ Hong Kong	Evaluating WEEE generation, disposal decision and consumer preferences in support of reverse logistics for a circular economy in Hong Kong
A187	Dr. Maher Hamdan/ Palestine	Municipal Solid waste management in West Bank/Palestine (challenges and solutions)
A217	Ms. Dharani B/ India	Zero waste: Current mechanism and new innovative ideas for collection and segregation of waste in Karaikudi
A304	Prof. Muhammad Abu	A comparison among the CDW schemes of Infrastructure construction

	Eusuf/ Bangladesh	Industry: An experience from the scenario of Bangladesh and Malaysia
A319	Mr. Leo Dyaji/ Malaysia	Occupational health risks associated with scavenging in Gosa dump site, federal capital territory, Abuja-Nigeria
A347	Dr. Nallapaneni Manoj Kumar/ Hong Kong	When and How Solar Photovoltaic Waste Would Become a Burden for Hong Kong? and the Actionable Insights for Effective Management
A348	Dr. Nallapaneni Manoj Kumar/ Hong Kong	Cross-border industrial symbiosis over in-city industrial symbiosis for Hong Kong city's circular dream
A196	Ms.Zesizwe Ngubane/ South Africa	Solid waste management in different economic settings: A case study of uMsunduzi Catchment, South Africa/ Online
A275	Prof. Ayyakannu Arumugam/ India	Zero waste management community adapted in karaikudi, tamil nadu, environmental problem solving, and sustainable development/ Online
A281	Ms. Archana Kumari/ India	An analytical study on management of bio-medical waste in selected hospitals of Patna municipal ward: A northern city of India/ Online

Waste utilization & recycling		
A030	Dr. Ankur Rajpal/ India	Potential utilization of sewage sludge for cost effective natural farming in India: Characterization and treatment
A040	Mr. Jiajun Chen/ China	Simultaneous adsorption abilities of inorganic-organic modified montmorillonite as affected by different adding sequences
A066	Mr. Yue Qiu/ China	Preparation of nano-$CaCO_3$ by-product of biogas decarbonization with microfluidic device
A070	Ms. Yu Zhang/ China	Interfacing Biosynthetic CdS with Engineered *Rhodopseudomonas palustris* for efficient visible light-driven CO_2-CH_4 conversion
A146	Dr. Yemane Asfaha/ Ethiopia	Application of hybrid solar-powered electrocoagulation and electrooxidation system for textile wastewater treatment
A152	Dr. Atreyee Kundu/ India	Biodegradability of non-biodegradable and biodegradable plastic through circular economy
A185	Dr. Musa Abubakar Tadda/ China	Utilization of baobab fruit shell waste as a filler-fibre for enhancing polyethylene biodegradation and improving soil fertility
A209	Mr. R S Kaarmukhilnilavan/ India	The Carica papaya plant latex as potential bioflocculant for STP applications
A258	Mr. Tao Song/ China	Fe_3^+ addition for enhancing the formation and stabilization of aerobic granular sludge
A624	Prof. Lan Xiang/ China	Separation of low-grade phosphate ores by novel semi-through hydraulicbarrier hydrocyclone
A625	Prof. Lan Xiang/ China	Preparation of purified gypsum from phosphogypsum via selective adsorption route
A646	Dr. Wencong Yue/ China	Optimum strategies of regional kitchen waste treatment against a background of carbon mitigation
A657	Dr. Lizhu Yuan/ China	Influence of C14 alkane stress on Cd and nutrient elements uptake by four potential petroleum hydrocarbon remediation plants
A669	Mr. Wei Sun/ China	Carbon-driven persulfate activation for nonradical antibiotic degradation in aquatic surroundings
A710	Mr. Ning Jie Wang/ China	Odor emission characteristics from unorganized source of kitchen waste management plant and control strategy
A367	Mr. Wei-Jhu Wang	A study on improving the mechanical properties of asphalt concrete by using EAF stainless steel slag

A065	Ms. Hayat El Amri/ Canada	Electrolytic treatment of septic tank sludge/ Online
A081	Dr. Sudhansu Shekhar Mahanand/ India	Effect of partial replacement of feed with biofloc on water quality and growth for Indian Major Carp (IMC) culture/ Online
A104	Ms. Alae Bengui/ Canada	Development of an electrolytic process dedicated to the in-situ treatment of septic sludge as an adaptation measure to climate change/ Online
A214	Mrs. Belhadri Mazouri/ Algeria	Characterization and valorization of marine sediment/ Online
A221	Ms. Ghazal Srivastava/ India	Insights on comprehensive qualitative and quantitative approaches for diverse microbial community analyses, wastewater characterization, and biochemical process performance of full-scale SBR plant in Roorkee, India/ Online
A328	Mr. Ajay P/ India	Circular and green economy in solid waste management/ Online

Thermal Treatment & Biochar Applications		
A205	Mr. S. Srinivasan/ India	Synthesis of waste face masks assisted magnetic-biochar for the removal of malachite green from aqueous solution
A303	Mr. Yuchao Shao/ Hong Kong	Humic acid from hydrochar: Correlation between unsaturation and hydrothermal humification of hydrochar
A705	Dr. Jun Wang/ China	High-quality syngas generation from waste plastics by catalytic pyrolysis over iron-based oxygen carriers
A774	Mr. Chao Li/ A774	Co-pyrolysis of food waste and rice straw: Hydrogen yield optimization study
A069	Ms. Lina Qian/ China	Effective degradation of chloramphenicol in wastewater by activated peroxymonosulfate with Fe-rich porous biochar derived from petrochemical sludge
A345	Prof. Kumarasamy Murugesan/ India	Biochar Derived from *Miscanthus sinensis* and Its Applications: Removal of Antibiotics from Aqueous Media
A079	Mr. Rui Hong Teoh/ Malaysia	Evaluation of the efficiency of wet torrefaction of EFB fibre and palm fronds for solid fuel production/ Online
A205	Mr. S. Srinivasan/ India	Synthesis of waste face masks assisted magnetic-biochar for the removal of malachite green from aqueous solution/ Online

Catalytic Conversion Technologies		
A016	Dr. Wenfei Cai/ Hong Kong	Renewable fuels production from catalytic fast pyrolysis of biomass with montmorillonite clay loading single-atomic-site iron catalyst
A112	Dr. Jian Ye/ Hong Kong	Functionalized rGO Nanoconfined Membrane-Induced Ultrafast Molecular Oxygen Activation for Enhanced the Gas-Solid-Liquid Interfacial Mass Transfer
A080	Ms. Gaihong Wang/ Hong Kong	Catalytic degradation of chloramphenicol by persulfate oxidation with endogenous nitrogen-doped biochar derived from chicken manure
A113	Ms. Mengge Shang/ Hong Kong	Sodium alginate-based carbon aerogel supported ZIF-8 derived porous carbon as an effective adsorbent for methane gas
A114	Dr. Wenhua Xue/ Hong Kong	The impact of water on photocatalytic 5-Hydroxymethylfurfural conversion over Cd-based catalyst
A181	Dr. N Raghavendra/ India	Development of Nb_2O_5/rGO nanocomposites for their electrochemical

		sensor & photocatalytic applications
A292	Dr. Zhi Zhu/Hong Kong	Construction of direct dual Z-system CeO_2@N-GO/g-C_3N_4 photocatalyst for enhanced wastewater degradation
A570	Ms. Wenjing Ma/ China	A novel nickel catalyst supported on coal gangue for producing high-value carbon nanotubes and hydrogen
A204	Dr. Periyasamy Soodamani/ India	Biochar-fabricated magnesium ferrite (BC@$MgFe_2O_4$) Nano-bio composite for the removal of emerging pharmaceutical pollutants from water/ Online

Innovative Waste Management Practices		
A188	Ms. Gefei Liu/ China	Study on calculation method of carbon emission reduction of Industrial solid wastes based on fossil carbon fraction
A218	Mr. Anurag Tomar/ India	Treatment of black water by advanced anaerobic baffled reactor
A295	Mr. Paschal Milindi/ Hong Kong	Food waste-Energy-Water-Emissions (FEWE) nexus in the food service sector: Comparative Life Cycle Assessment of locally produced vs imported meal
A032	Dr. Yaping Qi/ China	Rapid determination of moisture content of multi-source solid waste using ATR-FTIR and multiple machine learning methods
A102	Mr. Sushil Kumar/ Canada	Environmental friendly approach of treatment of commercial laundry wastewater using extracellular polymeric substances (EPS)/ Online
A252	Mr. Kunsen Lin/ Singapore	Transfer learning based Visual Geometry Group Network (TLVGGNet) for classification of recyclable waste in China: Estimation of energy saving potentials, CO_2 emission reduction, and economic analysis/ Online

Electronic waste management		
A197	Mrs. Pushpa Gautam/ India	Facile recovery of CuO nanostructures from discarded printed circuit boards: Evaluation of photocatalytic activity
A233	Mr. Harsh Chhangani/ India	Disposing habits and treatment awareness of e-waste in universities of Rajasthan state of India: A case study
A234	Prof. Manoj Kumar Singh Chhangani/ India	A review on recovery of metals from electronic waste
A235	Dr. Vivek Mandot/ India	A review of recycling technologies of PCBs
A237	Mr. Niyant Mandot/ India	E-Waste management for environmental sustainability: An investigative study
A238	Dr. Sridhar Pilli/ India	A review on improved collection approach for small IT and telecommunication equipment waste in India under circular economy
A239	Dr. Monika Roat/ India	The role of communication medium in awareness of e-waste recycling in colleges
A240	Dr. Dharmendra Kumar Meena/ India	E-waste hazards: Encourage the need for green electronics
A279	Dr. Chun Ho Lam/ Hong Kong	A Green Slurry Electrolysis to Recover Valuable Metals from Waste Printed Circuit Board (WPCB) in Recyclable pH-Neutral Ethylene Glycol
A358	Mrs. Teema Thomas/ India	Effect of magnetized nutmeg seed shell-based biochar on the bioleaching of printed circuit boards/ Online

Hazardous, Industrial & Special Waste Management		
A211	Mr. Vishal Singh/ India	Extraction of Iron from industrial metal waste using bioleaching process
A195	Dr. Prajaks Jitngernmadan/ Thailand	Automation and coding to tackle SDG 11 & 12 – A Thai-EU higher education institutions' project
A551	Mr. Shafeeque ur Rehman Laghari	Effects of indoor air pollution on health and olfactory system by using Internet-Of-Things (IoT) and smart sensors
A362	Dr. Roghayeh Karimirad/ Hong Kong	Global energy under the impact of the coronavirus pandemic
A161	Ms. Chunyue Lu	Impact of pre-to-post COVID-19 lockdowns on air quality index (AQI): A tale of three cities with different lockdown policies and strategies
A361	Dr. Rahul Baidya/ India	Hazardous industrial waste co-processing in cement plants/ Online

Landfill Management		
A010	Dr. Syeda Azeem Unnisa/ India	Jawaharnagar municipal landill leachate treatment, Hyderabad, Telangana state
A299	Ms. Ayat Asma/ Algeria	Exploitation of prickly pear cladodes powder and valorization of waste food (date stones) in landfill leachate treatment
A344	Mr. Arghya Ghosh/ India	Assessment of total content and leaching potential of heavy metals from landfill-mined fine fractions under various reuse scenarios/ Online

International Conference on Solid Waste 2023:

Waste Management in Circular Economy and Climate Resilience

Keynote Speeches

Manufacture of Organic-Based Fertilizers to Ensure Development of Sustainable Agriculture

S. Qirong[1]

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Here, we performed four parts of work related to the development of organic fertilizers and bio-organic fertilizer, as well as their regulation effect on soil microbiome. (1) Developed a high-quality compost manufacturing technology: we developed a pH-adjusting technology to reduce ammonia volatilization and improve nitrogen nutrition levels during composting. A compost inoculum was established that can significantly promote rapid temperature rise and humus synthesis, leading to a 40% increase in composting efficiency. Furthermore, we designed a new composting and fermentation process that combines static oxygen supply and stack-type tilting oxygen supply, reducing the composting period from 2 months to 20 days. This fertilizer promotes the synchronization of soil nitrogen supply and crop nitrogen demand, improving nitrogen usage rates from 30% to 40% by stimulating microorganisms to fix fertilizer nitrogen in the early stage and release nitrogen in the later stage. (2) Developed the manufacturing process of secondary solid fermentation technology for *Bacillus* biofertilizer, which has played a significant role in the development of China's biofertilizer industry: we screened *Bacillus velezensis* SQR9, which promotes plant growth by 30%. It was discovered that Bacillomycin D functions as the signal substance that determines the formation of biofilm on the root surface of *Bacillus* and that the strength of biofilm formation determined by the phosphorylation level of the regulatory factor DegU. Furthermore, it was found that after colonizing the root surface, SQR9 synthesizes IAA mainly through the indole pyruvate, tryptamine, and indole acetonitrile pathways, thus promoting root growth. The high pH of the product resulted in ammonia volatilization and suffocation of functional bacteria, which limited their survival in biological fertilizer products. To address this issue, he developed a second solid fermentation technique to produce Bacillus bio-organic fertilizer by adding 10% acidic amino acid solution to the compost before *Bacillus* inoculation. This method increases the content of beneficial bacteria in the product to more than 10 billion spores/gram, and the product's pH is controlled at 6.5–7.5 to ensure that the content of beneficial bacteria meets or exceeds industry standards through the product's shelf life. (3) Developed a low-cost solid fermentation process for Trichoderma, providing continuous support for technological innovation and product upgradation in China's biofertilizer industry: we screened the *Trichoderma harzianum* fungus (NJAU4742), which significantly promotes plant growth and controls pathogen growth, and found that NJAU4742 promotes the development of plant lateral roots through the secretion of expansion proteins and auxin from the mycelium, resulting in improved nutrient and water absorption by the host plant. Based on the acid resistance of NJAU4742 and its inability to grow under low pH conditions, a solid-state fermentation process for the efficient production of *Trichoderma* spp. spores using straw amino acids and acid-hydrolyzed animal protein wastes were developed. This technology has reduced the production cost of Trichoderma by 40%. (4) Formed a theoretical and technical system for the regulation of soil microbial flora: The cultivation of disease-resistant soil is crucial for the sustainable development of the economic crop industry, and the microbial flora in the soil plays a vital role in the development of disease-resistant soil. We pioneered research on the characteristics and manipulation of disease-suppressive soil microbiomes domestically and internationally. By applying bio-organic fertilizer in conjunction with soil fumigation, more niches become available for the colonization of exogenous beneficial strains in the soil. Additionally, the application of organic fertilizer provides additional niches for the effective colonization of beneficial strains, thus achieving the goal of soil microbial community assembly manipulation.

The Role of Biogenic Waste and Residues in the Bioeconomy & Energy System – Strategic, Technical, Ecological & Economical Aspects

M. Nelles[1,2]

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It may be difficult in the face of the brutal Russian attack on the Ukraine, but other global challenges continue demand our attention. This especially holds true for the transformation of our society into a climate-neutral one – bearing in mind that this is also one key prerequisite for preventing future armed conflicts. Put very simply, climate neutrality will only happen if the following formula is observed: Climate neutrality (CN) = Renewable energies (RE) + Circular economy (CE). As explained in the present paper, Germany still has a long way to go towards its 2045 goals. In 2021, the country emitted 762 Mg CO2, and reduction rates compared with 1990 are back to below 39 %. On the one hand side, the share of RE in both primary energy consumption (PEC) – currently just under 16 % – and total final energy consumption (FEC, <20%) is still quite low. For PEC as well as for FEC, the share of bioenergy in total RE was about 60% in 2021. This means we must halve our current energy consumption as fast as possible. Both rigorous energy saving actions and substantial increases in energy efficiency will be required to achieve this. Germany's energy supply must switch to RE completely and in all sectors over the next decades. This will require a massive expansion and optimised integration of wind, solar, bio-, geothermal and hydro-energy for heating/cooling, electricity and transport. Bioenergy will primarily be required to close the gaps where other RE cannot guarantee security of supply. Moreover, energetic use of biogenic resides and wastes will continue to increase in importance. On the other hand side, our linear economic system must become a true circular economy. Currently, we are still far from achieving this. Organic raw materials for industry need be bio-based instead of petroleum-based, as far as possible. Again, an optimised use of biogenic residues and wastes for materials and energy will be key here. Such integration of biomass into a sustainable bioeconomy and energy system can only be realised in the long term if the former is used efficiently, in an environmentally compatible way and to a maximum total economic benefit. This will require new technological concepts, increased coupled and cascading usage as well as negative emissions, which are generated by storing "green" carbon. The biomass must also come from biogenic residues and wastes, or from sustainable cultivation. The current technical potential of biogenic residues and wastes in Germany amounts to 85.6 to 139.6 Mt dry mass. Between 67 and 85 % of this are already being used for material or energy production. The DBFZ assumes that, one the one hand side, the existing usage can still be optimised, and on the other hand side, an additional 12.8 to 45.5 Mt dry mass could and should be mobilised for further processing. These are also central research areas of the German Biomass Research Centre (DBFZ-Deutsches Biomasseforschungszentrum gGmbH) and the Chair of Waste and Resource Management at the University of Rostock.

Keywords: Organic waste, Bioenergy, Bioeconomy, Energy system, Climate neutrality

Sustainable Treatment and Utilization of MSWI Fly Ash

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Municipal solid waste (MSW) encompasses a significant fraction of food waste, paper, plastic, wood, textile, etc., and the global yield of MSW is constantly increasing with rapid urbanisation and improvement of people's living standards. Incineration is one of the mainstream MSW treatment approaches, which could utilise renewable energy from waste. However, municipal solid waste incineration (MSWI) fly ash is inevitably generated and the MSWI fly ash is classified as hazardous waste in many countries due to its high contents of heavy metals and other contaminants (dioxins, furans, sulphate, chloride and acids, etc.). To maximize environmental, social, and economic benefits, the development of low-carbon and sustainable stabilization/solidification (S/S) technologies for MSWI fly ash has attracted extensive interest in recent years. In this work, the latest understanding of S/S mechanisms was elaborated for guiding the design of S/S binder. Various cementitious materials, such as ordinary Portland cement (OPC), calcium aluminate cement (CAC), and magnesium oxysulfate cement (MOSC) were designed for low-carbon S/S of MSWI fly ash. Results showed that single use of OPC showed low compatibility with MSWI fly ash, however green materials incorporated binder could effective immobilization of toxic elements. Besides, CAC had an excellent immobilization efficiency of toxic elements in MSWI fly ash and the incorporation of phosphates enhanced the S/S performance of CAC-treated samples. Moreover, MOSC could generate favorable reaction products (e.g., 5-1-7 phase) for S/S of toxic elements in MSWI fly ash. Pb^{2+} in MSWI fly ash coordinated with SO_4^{2-} and substituted Mg^{2+} ions in the 5-1-7 phase internal structure, whereas AsO_3^{3-} replaced SO_4^{2-} in the large interlayer spaces of 5-1-7 phase. Therefore, MOSC is low-carbon and high-efficiency cementitious materials for the S/S of MSWI fly ash containing both metallic and metalloid elements. Moreover, catalytic pyrolysis combined with mechanochemical treatment has been established to remove the dioxins and heavy metals in MSWI fly ash for subsequent resource utilization. Results showed that removal efficiency higher than 97% for dioxins was achieved by pyrolysing at temperature 350℃ for 10 mins. The fingerprint of the dioxins indicated that dechlorination dominates dioxin degradation in the pyrolysis process. Besides, water washing can effectively reduce chloride content in MSWI fly ash and lower the pyrolysis temperature to even 250℃. Toxic equivalent quantity (TEQ) concentrations of dioxins in pyrolyzed fly ash were lower than the European end-of-waste criteria (20 ng TEQ/kg) and met Chinese resource utilization standards. The mechanochemical (MC) treatment as a green method shows excellent stabilization of heavy metals and improved the reactivity of fly ash for resource utilization. The MC treatment with NaH_2PO_4 as an additive showed a significant inhibitory effect on heavy metals, the leaching concentration of Cd, Cr, Cu, Ni, Pb, and Zn. In addition, the modified fly ash by MC treatment can be used as supplementary cementitious material due to the enhanced pozzolanic effect. Therefore, catalytic pyrolysis combined with mechanochemical treatment can effectively remove the dioxins and stabilize the heavy metals, delivering a promising method for green fly ash disposal. Furthermore, a novel technology of converting MSWI fly ash into insulation material through oxygen-enriched melting is developed. By combining MSWI fly ash melting process and the insulation material production process, a new insulation material is produced from MSWI fly ash. Results show that the dioxin is reduced by 98.3% after melting, whereas heavy metals are successfully immobilized. The utilization of oxygen-enriched melting saved fossil fuel consumption during the melting process and reduced the flue gas emission and energy loss. The production of insulation material with the addition of MSWI fly ash not only saves the consumption of ore resources but also generated extra economic benefits, which can be an effective and sustainable approach for the utilization of MSWI fly ash.

Keywords: MSWI fly ash, Hazardous waste treatment, Stabilization/ solidification, Oxygen-enriched melting, Sustainable construction materials

Microplastics and Nanoplastics Pollution and Their Sustainable Management

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The countries around the world are suffering with the ubiquitous influence of plastics. From polar regions to deep oceans, aquatic ecosystems and terrestrial areas, plastic proliferation is everywhere. They remain in the environment for a very long time and their surfaces gets weathered resulting in numerous micro- and nanosized plastics. Due to their small size, these microplastics and nanoplastics have the potential to be ingested by the biota thus, entering into the food webs and causing adverse biological effects. In addition, they can travel globally and have the potential to accumulate and interact with toxic pollutants existing in environment.

The pollution and health hazards caused by the microplastics (MPs) and nanoplastics (NPs) in the environment (freshwater, marine water and terrestrial ecosystems) have become serious concerns globally. The microplastics have been detected around the globe and have impacted seriously to biota and humans. In order to understand the possible risks, provide recommendations for future studies and develop technologies to eliminate the micro/nanoplastics, it is important to understand their sources, distribution and occurrence, interactions with other contaminants, interactions with biota and their sampling and detection methods. The term ‘microplastic’ was introduced in 2000; while initial studies focused on marine sources, the focus during 2010-2015 shifted on the estimation of MPs from freshwater and soil, impacts on environment, adsorption of co-pollutants, bioplastics as potential alternate and during 2015-2020, it has on the estimation of MPs from air, snow, ecotoxicity, impacts on health, fate and migration, policy development. The current trend is on atmospheric transport and impacts on air, micro-nano-plastics (MNPs), economy, feasible solutions. This lecture will discuss the recent advancements and research in the field of micro-/nano-sized plastics and future research perspectives to tackle the plastic pollution.

Enhanced Landfill Mining – Technologies, Products and Costs

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The mining of landfills (LFM) is, or has been operated for different reasons, like the reduction of environmental impacts or an alternative, higher-value use of landfill areas. Most of the projects carried out in the past have focused on groundwater protection and land reclamation for infrastructure measures. These measures were generally based on the relocation resp. repositioning of the landfilled waste. In the more recent past, landfill mining projects have increasingly been implemented with the aim of gaining landfill volume. The volume generation is not only achieved by more efficient installation methods, but in particular by measures for recycling and energy recovery. Because of the fact that a shortage of resources is to be expected in the future as well as an increase in prices, the aspect of mining of recyclable fractions from landfills is becoming more and more into consideration. The feasibility of landfill mining, especially the economic viability, is subject of many discussions. The paper will show the potential – quality and quantity - of resources in landfills and evaluate the contribution of these secondary raw materials to energy and material supply. In addition, details about suitable technologies for deconstruction, processing and confectioning of the deconstructed waste from landfills are given. Of great importance for landfill mining are information about achievable product qualities, as a basis for the marketing of the secondary raw materials that have been extracted.
The experiences from LFM show that (as a worldwide average) more than 60 % of the deposited waste consists of minerals, which usually are not reused, because of the often highly contaminated finer soil parts. On the other hand, the demand for building materials, especially in Asia, is currently high and will continue to be so in the future The recycling of parts of the mineral-rich fine fraction (< 60 mm) and the production of alternative fuels (RDF) are a key focus in this context.

Valorization of Wastes to Bioplastics: Challenges and Opportunities

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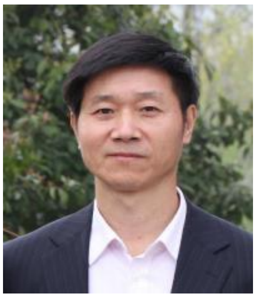
The hazardous effects of synthetic plastics can be prevented by using biopolymers which are biodegradable, environment-friendly and naturally produced by microbes. Among them, polyhydroxyalkanoates (PHAs) have achieved a greater attention due to their biodegradable nature and properties similar to petro-plastics. PHAs can be produced by a variety of micro-organisms and get accumulated as carbon and energy reserves under nutrient imbalance. They have applications in biomedical implants, tissue engineering, drug and nutritional supplements, packaging materials, agriculture, and biofuels industry. Despite their numerous benefits, the large-scale production of PHA is restricted due to its high production cost. The high PHA cost is due to the high raw material cost, low PHA yield, low PHA productivity and high recovery cost. Wastes and industrial by-products (waste lipids, crude glycerol, wastewater, sewage sludge and agro-food wastes) have been investigated to lower the production cost.

However, the heterogenous nature and presence of impurities in the waste substrates may result in low biomass and product yield. Low utilization of wastes by the microbial strains can be overcome by developing pre-treatment strategies for waste feedstocks, optimizing growth and operational parameters, supplementing nutrients and using efficient and robust microbial strains. The PHA produced using wastes may also contain several impurities that can impede their applications, therefore, stringent and efficient downstream processing is required. Designing the downstream processing depends on several factors like feedstock type, biomass concentration, biomass PHA content, type and properties required.

The combination of utilization of inexpensive carbon substrates and recovery of useful co-products is a significant step to make the process cost-effective and sustainable. Integrative approaches to valorize industrial waste streams to PHA and recover value-added co-products such as microbial proteins, extracellular polymeric substance (EPS) and lipase synthesized along PHA will be discussed. After fermentative PHA production and downstream processing, various liquid streams (such as waste stream generated after treatment of PHA-rich biomass and wash waters) are released which are generally discarded. Various recycling strategies were developed for these streams to be recycled in the subsequent PHA production process. The opportunities of recovering high value-added co-products during PHA production as well as minimizing the ecological risks by recycling precarious waste streams generated during the process in more than one fashion to maintain circular bioeconomy will be presented. Therefore, the various technical, biological and economical challenges along with the future perspectives for sustainable valorization of wastes to PHA will be discussed. Furthermore, the key insights on pre-treatment techniques, process optimization, technological approaches, recovering value-added co-products and recycling of waste streams generated in the process will be presented. The integration of pilot-scale biorefineries with PHA production technologies which is required for sustainable production of bioenergy, biofuels and biochemicals will also be discussed.

Keywords: Polyhydroxyalkanoates, Biopolymers, Bioprocess, Downstream processing, Waste streams, Co-products.

Pristine and Modified Biochars Derived from Urban Green Waste for Remediation of Contaminated Environments



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With continuous improvement of the urban environment, urban green wastes have increasingly become a management challenge faced by many municipal governments. On the other hand, woody green wastes have the potential to be converted to biochar with pyrolysis technology. Pristine and engineered biochars have been proven to be effective materials for the remediation of environments contaminated with a wide spectrum of (in)organic pollutants. In this presentation, we will report recent research progress in our laboratory on using green waste-derived biochar materials for decontamination of polluted water and soils.
Our research focused on using designed-biochar materials for environmental remediation associated with typical contaminants, e.g., enhanced sorption of trivalent antimony by chitosan-loaded biochar in aqueous solutions: characterization, performance and mechanisms; the adsorption mechanisms of oriental plane tree biochar toward bisphenol S: a combined thermodynamic evidence, spectroscopic analysis and theoretical calculations; biochars improved nutrient bioavailability, enzyme activity, and plant growth in metal-phthalic acid ester co-contaminated soils: a trial for reclamation and improvement of degraded soils; iron-modified biochar and water management regime-induced changes in plant growth, enzyme activities, and phytoavailability of arsenic, cadmium and lead in a paddy soil; elucidating the redox-driven dynamic interactions between arsenic and iron-impregnated biochar in a paddy soil using geochemical and spectroscopic techniques; effect of biochar aging and co-existence of diethyl phthalate on the mono-sorption of cadmium and zinc to biochar-treated soils; and pristine and iron-engineered biochars enhanced bacterial abundance and immobilized arsenic and lead in a contaminated soil.

Keywords: Engineered biochar, Biowaste, Adsorption, Soil remediation, Wastewater treatment.

Influences of Waste Segregation Policy on the Climate Change Impact of Waste Management Systems

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The implementation of waste segregation in China has impacted the waste management systems, both in urban and rural areas. However, whether the change is positive or negative is still inexplicit. In this study, influences of waste segregation on the climate change impact of waste management systems in both urban and rural areas were quantified using life cycle assessment method based on field investigations and literatures. In the urban cases, two scenarios representing the waste management systems before and after the implementation of waste classification in Shanghai were set up. And in the rural case, two scenarios with either a landfill site or a waste-to-energy (WTE) incineration plant to treat all mixed waste were built to represent the most common situation before the implementation of wastesegregation in rural areas. Besides, two scenarios in which waste segregation is implemented and waste are divided to organic fraction and residual fraction were established. The organic fraction was treated by composting and anaerobic digestion (AD), and the residual fraction is disposed in either a landfill site or a WTE incineration plant. Sensitivity analysis was also performed. The results showed that for treating 1000 kg waste, 208 kg CO_2-eq GHG was emitted in average before waste segregation and 40.4 kg CO_2-eq GHG in average after that in urban areas. It was indicated that waste segregation helps mitigate the climate change impact of waste management systems in urban areas. The largest contributor was the avoidance of directly landfilling waste because waste segregation separated organic fractions for AD and the capacity of WTE plants became enough for residual fraction. In rural areas, the average values of climate change impact of landfilling and incinerating 1000 kg mixed waste were 226 kg CO_2-eq and -32.4 kg CO_2-eq, respectively. Those of landfilling and incinerating residual waste from 1000 kg mixed waste were 119 kg CO_2-eq and 18.0 kg CO_2-eq, respectively. It was indicated that after waste segregation and organic fraction separated from mixed waste stream, the climate change impacts of scenarios with a landfill site decreased and those of scenarios with a WTE plant increased. The common conclusions for both urban and rural areas are that avoiding direct landfill of organic fraction can decrease the climate change impact of waste management systems and that the climate change impact of incinerating residual fraction is higher than that of incinerating mixed waste when all conditions are the same. Based on this study, it can be concluded that waste segregation helps mitigate the climate change impact of waste management systems and that improving the energy recovery in WTE plants in China simultaneously will further decrease the impact.

Keywords: Climate change impact, Waste management, Rural, Urban, Landfill, Waste-to-energy.

Sustainable Biowaste Management: Opportunities and Challenges in Circular Economy

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The world generates ~2.01 billion tonnes of municipal solid waste (MSW) annually which is expected to increase by ~70 percent to 3.4 billion metric tons by 2050. Food waste is a major contributor of environmental pollution accounting for nearly 50% of global MSW. The global food waste causes several environmental and economical consequences such as ~8-10% of global greenhouse gas (GHG) emissions and wastage of 25% of the world's freshwater. The direct economic consequences of food waste estimated by UN is ~1 trillion USD, hence, the smart waste management market is projected to be worth ~6.5 billion USD by 2026. The carbon footprint of food waste is estimated to be 3.3 billion tons of CO_2 equivalents released into the atmosphere a year. Considering the depleting natural resources, food waste can be used as a potential resource due to the presence of intact energy, carbon, nutrients, vitamins, minerals, and metals that need to be recycled back into our fossil-based economy. Hence, it is the need of the hour to develop the efficient and innovative technologies to convert food waste biologically and chemically into energy and value-added products such as biofertilizers and industrial biochemicals such as pigments, bioplastics, etc. Currently, energy from biomass is the leading renewable energy source accounting for 55% of renewable energy and over 6% of global energy supply. However, significant technological efforts are needed to accelerate modern energy production from biowaste. Further, the global biofertilizers market is estimated to grow significantly due to the physical barrier against pests, pathogens, increasing demand for organic food and rising prices of chemical fertilizer. Besides, bioproducts from biowaste such as biosurfactants, biopolymers etc. has attained increased attention to replace the fossil-based sources demanding for the development of novel and integrated approaches. Apart from biological approaches, chemical conversion technologies are progressing in the past decade for valorisation of biowaste into hydrogen and other value-added products such as precursors of biopolymers, bio-insecticides, medicines etc. To achieve this, development of commercially viable conversion technologies with efficient catalysts are needed to comply with the principles of green chemistry. Overall, the sustainable biowaste management provides several benefits such as mitigation of GHG emissions, improvement of soil quality, reduced waste disposal cost, alternative for fossil-based sources and job creations. However, the efficient management of biowaste should consider the suitable technological approaches based on the availability of resources, local economy and need to cater for the increasing circular economy. Hence, in this work, the available and possible niches of development for the biological and chemical treatment technologies for sustainable food waste management are discussed.

Keywords: Biowaste, Organic resource, Circular economy, Waste to energy, Bio-products.

Total Recycling of Concrete Waste Using Accelerated Carbonation

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The world is facing critical environmental challenges due to climate change which is believed to be related to CO_2 emissions. Also, accelerated urbanisation and redevelopment generate huge amounts of concrete waste. Carbonation of waste concrete can utilise concrete as a carbon sink due to the rapid chemical reaction between CO_2 and the hydration products of cement. This presentation will focus on applying carbonation technologies to achieve the total recycling of concrete waste. Different approaches and technologies to carbonate the recycled coarse aggregates (RCAs), recycled concrete fines (RCFs) and recycled concrete powders (RCPs), depending on their particle sizes, will be introduced. The research results at the Hong Kong Polytechnic University show that carbonation of waste concrete with different particle sizes can generate carbonated coarse aggregate, carbonated fine aggregate, and high-value products, including novel supplementary cementitious materials, nano-silica gel, micro-fibre, etc., achieving the total recycling of concrete waste.

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Plenary Lectures

Pretreatments of Organic Substrates and Their Indigenous Bacteria for Dark Fermentation

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Anaerobic digestion is particularly attractive for renewable energy production and biogas sector is currently facing strong development for agricultural, municipal and industrial waste valorisation. However, intermediates products such as biohydrogen and volatile fatty acids, that can be obtained by dark fermentation, present higher economic value than biomethane. Inoculum of dark fermentation is usually thermally pretreated to inactivate methanogens and on the other hand, substrate pretreatments such as thermal-acid or sonication can be used to promote sugar solubilisation. The objective of this study was to analyse the impacts of pretreatments of substrates and their indigenous bacteria on further dark fermentation performance and bacterial communities. The impact of thermal pretreatment (90°C for 15 min, usually applied to inoculum) was studied on 7 substrates (dates, corn silage, sorghum, microalgae, sewage sludge, organic fraction of municipal solid waste (OFMSW) and food waste). Biochemical hydrogen potential tests (BHP) were carried out in different conditions: 1) untreated substrate without inoculum, 2) pretreated substrate without inoculum, 3) with inoculum and without pretreatment, and 4) substrate and inoculum were pretreated simultaneously. Except for protein-rich substrates (sewage sludge and microalgae), hydrogen yields, total metabolite production and metabolic pathways were similar for indigenous bacteria (both thermally pretreated and non-pretreated) and pretreated inoculum. In order to have further insights on the role of substrate indigenous bacteria, they were inactivated by gamma irradiation of sorghum and OFMSW samples. In comparison to non-irradiated substrates, irradiated samples led to equal or lower hydrogen yield, different metabolite pathways, final microbial consortia and higher variability among quadruplicates. Finally, thermal-acid (90°C- 30 min, 10% TS with [HCl]=11.0 mmol/gVS or [H_2SO_4]= 22.8 mmol/gVS) and ultrasound (59.4 kJ/gTS) pretreatments were carried on OFMSW. Both pretreatments were inefficient to improve H_2 yield although significant increase in soluble sugars. Nevertheless, pretreatments induced metabolic changes from acetate toward butyrate or ethanol, correlated to a decrease in *Enterobacter cloacae* and an enrichment in *Clostridium sp*. When indigenous bacteria were de-activated, metabolite and bacterial compositions were identical with or without acid pretreatment. In conclusion, the present results show the importance of substrate endogenous bacteria for dark fermentation process. Their thermal-acid or sonication pretreatments led to some changes in the distribution of metabolites and bacteria at the end of fermentation and to the increase of the variability of batch fermentation results. For some feedstocks, cost effective fermentation can be carried out without inoculation nor pretreatment.

Keywords: Biohydrogen, Volatile fatty acids, Organic fraction of municipal solid waste, Thermal, acid, ultrasound pretreatment, fermentation.

Composting Microbes: Past, Present and Future

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Composting is a biological and natural process that driving by microbes, and then degrading organic wastes into mature compost to become stable and valuable. The whole composting process could separate into three periods following different temperatures, mesophilic, thermophilic and cooling phases, at the same time, the dominant microbes were also distinct during these periods. With the development of analyzing technologies, studies on composting microbes had already gone through three stages: traditional microbial culture, molecular biology and integrated meta-omics. The methods of the traditional phase were using microbial isolation, cultivation, and microscopic counting to study the changes of CFUs in bacteria, fungi, and actinomycetes, while the steps of these methods were so complicated and had huge workloads. Molecular biology technologies, for instance, denatured gradient gel electrophoresis (DGGE), phospholipid fatty acid (PLFA), terminal restriction fragment length polymorphism (T-RFLP) and high throughput sequencing, could reveal the dynamics of microbial communities during the composting process, no matter whether the microbes alive or not. The review found that Firmicutes, Proteobacteria, Actinobacteria and Bacteroidetes were the dominant phyla during the composting process, and the priority of phylum in different kinds of manures was distinct. For example, Proteobacteria was prevalent in sheep and cow manure, while Firmicutes was dominant in swine and chicken manure. For fungi, the highest relative abundance of phylum was Ascomycota in all kinds of livestock manures. However, the other disadvantages of these technologies were poorer repeatability and lower sequencing accuracy. Integrated meta-omics, based on bioinformatics could deeply attain so much information about microbial composition, gene function, metabolic pathways and key substances during the composting process, and then estimate the biological mechanism of functional microbial succession. Using PICRUSt and FUNGuild based on metagenomics analysis could found that the cellulase activity generally increased first and then decreases, while the protease activity gradually decreases, and the dehydrogenase activity was related to the microbial activity. Firmicutes was preferring to live in a low C/N environment, Bacillus was the most active genus, and Actinobacteria was prevalent in a higher C/N environment. For composting microbes, the advanced research was focused on two aspects, the mechanism of indigenous or inoculating microbes. A lot of research was implying that additives were highly useful and likely to maintain the thermophilic phase, shorten fermentation time, accelerate the degradation of organic wastes, enhancing nutrient content. In this review, we aimed at introducing the history of microbes in composting, and the development of inoculants, and then provide technical support in order to push functional composting by adding inoculants and prompting indigenous microbes.

Keywords: Compost, Microbes, Inoculant, Traditional microbial culture, Molecular biology, Integrated meta-omics.

Moving Plastic Waste Management from Liner to Circular Economy: Role of Dumpsite Plastic Mining

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Disposal in landfills and open dumpsites is a common practice in most countries. Globally, nearly 40% waste goes to landfills and 33% is still openly dumped among the low-income countries. Particularly in South Asian countries, 75% of the wastes are openly dumped. With the increase of global waste generation projected at 2.59 billion tonnes in 2030 and 3.4 billion tonnes in 2050 the carrying capacities of the open dumpsites in the developing countries would have to be stretched far beyond the current rates. There are a few practical options that are considered by the policymakers, local government, and engineers to rehabilitate the dumpsites and to reduce the environmental burden associated with it. Among these, Dumpsite mining has created a lot of traction especially in the developing countries of South Asia and Southeast Asia (like Thailand, India, Sri Lanka, Vietnam, Indonesia) because of its advantages in *Waste to Energy recovery options*. The state-of-the-art heavy and stationary/mobile machineries are used to excavate wastes and segregate them based on the technology employed to utilize the wastes. A large quantity of incinerable materials such as Refuse Derived Fuel (RDF) consisting of plastics, clothes, leather and other incinerable fractions, recyclables are usually separated using material segregating equipment such as Trommels, Ballistic separators, Vibrosievers, Magnetic separators, Air density separators, and other equipments. The recovered materials are scientifically tested and utilized in compliance with national/local regulations. This environmental pollution remediation method can provide much bigger environmental benefits in addition to the local social benefits. Often, Dumpsite mining is considered as a strategic tool to rehabilitate dumpsites among the policymakers, academic researchers, local government officials and dumpsite mining operators. Large dumpsite mining firms collaborate with cement factories and easily dispose of their recovered plastic fractions. In cement kilns, the plastic fractions as used as a replacement for coal reducing overall carbon footprint. In developing countries, this method of smart waste management system at the top-level of governance can bring in safe disposal and aid in maximum utilization of wastes and move from liner to circular waste management approach. Suitable collaborative involvements must be financially encouraged at the national and local levels to motivate different players into dumpsite mining and waste to energy options. This can be pragmatic step-forward for developing countries which are struggling to keep up with sustainable energy goals and integrated circular waste management options.

Gasification of Municipal Solid Waste as a Disposal Route for Circular Economy

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Producing H_2-rich syngas from municipal solid waste using oxygen-lean thermal treatments presents a promising waste-to-energy pathway for realizing the circular economy of modern society. This presentation overviews the contemporary research efforts, particularly on developing syngas upgrading and gasification processes, to make thermal treatment a sustainable and affordable option for final disposal of the municipal solid waste.

Metabolic Insights of Carboxydotrophics in Syngas Fermentation for Low-carbon Chemicals/Fuels

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Carboxydotrophic mediated syngas fermentation regulates by the Wood–Ljungdahl pathway (WLP) for bioconversion of syngas to C2-C4 chemicals. Lab scale and semi-pilot scale systems were operated with the metabolically active carboxydotrophic consortia and isolated strains. Comparative bioprocess monitoring will be performed to predict the conversion abilities of the different biocatalysts with varying operational conditions. Enzyme regulation studies (CooC2, adhE1, Fdhl) and profiles of the biobased products in the medium will be analysed at regular intervals. The metagenomic analysis will be performed to know the diversity changes under the different experimental conditions.

Keywords: Syngas fermentation, Platform chemicals, C1 fixation, Metabolic shift.

Nitrogen Transformation During Pig Manure Composting with Diatomite Addition

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Composting is an economical and effective way to recycle livestock and poultry manure harmlessly. However, due to the harmful effects of aerobic composting on atmospheric environment and the negative effects on the efficiency of compost products, reducing nitrogen loss has attracted more and more attention. Recently, the application of mineral additive to increase nitrogen conservation was a prosperous filed. Diatomite (DM), siliceous materials, which has a large specific surface area and abundant surface functional groups, had been used as a novel mineral additive to reduce nitrogen loss during pig manure composting. Whereas, nitrogen conservation mechanism and optimum added dosage of DM are not clear, which are crucial for composting technology in theory and practice. In this study, the 0%, 2.5%, 5%, 10%, 15% and 20% of DM were added into initial mixtures of pig manure and sawdust for 42 days aerobic composting. Results showed that adding DM facilitated the conversion from NH_4^+-N to amino acid nitrogen and hydrolysis undefined nitrogen, and then reduced NH_3 and N_2O emission by 8.63−35.29% and 14.34−73.21%, respectively. Moreover, the maximum value in nitrogen conservation was observed in treatment with 10% DM addition, and it was confirmed that adding DM amendment reduced the relative abundance of nifH, nirK, nirS, nosZ and narG. Furthermore, C/N (57.30%) was supposed to control the reduction of nitrogen loss among all physio-chemical parameters. Therefore, adding DM was a practical way to enhance nitrogen conservation and improve quality of end products, and the optimum added dosage was 10%.

Keywords: Pig manure, Composting, Diatomite, Nitrogen transformation.

Assessing the Baseline of Food Waste Generation in Greek Households

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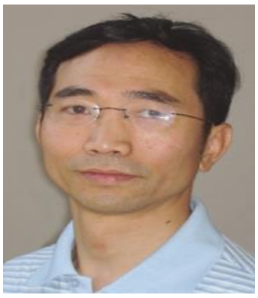
According to the Directive 2018/851/EC the member states of European union (MS-EU) should take measures to promote prevention and reduction of food waste in line with the 2030 Agenda for Sustainable Development of the United Nations. In addition, MS-EU should record the progress they make towards this goal, through the use of a common measurement methodology, which is set out in Commission Delegated Decision EU (2019) 1597 of 3 May 2019. The EU committed its member states to measure and report the amount of food waste produced at each stage of the food supply chain during a full calendar year on an annual basis. At the same time, the MS-EU must measure and report the amount of food waste produced at each stage of the food supply chain (at least) once every four years, using the methodology of Annex III of the Delegated Decision. In the first submission period, which was completed by 30/6/2022, MS-EU measured the amount of food waste for all stages of the food supply chain for the year 2020, using the set methodology. This study aimed to set a baseline for the food waste generated in Greek households, in context to the EU legislation and guidelines. It was based on a study assigned by one of the largest supply chains in Greece, AB Vassilopoulos, to the Sustainable Environmental Mangement & Technology Team of Harokopio University (HUA). The approach of detailed self-reported food waste diaries was used to determine the amount of food waste. The design of the online diary was based on the food waste diary, which was used by HUA for the first food waste generation study of Greek households in 2013-2014. The participants were instructed to keep track of the type and quantity of the edible and inedible food waste of their households. Given that there does not exist a common knowledge base regarding conversion factors of food waste volume/items to mass, the processing of the collected data was based on data from international nutrient and food component databases, and the database of the Department of Nutrition and Dietetics, HUA, for Greek foods. A total of 1,102 respondents completed the diary for a period of 1-7 days. Participants were required to classify their edible food waste into eight different food type categories, record the weigh or volume of each item discarded, as well as the reason for not consuming it. Inedible food waste was classified into two types: of plant or of animal origin. Recent studies have shown that the number of household members has a direct impact on the food waste generation. On this basis, the average food waste quantities were calculated for each household size class and values multiplied by the estimate of the Hellenic Statistical Authority for the size distribution of Greek households. The analysis of the results indicates that households in Greece generated 930,323 t/y (95.5 kg/y/ca) of food waste, of which 403,628 t (38.7%) could have been avoided. “Fruits & vegetables”, “bakery products”, and “pasta, rice & cereals” were responsible for the largest part of edible food waste, corresponding respectively to the 51.8%, 18.6% and 7.6%.

Keywords: Food waste, Households, Greece.

Catalytic Microwave-Assisted Pyrolysis of Organic Solid Waste for Fuels, Chemicals, and Materials Production



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Catalytic microwave assisted pyrolysis/gasification of renewable biomass and recycled plastic wastes for green fuels, chemicals, and materials provides an attractive solution to alleviate the climatic changes and achieve the 1.5 ºC Paris climate goal. To improve feasibility and scalability of the microwave-assisted pyrolysis process, a novel system of continuous microwave-assisted pyrolysis (CMAP) featuring a mixing SiC ball bed was developed and first tested for hydrogen-rich gas production from biomass. At temperature of 800 ˚C, gas with a high energy content of 18.0 MJ/ Nm^3 and a high syngas (H_2+CO) content of 67 vol.% was obtained at a gas yield of 72.2 wt.% or 0.80 Nm^3/kg d.a.f. wood pellets. Downstream condensation and physical adsorption lowered the tar concentration from 7.83 g/Nm^3 at the exit of pyrolysis reactor to below the detection limit at the end of the process. Energy balance analysis showed that a cold gas efficiency of 73.3% was achieved at 800 ˚C, which consumed 7.2 MJ electrical energy per kg of wood pellets, outperformed many other technologies. In addition, this CMAP technology is developed to achieve the conversion of waste plastics to high quality naphtha, that can be injected to new plastic manufacturing, with the hope of creating a circular economy and minimizing greenhouse emission. The key for catalytic cracking of waste plastics is to mitigate the coke formation and improve the catalyst lifetime. First, the relationship between the catalyst structure and catalyst lifetime was studied comprehensively by fine-tuning the acidity and pore structure of zeolites. It was confirmed that proper acid density and larger pore size significantly improved the catalyst lifetime. Considering that the pore size of conventional ZSM-5 catalyst is too small for plastic pyrolysis intermediates entering into the pore system, which will limit the diffusion of intermediates, block the pore opening, and result in fast deactivation of catalyst, the hierarchically macro-meso-microporous high Si/Al ratio ZSM-5 zeolite was developed and tested. It was confirmed that the catalyst lifetime of hollow ZSM-5 is over five times longer than the conventional ZSM-5 due to the better diffusion channels and improved accessibility of acid sites inside the modified catalysts. After producing fuels or chemicals, 30~40 wt.% non-condensable gases (mainly composed of hydrogen and C_1-C_4 hydrocarbons) will be left, to be further utilized. So, we have used a three-dimension metal foam to catalytically decarburize the non-condensable gases for carbon material and hydrogen production. When the non-condensable gas products pass through a high temperature reactor packed with an effective Ni-Fe/Al_2O_3 catalyst, high yield of hydrogen (over 88% hydrogen selectivity) can be achieved, with carbon products being produced. In summary, our studies indicated that the CMAP is a low-cost and highly efficient technology to convert waste plastics and biomass to valuable fuels, chemicals, and materials.

A Novel approach for Purifying Anaerobic Food Waste Digestate Through Bio-conditioning and Dewatering Followed by Activated Sludge Process: A Case Study

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Anaerobic digestion is the mainstream technology for the treatment of food waste, but the resultant digestate is very difficult to be biochemically purified due to its high pollutant concentration. In this study, taking a typical food waste treatment plant with 200 t/d as an example, we explored the reasons for the difficulty in treating food waste anaerobic digestate and developed a novel process called as bio-coagulation dewatering followed by activated sludge process to purify the digestate. Results showed that high concentration of fine particles/colloids (16438.6±475.0 mg/L), chemical oxygen demand (COD) (14561.9±1174.4 mg/L), and NH^{+}_{4}-N (2641.0±90.9 mg/L), affected negatively the treatment efficiency of food waste anaerobic digestate by conventional biochemical treatments such as activated sludge process. After advanced solid-liquid separation through bio-conditioning followed by dewatering by using diaphragm pressure filter, nearly 100% of suspended solids and total phosphorus (TP), about 85%-90% of COD, and 40%-50% of total nitrogen (TN) and NH^{+}_{4}-N in the digestate could be effectively removed and harvested into semi-dry sludge cake with less than 60% of moisture content. As a result, the transparent filtrate was produced and contained relatively low pollutant concentration. Furthermore, after ammonia stripping and biochemical treatment using activated sludge process (A^2O) for the filtrate, the concentrations of COD, TN, NH^{+}_{4}-N, and TP in the effluent, ranging from 148-254, 21.3-59.3, 0.97-4.29, and 0.4-0.8 mg/L, respectively, satisfied the relevant sewage discharge standard governed by China. This novel approach, bio-conditioning and dewatering followed by activated sludge process, has a stable working performance and low running cost, which provides a new solution to purify food waste anaerobic digestate.

Keywords: Food waste, Anaerobic digestate, Bio-coagulation dewatering, Purification, New solution.

China's Livestock Transition: Driving Forces, Impacts, and Consequences

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China's livestock industry has experienced a vast transition during the last three decades, with profound effects on domestic and global food provision, resource use, nitrogen and phosphorus losses, and greenhouse gas (GHG) emissions. We provide a comprehensive analysis of the driving forces around this transition and its national and global consequences. The number of livestock units (LUs) tripled in China in less than 30 years, mainly through the growth of landless industrial livestock production systems and the increase in monogastric livestock (from 62 to 74% of total LUs). Changes were fueled through increases in demand as well as, supply of new breeds, new technology, and government support. Production of animal source protein increased 4.9 times, nitrogen use efficiency at herd level tripled, and average feed use and GHG emissions per gram protein produced decreased by a factor of 2 between 1980 and 2010. In the same period, animal feed imports have increased 49 times, total ammonia and GHG emissions to the atmosphere doubled, and nitrogen losses to watercourses tripled. As a consequence, China's livestock transition has significant global impact. Forecasts for 2050, using the Shared Socio-economic Pathways scenarios, indicate major further changes in livestock production and impacts. On the basis of these possible trajectories, we suggest an alternative transition, which should be implemented by government, processing industries, consumers, and retailers. This new transition is targeted to increase production efficiency and environmental performance at system level, with coupling of crop-livestock production, whole chain manure management, and spatial planning as major components.

Keywords: Manure, Sustainable livestock production, Nutrient loss, Biofertilizer.

Technological Barriers of MSW Classification, Reduction and Resource Utiliz ation in China

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With the continuous progress of municipal solid waste (MSW) classification in China technological problems in resource utilization of classified waste have become increasingly prominent.

At the front end, the intelligent level of the collection, storage, and transportation system does not meet the criteria of MSW classification resulting in low classification quality and serious odor pollution. As for transportation, the lack of transportation facilities matched with the “Four- category classification method” has led to difficulties in the reduction of waste and secondary pollution.

In terms of resource utilization, kitchen waste after classification has a high impurity rate, which challenges pretreatment equipment, results in low biomass recovery rate, poor biogas productivity, and high residues in anaerobic digestion. On the other hand, high energy consumption and operating costs have become obstacles in practical aerobic treatment. Furthermore, due to the lack of relevant application standards, it is almost impossible for compost products to be used in lands.

In addition, with the concentration of kitchen waste, its utilization facilities are also facing the problems in the treatment of male-odor and high-concentration wastewater. Therefore, in order to smoothly progress the MSW classification in China, nowadays, it is critical urgent to improve its classification, reduction, and resource utilization technologies.

Novel Step Pyrolysis Technology for Recovery Valuable Products from Waste Tires

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The black pollution caused by waste rubbers, especially waste tires, has attracted extensive attention all over the world in recent years. According to statistics, about 1.5 billion units of waste tires were produced annually, which gave rise to around 17 million tons of waste tires. Owing to the stable molecular structure of rubber, waste tires have strong heat resistance and biodegradation resistance, which make them difficult to degrade naturally. Recycling high-value chemical products from waste tires by pyrolysis was a promising and attractive method. The pyrolysis behaviour of rubber particles under different heating rate was detailed examined based on delicately designed furnace and the pyrolysis product was carefully analysed through Py-GC-MS. Innovative stage pyrolysis system was developed based on a hollow-auger reactor with a capacity of 1 ton per day. The pyroysis reaction was separated into three steps with temperatures of 475ºC, 500ºC, and 550ºC respectively. The whole system was heated by burning hydrogen and methane enriched pyrolysis gas and the pyrolysis efficiency reached 99% after 72 hours continuous test. Volatile was cooled down to get high quality oil which can be used as fuel or raw chemical feedstock for BTEX production. After milling, the raw black-carbon could replace the N660 commercial black carbon for tire manufacture.

Keywords: Waste tires, Step pyrolysis reactor.

Biomass to Green Energy: An Asian Perspective

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Biomass has become progressively important as a renewable alternative energy source. One of the most critical aspects associated with the use of biomass is its management. Indeed, in order for the use of this type of energy resource to become viable, its supply chain and management, from collection and transport to storage and distribution, needs to be well structured and optimized. In this context, Issues related to depletion of conventional fuel resources and environmental concerns have become the driving force to explore an eco-friendly, renewable, economical and sustainable alternate energy source. Massive quantities of agriculture biomass are being produced globally which can be transformed to biofuels by utilizing various procedures. However, issues for example environmental damages and competing uses of agriculture biomass need to be investigated factually considering the short as well as long-term acuity considering its effect on the soil and conversion to biofuels. This paper provides an insight into the potential of various biomass as an energy source. Presently available conversion techniques to convert biomass to energy in various phases are discussed. The review also addresses the technical, socio-economic and environmental concerns and limitations with the appropriate control measures. The information provided will help stakeholders, energy managers and decision makers working in the sustainable and renewable energy sectors to consider agriculture biomass for energy production at a larger scale. The utilization represents reuse, composting, energy recovery, bio-methanation and other techniques carried out in Asia and Pacific region. Resource circulation of agricultural biomass waste through 3R (reuse, recycle, recover) depends on the type of agricultural biomass waste and other characteristics such as moisture content, energy content, and others. Reusing of agricultural biomass waste includes livestock fodder, mulching, mushroom cultivation, incorporating into the field and others. It is also used as fuel for domestic and industrial sectors and recycling includes aerobic and anaerobic digestion of agricultural biomass waste. It must be noted that recycling of horticulture waste is higher in Singapore (80%) as compared to food waste (19%) in 2020. Similarly, utilization of agricultural biomass waste in Hong Kong SAR includes food waste, yard waste and livestock waste where recycling of livestock waste is relatively higher than recycling of putrescible waste. Among the countries of Asia and Pacific, Japan has relatively higher resource circulation of agricultural biomass waste where about 70% of waste is utilized as fertilizer, feed, fuel and generation of heat and energy. Several initiatives have been taken and schemes have been formulated that have circular economy at its core. For instance, a biogas plant and composting facility was built near sludge treatment facility in Shikaoi Town, Tokachi District, Hokkaido, in 2007, which is known as 'Hokkaido Shikaoi Environmental Preservation Centre'. The sewage sludge from sludge treatment facility, livestock waste and food waste are treated in Hokkaido Shikaoi Environmental Preservation Centre. Biogas plants generates power which is used within the facility and remaining power is sold to Hokkaido Electric Power Corporation under FIT (Feed-in-Tariff) scheme. Additionally, digested liquid is used as biofertilizer and heat is utilized by aquaculture and fruit culture, thereby creating a local-level recycling-based society. Japan is also aiming towards establishing Biomass Industrial Areas that will build an integrated system of economy and development of village/town centred biomass industry. Agricultural biomass waste is generated more in agriculture intensive countries of Asia and Pacific than the industrial intensive ones. Based on the national legislations, plans, and strategies, as well as management practices, agricultural biomass waste is seen more as a commodity for energy extraction than a resource to be reused and recycled. Partly, it is influenced by the shortages of energy in developing countries of Asia and Pacific and by the willingness to shift from non-renewable energy to renewable energy in developed countries of Asia and Pacific. Therefore, technologies such as bio-gasification, cogeneration, co-firing and fermentation for biofuels are commonly deployed in Asia and Pacific. Anaerobic digestion is the most commonly deployed technology for the treatment of agricultural biomass waste, the use of cogeneration, gasification, composting, and incineration may still contribute to the generation of GHG emissions, albeit less. Moreover, several countries in the Asia and Pacific region have been putting efforts into improving the socioeconomic and environmental situation of rural areas which are also supported by national legislations in the respective countries.

Spatial Distribution of Fecal Pollution Indicators in Sewage Sludge Flocs and Their Removal and Inactivation During Sludge Conditioning Processes

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Fecal contamination in wastewater treatment system may pose severe threats to human health, while sludge reuse and utilization is one of important routines of disseminating fecal pollution to surface water and groundwater. However, it remains unclear the spatial distribution of fecal bacterial and viral pathogens in sludge flocs and their reductions during sludge treatment processes. In this study, the abundances of fecal pollution indicators including cross-assembly phage (crAssphage), JC and BK polyomavirus (JCPyV, BKPyV), human adenovirus (HAdV), the human-specific HF183 Bacteroides (HF183) and *Escherichia coli* (EC) in soluble extracellular polymeric substances (S-EPS), loosely-bound EPS (LB-EPS), tightly-bound EPS (TB-EPS), and pellets of sludge flocs were determined, and the effect of sludge conditioning treatments on their removal and inactivation was investigated by using both qPCR and viability-qPCR. We found that the serial tenfold dilution effectively reduced the PCR inhibition effect when determining the abundances of fecal markers, while the utilization of negatively charged HA membrane was effective to recover fecal markers from sludge supernatant. The results of a six-month monitoring revealed that gene markers of CrAssphage, JCPyV, HF183, BKPyV, HAdV, and EC can be detected in municipal sewage sludge collected from a local wastewater treatment plant, and all investigated indicators were detected in each fraction of sludge flocs. Among the investigated five chemical conditioning methods, i.e., chemical conditioning with polyacrylamide (PAM), Fe[III]/CaO, potassium ferrate (PF), or Fenton's reagent, and chemical acidification conditioning, chemical conditioning with PF was much more effective than the other conditioning methods to reduce the abundances of fecal markers in the supernatant and solid of conditioned sewage sludge. The overall reductions of human fecal indicators in sludge determined by qPCR were 0 to 1.30 logs, which were 0-2 orders of magnitude lower than those of 0.69 to 2.39 logs detected by viability-qPCR. Therefore, it is feasible to alleviate the human health risks associated with fecal pollution in sewage sludge via selecting suitable sludge conditioning approaches.

Keywords: Municipal sewage sludge; Conditioning treatment; Fecal pollution indicators; Spatial distribution; Inactivation.

Microwave Processing of Waste for Circular Waste Management

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Microwave processing involves the use of microwave radiation as a heat source in an inert environment that can break down and convert waste materials to produce useful liquid oil, gases, and char products. This technique has been applied for recovering the energy and chemical value of various types of waste materials, comprising forestry waste, furniture waste, fruit waste, waste cooking oil, agricultural waste, palm oil waste, etc. This technique shows advantages in providing a fast heating, relatively shorter process time and lower energy consumption, representing a method that is potentially faster and more energy efficient compared to that shown by the method commonly performed using conventional heating source. The technique produces liquid oil product that can potentially be re-used as fuel for power generation, hence representing and promoting a circular approach for waste management, and the oil product is potentially cleaner with promising features to also be used as feedstock for bioplastic production. The technique also produces solid products such as biochar and activated carbon that can be refined for use as catalyst in pyrolysis process, which is also a potential route for circular waste management. The solid products also possess beneficial features for application in waste treatment. Our findings show that microwave processing shows potential as a promising approach with improved heating performance and generation of useful products with desirable properties for circular waste management. These have led to outputs such as joint research with international partners, patent filing, company licensing, journal publications, awards and industrial partnership for prototype development, distribution and application.

Green Technology with Biochar for Waste Recycling and Carbon Reduction

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Biochar, a carbon-rich material made from partial combustion of biomass wastes, is an emerging material of interest as it can serve as a negative carbon emission technology and tackle environmental problems in diverse applications. In this talk, we will discuss the applications of biochar in soil environment, brownfield decontamination, low-carbon construction, sustainable biorefinery, and water pollution control. By adequate engineering the biomass feedstock and pyrolysis conditions, biochar can be designed to manifest desirable physicochemical properties targeting at various reactions and green technologies. The feasibility of scaling up biochar production with versatile, application-oriented functionalities must be actualised in collaboration with multidisciplinary stakeholders to maximise the ESG value.

Sustainable Strategies to Overcome Inhibition of Biomass Hydrolysates and Get More Value from Lignocellulosic Biomass

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Lignocellulosic biomass has a huge potential to be used as a feedstock for the sustainable production of fuels and chemicals through fermentation. However, toxic compounds present in the hydrolysates produced from such materials during the biomass pretreatment step represent a significant challenge for the efficient utilization of hydrolysates by microorganisms. Overcoming the toxicity of these compounds is crucial to achieve an efficient fermentation of lignocellulosic hydrolysates. To this end, sustainable pretreatment strategies should be developed to selectively release sugars with reduced or no formation of toxic compounds. Detoxification of the hydrolysate can also be an alternative to reduce the concentration of toxic compounds, resulting in hydrolysates more suitable for fermentation by microorganisms. However, detoxification may increase the final technology's cost. Alternatively, the performance of the fermentation process could also be improved by using microbial strains with better tolerance to toxic compounds or by using a combination of different microbial species for fermentation. This lecture will discuss all of these strategies, including their advantages and disadvantages, and potential contributions to improve the fermentation of hydrolysates and get more value from lignocellulosic biomass.

Green Processing of Cottonseed Oil Soap-Stock for Sustainable Waste Management

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Cotton is a source of fibre (s), protein, and oil. During the process of oil refining, a dark brown, gelatinous, and unpleasant chemical compound known as soap-stock is eliminated. A significant concentration of fatty acids is present in soap-stock, which can be utilised to produce lipase. Cottonseed oil soap-stock has been referred as a biobased feedstock for producing high-value products. *Actinomycete*(s) from cottonseed soap-stock were used in the study. Submerged fermentation was used to produce lipase using efficient lipolytic bacteria. Response surface methodology was used to investigate maximum lipase production, maximising the influence of several parameters including pH, temperature, nitrogen- & carbon- source. This presentation will cover important developments in the biotreatment of industrial effluent (s), with a particular emphasis on work done by the presenter's team on lipase-producing *Nocardiopsis alba* for the reduction of pollution load from textile industry reject.

Keywords: *Nocardiopsis alba*; Biodegradation; Central Composite Design; Lipase.

Soil Remediation and Resource Utilization of Red Mud

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The passivation effect of red mud-based materials of different proportions was studied by the index of available Cd content in the soil. After 56 days, available Cd content in the soil decreased significantly by 19.65%- 54.89% while 0.97~1.31 increase of pH was achieved. Result of the passivation test suggested an optimum ratio of red mud, diatomite and calcium oxide was 5:3:2. Adsorption test was conducted to study the adsorption mechanism of Cd by red mud based passivator. Comparison of the passivator before and after adsorption indicated that the red mud passivator had a high specific surface area with -OH, Si-O, Fe-O and other groups involved in the adsorption process of Cd^{2+}; however, the structure of passivator was not damaged and the adsorption of Cd^{2+} was proposed as physical and chemical adsorption.

Phosphate Adsorption of Mg and Ca-Biochar and Its P Bioavailability

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Biomaterial utilization from biomass is considered an important alternative to address resource and energy shortages. Among the biomass by-products, Korean pine cone residue (KPCR) is pyrolyzed to develop biochar (BC) as an adsorbent for adsorbing phosphorus during wastewater treatment. Biochar surface was supported with cationic metals (Mg, Ca) to enhance phosphorus adsorption capacity of wastewater and microorganisms attachment as carriers.

Adsorption kinetics (adsorption for 48 hours, 50 mg P/L, pH 6) of Mg-BC and Ca-BC showed the maximum phosphate adsorption capacity of 24.32 and 19.70 mg P/g BC, respectively. Phosphate was adsorbed by chemisorption by the cationic metals Mg and Ca. Isothermal adsorption (adsorption for 48 hours, pH 6) showed the maximum phosphate adsorption of 115.01 and 44.39 mg P/g BC for Mg-BC and Ca-BC, respectively. Mg showed better adsorption than Ca at high phosphate concentration.

The amount of metal released from Mg-BC and Ca-BC was 23.13% and 3.76% of Mg and Ca from the Mg-BC and Ca-BC, respectively. In addition, the bioavailability of phosphorus was evaluated in citric acid (pH 2), ammonium alkaline (pH 9.7), and distilled water (pH 5) by conducting phosphorus elution experiments from biochar (Mg, Ca-BC) after phosphorus adsorption, Mg-BC and Ca-BC released 74 and 53% of P in citric acid and 48 and 37% in ammonium alkaline (pH 9.7), respectively. Overall, cationic metal-supported biochar was very effective in phosphorus adsorption and the bioavailability of the adsorbed phosphorus was high for the application as a fertilizer.

Keywords: Adsorption, Bioavailability, Biochar, Phosphorus recovery.

Approaches for Valorisation of Biodegradable Organic Fraction of Domestic Solid Waste

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In developing countries, biodegradable organic fraction constitutes a major fraction of municipal solid waste (MSW). For instance, it accounts for 40-60% of the total MSW generated in an urban city or town in India. Due to its biodegradable nature, the putrescible waste causes bad odour due to release of obnoxious emissions in the form of nitrogenous and sulphur compounds present in the waste, if it is not stored properly. Nevertheless, the waste has great potential to produce a range of value-added products. Composting and anaerobic digestion are the conventional treatment processes for waste recycling and energy recovery, respectively. These processes have their own limitations in terms of applicability and extent of valorisation. Therefore, it is prudent to review the existing and futuristic approaches for the treatment of biodegradable waste to ensure maximization of resource recovery with minimal environmental impacts. One of the potential methods for the uncooked source-segregated waste is installation of the decentralized composting systems without or with provision for air supply. Using this method, substantial reduction in cost of waste transfer and processing can be achieved. At the same time, waste recycling at source will also be promoted. In addition, hydrothermal pretreatment is considered an emerging technology for the treatment of cooked food waste particularly produced from restaurant kitchens or hostel mess. The waste is generally treated by anaerobic digestion however, hydrolysis is often a rate limiting step. During hydrothermal pretreatment, the solid particles are solubilised and biogas generation and recovery is generally improved. At the same time, energy and nutrient rich hydrochar may also be produced depending upon the pretreatment conditions which can further be utilized either for energy recovery or as a soil conditioner. However, the challenges with these processes should be identified and addressed before implementation.

Keywords: Biodegradable wet waste, Circular economy, Resource Recovery.

Green Recovery from and Sustainable Management of Solid Waste Generated in Electrolytic Manganese Production

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The manganese (Mn) production process generates gasses, wastewater, and solid wastes, and these wastes have caused serious pollution to the environment. This paper focuses on the recovery and reuse of valuable elements in the liquid and solid wastes from Mn production industry. The paper first introduces the production processes of electrolytic manganese metal (EMM), generation of electrolytic manganese residue (EMR) and electrolytic manganese wastewater (EMW). Then, the paper describes several systems and processes for selective separation and recovery of Mn, silicon, and other value-added products from EMR. The paper also introduces innovative methods for the safe reutilization of EMR or for stabilizing heavy metals in EMR. Finally, the paper summarizes the current research and provides insight of future extended work and directions. By adopting the novel methods introduced in this paper, the electrolytic manganese industry can 1) reduce CO_2 emissions and the release of soluble manganese; 2) recover and reuse manganese carbonate; and 3) produce value-added products (e.g., environment-friendly material for construction and manganese-silicon fertilizer) from EMR and EMW.

Odours and Other Airborne Contaminants of Emerging Concerns Relating to MSW Storage and Transportation

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In recent years, the generation of domestic garbage in urban and rural areas has steadily increased. With the continuous progress of urbanization, municipal solid waste (MSW) storage stations and transfer stations, which are key points for garbage collection and transportation, have moved to residential areas than before. As a result, the gaseous pollution related to the front end of the garbage removal chain has attracted much attention. However, existing studies on gaseous pollution are more on the terminal facilities for MSW treatment and disposal, e.g. in composting plants or landfilling sites, while the studies oriented to the stage of MSW collection and transportation are still rare. Especially, under the new situation of MSW source segregation, it is wondered whether the gaseous pollution will change compared with the mixedly collection in the past.

Except for the traditional appreciable pollutants- odorous compounds, diverse emerging contaminants are of high concern. It would then be interesting to know the presence of airborne emerging contaminants. The emission characteristics of gas-phase emerging contaminants should be comprehensively assessed considering their health threats to workers and environmental risks.

Therefore, this study will present the results about the emission of different gaseous pollutants from odours to bioaerosols, airborne microplastics and airborne antibiotic resistance genes, during the process of storage, collection and transportation of MSW.

Keywords: Odorous compounds, Microplastic, Bioaerosols, ARGs.

Conversion of Biomass to 5-hydroxymethylfurfural-Derived Chemicals Using Carbon-Based Catalysts

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Biomass is a renewable natural resource with rich chemical components and diverse structural characteristics, and is widely used to produce biofuels, bio-based materials, etc. The utilization of biomass resources can reduce dependence on fossil energy and promote sustainable development. Therefore, biomass resource utilization plays an important role in addressing climate change and achieving carbon neutrality. The use of biomass raw materials to prepare high-value-added chemicals has also become one of the research hotspots. Biomass catalytic conversion is a technical process in which biomass raw materials are reacted under the action of a catalyst, and a series of separation and purification operations are performed to obtain the target product. Compared with traditional biomass conversion technology, biomass catalytic conversion has the advantages of abundant resources, environmental friendliness and sustainable development. At present, the research on the catalytic conversion of biomass to produce high-value-added chemicals has covered the range from single compounds to complex mixtures, and has made remarkable progress. Catalyst is one of the important factors affecting the catalytic conversion of biomass. Commonly used catalysts for biomass conversion include solid acid catalysts, basic metal catalysts, transition metal complex catalysts, etc. In addition, the control of reaction conditions also has an important impact on product distribution. In this study, a series of carbon-based composite catalysts were developed to be successfully used in the conversion of biomass raw materials to 5-hydroxymethylfurfural, 2,5-dimethylfuran, furandicarboxylic acid, etc. These chemicals are widely used in the production of plastics, fibers, paints, medicines, etc, and have good market prospects. Therefore, the research on the catalytic conversion of biomass to produce high-value-added chemicals is of great significance. In the future, on the one hand, it is necessary to further improve the biomass catalytic conversion technology to increase the yield of target products; on the other hand, it is also necessary to combine the biomass catalytic conversion technology with other technologies to achieve a more efficient and sustainable biomass resource utilization. At the same time, with the increasing demand for environmental protection and sustainable development, the research and application of biomass catalytic conversion to produce high-value-added chemicals will be more extensive in the future.

Keywords: Biomass, Catalysis, Carbon-based catalyst, 5-hydroxymethylfurfural.

Material Utilization of Straw Biomass as a Kind Agricultural by-products, the Acquirement and Practice

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Industrial utilization of straw biomass and other agricultural by-products, provides a very potential model for bioresource technology. Material utilization of straw is emphasized and several techniques have been developed, for producing water-free pulp, for biomass enriched rattan and furniture-making materials. New materials composited with straw biomass, starch and biodegradable plastics is of high value and environmental friendly.

Keywords: Straw biomass, bio-degreatabe plastics, Material utilization, Industry.

Measuring the Extent of Biodegradation of Plastics

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Measuring the extent of biodegradation by evolved biogas is suitable for estimating potential methane yields from natural organic material or the stabilisation of compost. Biogas evolution is not suitable for measuring the biodegradability of bioplastics because it does indicate whether the unaccounted carbon is biomass (microorganisms) or undegraded plastic. Solid residues from natural organic material are an import source of organic carbon in soils, while undegraded plastics are harmful, both aesthetically and ecologically. Both fossil-based plastics and bioplastics can form micro- and nano-plastics (MNPs) which cannot be accurately quantified by visual analysis. A plastic that is composed of one polymer can be demonstrated to be fully biodegradable by biogas evolution even if only a portion of the plastic biodegrades. The same inference cannot be made if a plastic is a composite material or if the plastic is an unknown proprietary material. In these cases, tests are needed to demonstrate that the plastic will not degrade to refractory MNPs. This paper presents a biodegradation study on a proprietary bioplastic. Five samples of bioplastic were digested at 55 ^{o}C in 180 mL serum vials using digested sludge as an inoculum. A bottle was opened after 15, 26, 50, 81 and 216 days. The bioplastic pieces remained intact and were fully recognisable. Despite this, significant biodegradation had occurred with 20.3±2.4% and 38.4% of the bioplastic carbon converted to biogas after 81 and 216 days respectively. The extent of biodegradation according to the volatile solids loss of the bioplastic pieces was 30.2% and 38.5% after 81 and 216 days respectively. The discrepancy between the biogas and gravimetric methods for the 81 Day sample indicates transient production of MNPs and soluble organic compounds. The recovered bioplastic pieces from the 15, 26, 81 and 216 day digestions were then enclosed in individual mesh bags and placed in the middle of a 40kg bed of garden waste that was composted at a temperature of between 55 and 60^{o}C for up to 67 days. The rate of VS loss during the composting phase was not significantly different to the rate of VS loss during the digestion phase. The VS loss of the sample digested for 216 days and composted for 67 days was 38.5 and 15% relative to the fresh VS content. The extent of degradation of the samples was also estimated by extracting the residual plastic in the composted samples by a pressurised dichloromethane wash. These results will be presented at the conference.

Keywords: Bioplastic, biodegradation, dichloromethane extraction.

Nanobubble Technology Applications in Environmental Remediation and Controlled Environment Agriculture

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Nanobubbles are an emerging gas delivery technology with potential opportunities in environmental remediation and the agriculture. Due to their several unique properties, such as their high gas solubility, high electrostatic interaction, and their potential formation of reactive oxygen species, nanobubbles can provide opportunities in various environmental remediation applications and different microbial-mediated processes where poorly soluble gases are difficult to supply using conventional technology. The perpetual generation of reactive oxygen species could also offer new avenues in pathogen and biofilm control. With rising population growth and soaring food demand, controlled environment agriculture has gained interest in recent years as a sustainable food production system. Due to the limitations of conventional aeration methods to increase the oxygen solubility threshold, applying an innovative nanobubble technology could bring dissolved oxygen levels beyond normal saturation, thus bringing improvements in plant yields. This presentation will showcase some of his efforts in diverse applications of nanobubble technology.

Landfill In-situ Aeration and Improvement of Landfill Gas Extraction Systems- Ways to pollution control and climate protection

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Landfills significantly contribute to climate change. Relevant amounts of gas escape from landfills during operation when no gas extraction systems are in place. But even during gas extraction from landfills without surface liner gas collection efficiencies are often not higher than 40- 50%. After landfill closure, gas and polluted leachate will still be produced over many decades. Depending on the size of a landfill, for more than 10 years landfill gas is produced in amounts suitable for gas utilisation. Afterwards landfill gas is still produced escaping in most into the atmosphere increasing climate gas emissions. Dependent on the specific landfill these emissions may amount to 20-30% of the total gas production potential. Since 1 m^3 of methane contributes about 25 times more to global warming than 1m^3 of CO_2 the emission of these residual gases should be largely avoided. One reduction method is the largely extraction of gas during landfill operation by means of horizontal gas extraction systems. Necessary in many cases is also the remediation of vertical gas extraction systems which may be partly clogged and /or broken after many years of operation; these effects reduce the gas extraction efficiency significantly. The other method to reduce climate gas emissions from landfills is in-situ aeration. This technology where air is injected at low pressure into the landfill has proven its effectiveness in Germany for more than 10 years. Due to the installation of aerobic conditions the degradation of organics to mainly CO_2 will be enhanced. As a result large amounts of climate gas emissions have been reduced so far. The German Government included in-situ aeration in its climate protection program and co-finances through its climate fund technical equipment. More than 70 landfills participate in this program, more are in preparation. In addition to the positive effect of in-situ aeration on climate gas reduction the emission potential of a landfill will also be reduced at a much shorter time compared to anaerobic conditions. By these means the long-term risks arising from landfills over up to ±100 years after closure are by about ± 90% reduced.

Thermo-Mechanical Treatment of Nonrecyclable Muncipal Solid Waste to Enhance Organics Recovery and Biochemical Processing

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The United States Environmental Protection Agency estimates that about 270 million tons of municipal solid waste (MSW) is generated annually. Despite years of efforts to divert waste from landfills by implementing source separation of recyclables and separate collection of green waste, still about 52% was landfilled. Half of the landfilled waste was organics made up of paper and cardboard (13.1%), yard trimmings (6.2%), food (21.9%) and wood (8.7%). The organic fraction of this stream can be potential resource for manufacturing biofuels and bioproducts through enzymatic solubilization or anaerobic digestion. However, the challenge is to produce a contaminant free organic stream from this heterogeneous mixture. The BurCell Technologies Inc. patented and proprietary BurCell® system processes raw, but size reduced nonrecyclable municipal solid waste (MSW) via a thermo-mechanical process. The raw material is wetted and heated. A rapid depressurization of the process vessel ensures the rapid formation of steam, which, while trying to reach thermodynamic equilibrium, builds up pressure in the vessel. The fast phase transition of moisture in the organics helps to break down their fiber structure, like a steam explosion process. Unlike a conventional steam explosion process, the BurCell® process starts under vacuum and therefore, never reaches the absolute pressure and temperature of a typical steam explosion process. Limiting the temperature is critical to prevent the degradation of plastics and minimize chemical contamination. The mechanical action further enhances the physical impact of the steam explosion. During the process, the BurCell® vessel rotates, and its contents are lifted and dropped by six large flights uniformly distributed on vessel inner surface. Plastics, glass, and metal are mostly unaffected by the BurCell® system operating conditions and become more easily separable from the bulk of the now sanitized and pulped organic material via screening. The organic streams produced by an industrial scale BurCell® system were sampled over a two-year period. During this period the facility processed MSW from various locations and sources. The proximate and compositional (cellulose, hemicellulose and lignin) characteristics of the samples were analyzed. Both enzymatic solubilization and anaerobic digestion experiments were performed on these samples. The visible contaminant content in the BurCell® system processed organic stream ranged between 3-5%, and on a dry matter basis the volatile solids content ranged between 75-90%, cellulose between 30-35%, and hemicellulose between 10- 18%. A C^{14} isotope characterization of the organic stream showed 100% of carbon of biogenic origin indicating no leaching and chemical degradation of compounds from plastics and other non-organic materials. About 80% of the volatile matter in this stream was solubilized by addition of a cellulase enzyme cocktail whereas only 40% was solubilized in non- BurCell® system processed samples. Both the methane yield and methane production rate were more than doubled from BurCell® system processed samples compared to non- BurCell® system processed samples. The BurCell® process produces a sanitized, and largely homogeneous organic stream with very little contaminants from a highly heterogeneous non-recyclable MSW feedstock. Thermo-mechanical processing also boosts the enzymatic solubilization and anaerobic digestability of the organics.

Keywords: MSW, Thermo-mechanical, Enzyme, Anaerobic Digestion, Biogas.

Microplastic Contamination in Compost Produced from Solid Waste

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Recycling of segregated solid waste generated from households, municipalities, and industries as compost or digestate produced from anaerobic digestion is a widely prevalent practice in circular bioeconomy. The application of compost into agricultural soil improves soil quality while reducing the demand for chemical fertilizers. However, compost application has recently been identified as a potential negligible top source of plastics and microplastics (MPs) addition to soil. MPs are a widespread emerging environmental contaminant identified as a global issue considering the threat on ecosystems and human health. This study investigated the MPs contamination in compost derived from mixed municipal solid waste, food waste, and compound waste in Thailand. Meso plastics (5-25 mm), larger MPs (1-5 mm), and smaller MPs (<1 mm) were extracted using a series of organic matter digestion and density separation method. MPs were identified using a microscope, FTIR (Fourier transform infrared spectrometry), and µ-FTIR. MPs were detected in compost with 100% detection frequency. MP abundance ranged from 100 to 23100 items/kg (dry weight), with an average value of 8083 ± 13013 items/kg (dry weight). White (53 %) colour and sheet (31%) shaped MPs were dominant in compost samples. Smaller MPs (<1 mm) were dominant in compost samples. Polystyrene, polyethylene, and polypropylene were the dominant polymer types. Compost produced from mixed municipal solid waste showed the highest MPs abundance. It was 231 times higher compared to the compost derived from food waste with the lowest MPs contamination. Results showed that MPs abundance varied based on the substrate used and technology utilized for compost production showing the unsuitability of using mixed municipal solid waste as a substrate. MPs found in food waste and compound mixed waste compost were identified as food wrappings and packaging materials based on visual and spectroscopic analysis, highlighting the importance of proper waste segregation and management while composting process. The results of this study provide insight into the current MPs contamination status in compost, demanding updating existing compost regulations and novel MPs mitigation techniques in compost and soil.

Keywords: Compost; Microplastics; Mixed municipal solid waste; Food waste; FTIR.

Emerging Pollutants in Wastewater Sludge: Lessons Learned from Perfluorochemicals

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Perfluorochemicals (PFCs) are a type of emerging pollutants with high-energy carbon-fluorine (C-F) bonds that make them structurally persistent. Different forms of PFCs are used in a wide range of industrial and consumer products, and they subsequently end up in the environment through waste streams, such as wastewater and its treatment sludge (biosolids). This finding has triggered a great concern in PFCs entering the food chains with agricultural activities employing biosolids and/or affected by the PFC-containing soils. Many studies have also revealed the adverse effects of PFCs toward human health. Therefore, a clear understanding of the fate and transport of the environmental PFCs and proper management technologies for this type of pollutants are crucial in reducing the PFC threat to our environment, agriculture, and public health. This presentation will first report our findings on the discharge characteristics of PFCs from municipal wastewater and its sludge. Then, the results of adsorption experiments for the selected PFC compounds on mineral surfaces will be demonstrated as an example of our understandings on the consequence of using PFC-containing biosolids for land applications or having agricultural activities on PFC-contaminated lands. Our results clearly indicate that, in addition to the mineral surface property, the PFC adsorption behavior is also influenced by solution chemistry. For example, the increase of pH can lead to a moderate decrease of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) adsorption, owing to the decrease of electrostatic attraction. The compression of electrical double layers and the calcium ion bridging effect between PFCs will also decrease the PFOS and PFOA adsorption on boehmite surface. Alternatively, thermal treatment (such as incineration) offers another management technology for wastewater sludge, and it can effectively break the robust halogen-carbon bonds in PFCs. However, the final products of thermally treated PFCs were found to be potent greenhouse gases, tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6). We introduced calcium-based minerals to assist the thermal treatment of the PFC-contained sludge and successfully achieved the fluorine mineralization with CaF_2 (calcium fluoride) and $Ca_5(PO_4)_3F$ (fluorapatite) to substantially reduce the emission of CF_4 and C_2F_6. The use of the state-of-the-art quantitative X-ray diffraction (QXRD) technique to analyze the fate and thermal transformation of fluorine in the PFC-contained sludge was demonstrated to obtain the detailed processing parameters for this new treatment design.

Keywords: Perfluorochemicals, Adsorption, QXRD, Wastewater Sludge, Thermal Treatment.

Sharing Construction Waste Materials Across Different Jurisdictions: Prospects and Challenges for a Smarter and Greener Greater Bay Area

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Construction waste, also called construction and demolition (C&D) waste, is the stream of solid waste generated from construction activities such as new building, renovation, and demolition. More than 95% of the construction waste materials (CWM) are inert and can be reused or recycled, e.g., for land reclamation, sub-base of road pavements, and recycled aggregates. As Hasegawa (1983) puts it, construction waste is just misplaced material. However, no matter how hard one tries, it is difficult for a single place to digest all the CWM generated from the locality. Visionaries are thus looking across different places for sharing such materials, as they could provide a bigger buffer in absorbing the materials for different beneficial reuse or recovery. Encouraging CWM sharing cases have been observed in the connections of Italy and Switzerland, particularly their Lombardy and Canton Ticino regions; of Singapore and its adjacent Southeast Asian countries; and of Hong Kong and the Pearl River Delta cities. Despite the prospects, numerous challenges are facing the innovative initiative of sharing CWM across different jurisdictions. For example, even under the Basel Convention not on the toxic waste, trading CWM can be stigmatized or lead to a predatory economy. Different jurisdictions will have different standards governing the CWM reuse or recovery. These jurisdictions will be too easy to work under different silos and treat this as a ‘zero-sum’ game. By situating it in the Greater Bay Area (GBA) of China, which is a city cluster witnessing exciting economic vibration, Prof. Lu will talk about the prospects and challenges facing the CWM cross-border sharing initiative. He will share his research on how to address the challenges, e.g., by certifying CWM as a sharable commodity, waste material passports, blockchain non-fungible token, and other innovative technical-institutional arrangements to boost the sharing economy to achieve a smarter and greener GBA.

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and Climate Resilience

Invited Lectures

Pre-treatment of Food Waste for High-rate Hydrogen Production

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Hydrogen is a clean fuel and estimated to meet 14% (i.e., 8.4 billion MMBTU per year) of the US final energy demand by 2050. The clean hydrogen R&D program funded by Department of Energy supported 22 Hydrogen hubs across the US with the clear road map of developing hydrogen economy and reduce the CO_2 emissions. Specifically, the set goal is to achieve the Clean Hydrogen Production Standard of less than $1 per kilogram of hydrogen with CO_2 emission less than 4 kg (i.e., 4 $kgCO_2e/kgH_2$) before 2030. Currently, more than 10 million metric tons of hydrogen are produced in US, in which 95% comes from steam methane reforming, 4% from partial oxidation of natural gas and 1% from electrolysis. The cost of production and carbon emissions from each technologies varies and still under debate. For example, electrolysis method is carbon intensive process, if wind or nuclear energy was not used, and cost of hydrogen will be $5-6 per kilogram. Therefore, alternative methods such as bio-waste (e.g., food waste) recycling need to be explored to meet the set goals.

In the US, more than 292.4 metric tons of municipal solid waste is collected every year, in which 22% are food waste (~ 63 metric tons). Utilization of food waste for hydrogen production and diverting from landfill is attractive and less carbon intensive, however, the characteristics of bio-waste (e.g., high carbon and moisture, etc) limits the process and product recovery. Here, the effect of different pre-treatment conditions is evaluated with the aim of high-rate hydrogen production from food waste. Among the pre-treatment methods tested and optimized, Ozonation and ultrasonication are found to be best pre-treatment options. But limitations in scaling up and commercializing these processes, heat and/or acid treatment are proposed as reliable technology for food waste to hydrogen recovery projects. With the heat and/or acid treatment, the recovery of hydrogen per ton of food waste increased threefold higher than the control tests without pre-treatments. Additionally, the pH of the initial reactor conditions is a key for high-rate hydrogen recovery. Based on a number of experiments under varying pH conditions, the best hydrogen production was achieved at an acidic pH of 5 or lower. In conclusion, food waste pre-treatment is necessary to improve the process and product recovery. The techno-economics of the different pre-treatment options also need to be taken into consideration otherwise, the process cost will be normalized for the total energy recovered.

Keywords: Hydrogen, Food Waste, Pre-treatment, Ozonation, Heat and Acid treatment.

Dynamics of Nutrients and Gaseous Emissions During Co-composting of Food Waste and Poultry Manure with Different Amendments

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Developed countries are generating a large amount of food waste (FW) about 1.3 billion tonnes, world-wide annually and is expected to rise more in the next two decades. Prohibition of land filling of FW, threats of greenhouse gases (GHG) emissions during incineration and increased administrative costs urges augmentation of newer strategies based on sustainable waste management instead of disposal strategies. On the other hand, Poultry manure(LM) is an organic matter and a rich source of macro and micro nutrients required for plant growth. Anyhow, the raw PM wastes has malodours and is ponderous, making it costly to transport and concomitant risks associated with it which may lead to severe ecological problems. Composting of FW is also not very productive because of its low porosity, high bulk density, poor C:N ratio, easy acidification, among other factors. The concepts of co-composting help in reducing the time and labour and also benefit economically. The present study proposes a system for co-composting of food waste and poultry manure amended with rice husk biochar, saw dust, and salts. Totally six different sets of compost treatments were prepared, as T1 (FW + PM+SD), T2 (FW + PM+SD+ BC), T3 (FW + PM+SD+ Salts), T4 (PM+SD+ BC+ salts), T5 (FW+SD+ salts) and T6 (FW + PM+SD+ BC+salts) in individual containers. All the compost treatments were degraded for 50 days and reached the good manural stability and maturity index after 90 days. Among the six treatments, the T6 treatment Carbon dioxide, methane and ammonia emissions were reduced and the nitrogen conservation was achieved at a greater level. This study implies that the biochar and salts addition for co-composting food waste and poultry manure is beneficial to enhance the property of the compost.

Keywords: Biochar, Composting, Food waste, Nitrogen conservation, Poultry manure, salts.

Oil Palm Biomass – Waste to Wealth Circular Approach

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The scarcity of conventional fossil-based energy (which will lead to eventual depletion) and the ever-increasing demand for new bio-sources have resulted in the world moving into efficient resources conservation. The Malaysian oil palm industry has been one of the largest contributor of oil palm biomass, with more than 90% of the country's total biomass deriving from 5.81 million ha of oil palms. The abundantly available oil palm biomass – totaling around 80 million tonnes (dwb) annually – are mainly obtained from oil palm plantations (oil palm trunks and oil palm fronds) and palm oil milling activities (mesocarp fibre, palm shell and empty fruit bunches). These biomass sources are anticipated to increase further in the future with increased world population, and thus higher productivity of oil palms for fresh fruit bunches mainly via biotechnological approach for palm oil extraction. Optimum biomass resource use efficiency, recycling and diversification, be it for energy or non-energy applications, present a huge business opportunity for developing a circular palm oil economy. This paper details the oil palm biomass availability, important physicochemical characteristics and potential waste to wealth circular approach, plus resources assessment in totality – in terms of economic and environmental impacts – for commercial exploitation. Relevant biomass to biomaterial and bioenergy conversion technologies, combustion-related problems and greenhouse gas profile, etc. will also be discussed. Overall, oil palm possesses huge potential as one of the largest alternative sources for biomass and bioenergy. Biomass business endeavors can be standalone or integrated along the supply chain, and ideally be centralized in a mill as a biorefinery to demonstrate a balanced impact on the environment, society and economy.

Keywords: palm oil, biowaste, bioenergy, biomaterial, biorefinery, circular economy.

Conversion of Waste Face Mask into Carbonized Functional Materials for Environmental Applications

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The SARS-CoV2 (COVID-19) disease outbreak has caused several health concerns, economic and environmental consequences all over the world. Use of face mask is the primary tool to prevent the spread of virus and lessen exposure to virus. It was estimated that globally 1.6 million tonnes of disposable face mask was daily evolved as waste in pandemic situation. The primary material utilised to create this surgical face mask is polypropylene, sometimes known as plastic. Besides, this mask is also made from various polymers, including polyester, polystyrene, polycarbonate, or polyethylene. Due to their inability to degrade, they got deteriorate into microplastics having less than 5 µm fragments causing various hazardous concern to terrestrial (disturb soil parameters, halt sewers, enters food web) and aquatic ecosystems. These bio-hazardous wastes impact the environment due to lack of knowledge on safe disposal and management strategies in developing countries. Turning the waste disposed facemask into value material towards useful applications could have multiple benefits.

In view of this, in this study, a functional carbonized material was produced by pyrolysis of disposable face masks under controlled conditions. At the suitable pyrolysis temperature, ranging from 500 to 600º C, the facemask waste mass was converted into a functional carbonized material. The chemical, structural and surface characterization studies suggested that the synthesized carbonized material has excellent properties suitable for adsorption applications. The FTIR characterization showed that the carbonized material has a major functional group of C-N responsible for the dye adsorption. The XRD spectra of adsorbent showed strong peaks at 2θ=26.629, 27.488, 27.810, and 29.404 those correspond to disordered graphitic plan while the SEM images of the material showed good porosity. Furthermore, the adsorption capacity of the material was explored with anionic and cationic dyes namely Congo red and Malachite green oxalate. The functional carbonized compound (CC) showed remarkable colour reduction in the malachite green oxalate aqueous solution at the absorbent dosage of 0.25 g/L. The Box–Behnken design was used to optimize the optimal conditions for the dye removal with CC. At the end of 17 experimental pre-runs the cubic model was found to be most significant for optimization with the P (0.0002) and F values (55.53). Finally, the optimized conditions were decided as CC concentration 432.28 ppm, dye concentration 31.41 ppm and Time 180 mins for maximum dye removal rate.

Keywords: Waste Face Mask; Carbonization; Biochar; Environmental Applications.

CO_2 Enrichment Regulates Acid Production and Methane Yield from Anaerobic Digestion of Food Waste

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The strategy of injecting exogenous CO_2 gas into the anaerobic digestion reactor can not only reduce CO_2 emissions but also promote the bioconversion of CO_2 to methane, which has received more and more attention in recent years. However, most of the existing research is in its infancy, and there is a lack of in-depth discussions and calculations on the injection method of exogenous CO_2, the enhancement effect of anaerobic digestion and the utilization efficiency of CO_2. This paper aims to explore the enhancement effect of the injection frequency and injection method of exogenous CO_2 on the methane production pathway, so that the quality of biogas can be improved on the basis of the effective utilization of CO_2. The exogenous CO_2 achieved the best effect under the frequency of once every two days. The concentrations of acetic acid and lactic acid reached 812 mg/L and 495 mg/L, which were 91.71% and 95.65% higher than those of the control group, respectively, while the concentration of propionic acid was significantly lower than that of the control group. At this injection frequency, the average daily production of methane reached 4234 mL, which was 26.50% higher than that of the control group. It indicated that the CO_2 enrichment reinforced acetic acid production pathway and weakened propionic acid pathway, thus the methane yield was enhanced. The continuous injection of exogenous CO_2 can also improve the hydrolysis process, as proved by the higher concentrations of SCOD, protein and polysaccharide. Results of microbial community analysis showed that different exogenous CO_2 gas injection frequencies had a great influence on the methanogenesis pathway. When exogenous CO_2 was injected at a more moderate frequency once every two days, the hydrogenotrophic methanogenesis pathway predominated; whereas the acetoclastic methanogenesis pathway was promoted when exogenous CO_2 is injected more frequently once a day.

Keywords: CO_2 utilization; Anaerobic digestion; Biogas upgrading; Methane production; Acid production pathway.

Decentralized Municipal Solid Waste Composting in Tamil Nadu, India – A Case Study

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Solid Waste management is a major challenge throughout the world, and a poor management can result in environmental deterioration and human health hazards. It is estimated that population of India would be about 1.8 billion by 2051 and about 300 million tons per annum of MSW will be generated that will require around 1,450 km^2 of land to dispose it in a systematic manner, if urban local bodies (ULBs) in India continue to rely on landfill route for MSW management. The major fraction of the MSW is the putrescible (biodegradable) organic waste such as the food waste. With the increase in population, urbanization and industrial development, the cost of handling the diverse nature of wastes is expected to increase 4 to 5 folds in countries like India exerting huge pressure. Thus, a low-cost technology to handle the organic fraction of the MSW is preferable for developing countries. Considering the application, level of scientific expertise required and the demand for the recycled products, composting is considered to be an ideal technology. Decentralized community on-site composting is a potential approach to reduce food waste requiring collection also resulting in significant reduction of monetary requirements. Tirunelveli city, the headquarters of Tirunelveli District in Southern Tamil Nadu, India, is the sixth Municipal Corporation in Tamil Nadu and the city spreads over an area of 108.65 km^2. The Corporation has been divided into 4 Zonal Offices with 55 wards and collectively generates about 181 tonnes of MSW per day. Currently, the Corporation is implementing the door-to-door collection of source segregated wastes and divert the OFMSW using battery operated vehicles into dedicated composting units. Each ward has been setup with one composting unit installed with pits used for composting referred as micro-composting facilities. Each facility is provided with 8 or 16 pits depends on the waste received in those wards. The organic fraction of MSW is placed in pits in a sequential manner. A microbial inoculum prepared using jaggery and curd is sprayed on the composting materials when fresh wastes are placed in the pits. The composting pits are turned once a week until they mature. The composting plants do not produce significant odour and the composts are produced in about 41 days. Composting at decentralized level can have its own characteristics. Although the general process conditions provide the process flow for efficient composting, it must be assessed for the specific conditions.

Keywords: MSW, Putrescible waste, Decentralized composting.

Food Waste Generation in The Grocery Retail Sector

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Grocery retailers operate in a consumer-oriented marketplace, selling produce and packaged food products. Because of their unique position at the heart of the supply chain, they have a lot of power to influence food waste minimisation decisions. However, retailers face contradictory challenges: at first, customers demand that a variety and quality of food be readily available, adding strain to inventory management. On the other side, high customer standards for freshness lead businesses to dispose of safe, edible food based on a perception that is past its prime. The main objective of the work reported here is to present the variation and composition of the quantities of unsold food, food waste and food donations in the operations (stores and warehouses) of the 2nd largest supermarket chain in Greece for the years 2019 and 2020, in the context of developing an efficient waste prevention plan. The retailer, committed to contribute to SDG 12.3, to half food waste in its own operations and contribute to the reduction of food waste by its suppliers and customers. To this purpose the retailer cooperated with Harokopio University to establish the food waste baseline for the year 2019, along its whole supply chain, with the aim to provide external verification to its yearly food waste assessment for its own operations, estimate food waste generation by its suppliers and customers, and set the basis for setting up and/or intensifying a range of food waste prevention activities. In terms of methodology, the detailed recordings of the quantity and value of each unsold food (or shrink) item were extracted from the company database into excel files. Depending on the product type, the quantity was recorded either directly in weight units or in number of items. In the latter case, it was calculated into weight, based product information which was included in the product description in the file, or, if not available, using product information files and/or information available in the online store. Net weight (excluding packaging) was used. Where such information was not available, typical unit weights of nutrition and dietetics databases were used. The results of our assessment indicate that food waste accounted for 1.98% and 1.90% of food handled for 2019 and 2020 respectively. In addition, food donated accounted for 0.20% & 0.16%, respectively, of food handled. And finally, regarding the composition, fruits and vegetables accounted for 32% of unsold food followed by dairy and bakery. The key outcome is that grocery retailers can - and should - make meaningful changes to help limit food waste. Establishing a reliable food waste baseline is the first, labour consuming but indispensable, step to this direction.

Keywords: Retail, Grocery, Supermarkets, Donation, Greece.

Catalytic Co-Pyrolysis of Sweet Sorghum Stalk and Polypropylene: Simultaneous Waste Reduction and Biofuel Production

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The COVID-19 pandemic has changed the lifestyle of people around the world. E-commerce is one of the major changes; online food delivery is widespread around the world. Therefore, the demand for single-use plastics has increased, worsening the plastic problem. Polypropylene (PP) food packets are widely used to deliver food online. In this study, used PP food packets are used for pyrolyzing with of Sweet Sorghum Stalk (SSS). Sweet sorghum is a perennial crop, can be planted in marginal lands. They had higher tolerance to salt and drought compared to sugarcane and with similar carbohydrate content as sugarcane. Their stalks are considered waste after processing. Intermediate pyrolysis of SSS yielded 42.9 wt% bio-oil and 28.6 wt% biochar as the major products. In the case of intermediate pyrolysis for PP, 52.3% of wax (highly viscous liquid) was resulted as the major product. There was no char as product in SSS pyrolysis. Remaining yield was left as uncondensed gases. Co-pyrolysis of SSS with PP were conducted with and without catalyst. The experiments were carried in a vertical tubular reactor using 30 g of feed at 600 °C and feed ratios of SSS to PP as 1:1. An increase in bio-oil yield and HHV were noticed when SSS was mixed with PP. Al_2O_3, ZSM-5, Ni- Al_2O_3 and Ni-ZSM-5 catalysts were tested for their catalytic activity on bio-oil yield and properties. However, there was no significant change in the yield when catalysts were used. The HHV for bio-oil for catalytic co-pyrolysis were about 41 MJ/ kg.

Keywords: Al_2O_3; Co-Pyrolysis; PP Plastic waste; Sweet Sorghum Stalk; ZSM-5.

Biogas Production from Agro-waste in Nanjing Tech University: Research and Practice

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Anaerobic digestion is becoming more and more attractive for the treatment of organic wastes and have been developing rapidly in the world. The biomethane production from inferior biomass through anaerobic digestion has the triple strategic significance of energy conservation, emission reduction, and resource utilization. China is one of the largest agricultural countries, which has abundant biomass resources, and the two most important types of biomass from organic wastes are the agricultural residues and animal manure. According to a 2020 estimate by the Ministry of Agriculture of the People's Republic of China, approximately 800 million tons of crop straw and 3.8 billion tons of livestock and poultry manure were produced in China. Using biogas processes, it is estimated that (1) in energy sector, 200 bm^3 of biomethane will be generated; (2) in environmental sector, CO_2 emission will be decreased 1 bton; and (3) with additional 30% fertilizer substitutions. Therefore, anaerobic waste treatment — biogas production from manure, straw and municipal wastes, is a tailored option to solve both environmental and energy issues sustainably in China. To develop new technologies and implement them into biogas processes with higher energy efficiency in a sustainable and harmless way is in the focus of research directed to next generations of biogas process. In the last few years, Nanjing Tech University got some projects about the biogas from our governmental. These projects aimed at developing a series of technology to achieve the stable and efficient biogas production and high-value use of bio-methane through the research of pretreatment of raw materails, high efficiency anaerobic reactor, new biogas purification technique, new biogas slurry utilization technology. Meanwhile, A biogas demonstration project (300 m^3 reactor) was built in the campus of Nanjing Tech University, which are combined with raw material pretreatment unit, anaerobic digestion process, biogas purification process, and the biogas slurry treatment unit. Biogas in the campus project is purified to biomethane (methane >97%) which can be used as substitute of natural gas for vehicle fuel or domestic gas, and the biogas slurry was used as fertilizer in the campus. Overall, this study confirmed that converting agro-waste to biomethane is a sustainable way for China.

Keywords: Agrofood wastes, Anaerobic digestion, Biogas, Microbial consortia, Biogas project.

Evaluation of Digestate-Derived Biochar on Humificaton and In-situ Odor Reduction During Food Waste Digestate Composting

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Anaerobic digestion is currently the most commonly used treatment method for food waste (FW) in China, accounting for approximately 80% of all operated FW treatment plants. Due to limited hydraulic retention time, FW cannot be completely converted to biogas during the anaerobic digestion process, resulting in a considerable amount of residue remaining as the byproduct, named digestate from FW (DFW). In general, digestate from food waste anaerobic digestion plants is rich in water, nutrients (e.g., nitrogen and phosphorus), and undegraded organic matter (OM). The degradation of OM contained in digestate could cause health and environmental problems if DFW is not properly managed. As a promising technology, composting can not only transform OM into stable humic substances but also recover nutrients. However, the emission of odorous gases, such as ammonia and reduced sulfur gases, is the main environmental concern associated with DFW composting. In addition, a prolonged duration is usually required for FW composting owing to the refractory OM.

In this study, DFW-derived biochar (BC-DFW) was produced in a furnace with a pyrolysis temperature of 600 ^oC. The properties of digestate-derived biochar were analyzed, including pore size, functional group structure, and the speciation of concentration of metals etc. DFW composting was performed using four 100-L cylindrical reactors, with a height and inner diameter of 70 cm and 43 cm, respectively. Different amounts of BC-DFW were added to those reactors to investigate the effects on the emission of odorous gases, including NH_3 and VSCs. Compost samples were taken to analyze for pH, conductivity, germination index (GI), and elemental composition. Moreover, the fluorescence spectra of the dissolved organic matter (DOM) were determined through excitation emission matrix (EEM) fluorescence. The results showed the addition of BC-DFW can effectively enhance FW composting process and decrease the emission of odorous gases. BC-DFW exhibited a highly porous structure and high metal concentrations. The addition of BC-DFW accelerated the degradation rate of OM, which helped increased the temperature and GI. The emission of total VSCs was decreased by 15-20% with the addition of BC-DFW. Results indication the addition of 25% BC-DFW was optimal for promoting the degradation of organic matter and humification and odor emission reduction.

Combined Steam Explosion and Water Leaching Pretreatments to Upgrade the Fuel Properties of Wheat Straw

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Vast amounts of lignocellulosic waste biomass can potentially be converted to bioenergy and industrial products, making positive impact on a low-carbon, circular economy. There has been growing interest in utilizing more varied types of lignocellulosic waste biomass aside from sawmill residues to produce biofuels in solid, liquid, or gaseous forms. These alternative biomass feedstocks include logging residues and non-woody (herbaceous) waste biomass such as cereal grain crop residues - wheat straw, rice straw, and corn stover. Using crop residues to produce power and bioenergy could also avoid severe air pollution problem due to open burning of the biomass in some parts of the world with densely populated agricultural regions. A major barrier that hinders the acceptance of straw as the fuel for thermochemical conversion processes (combustion, gasification, and pyrolysis) is its low and inconsistent quality compared to woody biomass. These shortcomings include higher moisture content and ash content, and lower biological stability. High biomass ash content will lead to reduced heating value; decreased yield, quality, and stability of the various desired products; or causing catalyst poisoning, and equipment fouling and corrosion problems. The presence of silica in straw would aggravate the fouling problem or otherwise trap the carbon particles making it unavailable for conversion. Hence, adequate pretreatment is required to improve the fuel properties of these waste biomass so they can become desirable feedstock for different types of biomass conversion systems.

This paper presents a new approach that involves combined biomass pretreatment techniques using auto/acid-catalyzed steam explosion and water leaching to upgrade the fuel properties of wheat straw. Results showed that acid-catalyzed steam explosion of wheat straw followed by water leaching at room temperature of 25 ^{o}C increased the higher heating value (HHV) from 18 to 22 MJ/kg, and the fuel ratio from 0.19 to 0.34 when compared to the untreated wheat straw. Furthermore, the removal efficiencies of ash, and the key inorganic elements Si and Ca were substantially greater at (82%, 98%, and 93%) as compared to (13%, 13% and 15%), respectively when pretreatment was done using water leaching alone. The ash content dropped to below 1.5% db, thus meeting the specifications in the ISO standard for fuel pellets. By comparison, wheat straw treated with auto-catalyzed steam explosion and followed by water leaching gave rise to much lower ash removal efficiency and Si removal efficiency at 41% and 46%. For all steam-treated samples with or without subsequent water leaching, the pyrolysis characteristics was enhanced in terms of the decomposition rate and the devolatilization index. As for the combustion process, the integration combustion index parameter increased substantially from 0.26 to 0.69 x 10^{-6} min^{-2} $^{o}C^{-3}$ at the devolatilization stage for the acid-catalyzed steam explosion method, and this value is greater than that observed for some woody biomass in previous studies. Together with a lower volatile matter content, this implies a better combustion performance of a power plant boiler in terms of feedstock reactivity, heat transfer efficiency, and the degree of complete combustion. Thus, the combination of water leaching and steam explosion pretreatment techniques could effectively upgrade the fuel and physicochemical properties of herbaceous waste biomass such as wheat straw.

Biochar Products, Systems and Processes in North America

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Biochar and carbon removal markets have led to the development of a variety of biochar products and systems in North America. This presentation will describe how organic recycling companies, compost facilities, farms, cities, and wood processing facilities are taking advantage of advances in science, technology, and government incentives to produce biochars suitable for agricultural and environmental markets. Results of a recent survey of the US biochar industry will be presented. Approximately 200 producers supply biochar or biochar enhanced products in North America. Production has grown to 100,000 tpy biochar (450,000 m3). Biochar markets and uses are expanding. Biochars and biochar enhanced products are found in diverse markets such as retail garden, landscaping, and agriculture. They are delivered in packaged and bulk consumer products with composts and biochar-compost blends, with biological inoculants, as biochar enhanced fertilizers, and in soil amendments, which are sold wholesale to specialty crops, horticulture, and landscape turf and tree services. Biochar products are available through major wholesale and retail outlets. Granulated products are made for horticulture, hydro-seeding, and oilfield remediation. Biochars are also used in building products. Producers expect markets to grow in crops, water filtration, odor control, and animal feed. New markets are emerging in environmental remediation, erosion control, mine reclamation, odor control and PFAS reduction in sewage treatment, and in stormwater filtration. A variety of commercial and developmental systems are used to make biochars. They are produced in small-scale systems and as co-products in large industrial gasifiers and renewable energy processes. New technologies are make biochars with biofuels and biomass energy from urban and agricultural residues.

Highly Selective Butyric Acid Production by Coupled Acidogenesis and Ion Substitution Electrodialysis

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Selective production of carboxylic acids (CAs) from mixed culture fermentation remains a difficult task in organic waste valorization. Herein, we developed a facile and sustainable carbon loop strategy to regulate the fermentation micro-environment and steer acidogenesis towards selective butyric acid production. This new ion substitution electrodialysis-anaerobic membrane bioreactor (ISED-AnMBR) integrated system demonstrated a high butyric acid production at 11.19 g/L with a mass fraction of 76.05%. In comparison, only 1.04 g/L with a mass fraction of 30.56% was observed in the uncoupled control reactor. The carbon recovery reached a maximum of 96.09% with the assistance of ISED. Inorganic carbon assimilation was believed to be an important contributor, which was verified by 13C isotopic tracing. Microbial community structure shows the dominance of Clostridia (80.16%) in the unique micro-environment (e.g., pH 4.80–5.50) controlled by ISED, which is believed beneficial to the growth of such fermentative bacteria with main products of butyric acid and acetic acid. In addition, the emergence of chain elongators such as Clostridium sensu stricto 12 was observed to have a great influence on butyric acid production. This work provides a new approach to generate tailored longer chain carboxylic acids from organic waste with high titer thus contributing to a circular economy.

Technological Advancement and Development of Circular Waste-based Biorefinery for Sustainable Production of Chemicals, Materials and Fuels

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There is a growing demand to establish waste-based processes for chemicals, materials and fuels production which can decrease our dependency on dwindling oil reserves and reduce greenhouse gases emission. Furthermore, the increasing production of petroleum derived products has led to concerns related to plastic pollution and its impacts on environment. These novel bioprocesses are incorporated into biorefineries, which are integral units converting different renewable feedstocks into a range of useful products, as diverse as those from petroleum using green and sustainable technologies. At the same time, there are growing concerns over organic waste generation and insufficient resource supply due to the increasing global population and the cradle-to-grave system of material flows in the linear economy. Therefore, waste-based biorefinery valorisation research conducted in our team aims at valorising organic waste materials through bioconversion processes to recover their inherent nutrients for transformation into value-added products. In this talk, research projects including the bioconversion of food and beverage waste streams, agricultural residues for the nutrient recovery of value-added products, and textile waste recycling will be introduced to illustrate how science and engineering can be applied for organic waste valorisation.
The first part of the talk will illustrate the roles of various bioprocesses in waste transformation, with specific focus on biobased production of polylactic acid (PLA), succinic acid, fructose, biosurfactant, and valorisation of textile waste. State-of-the-art strategies for managing food waste in the context of techno-economic evaluation and the movement towards a circular bioeconomy will be discussed. The second part of the talk will introduce bioconversion of food and textile wastes into value-added products, with special focus on production of lipase, bacterial cellulose, polyurethane foam, personal protective equipment and sustainable aviation fuel will be elucidated.

Valorisation of Cocoa Pod Husks in Cellulose Triacetate and Lactic acid

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Cocoa pod husk (CPH) is a carbohydrate-rich lignocellulosic biomass, and it is abundant and readily available in Côte d'Ivoire to produce cellulose triacetate (CTA) and microbial lactic acid (LA) from this residual biomass. This cocoa belongs to the Amazonian *Forastero* type. The main sub-varieties are Amelonado and Arriba, and the Ivorian cocoa is of the *Amelonado* subgroup. CTA was produced after isolating cellulose from CPH, by alkaline pretreatment with 5% (w/v) NaOH and bleaching with 2 % (v/v) hydrogen peroxide. A yield of 54 % (w/w) of cellulose was obtained. Then, TAC was synthesized by acetylation reaction of the extracted cellulose in the presence of acetic acid and anhydride catalyzed by sulfuric acid. A degree of substitution of 2.87 and an acetylation percentage of 43.75 % were obtained. FTIR results confirmed the formation of cellulose acetate by the appearance of ester group (C=O) and acetyl group (C-O) stretching. XRD gave a cellulose crystallinity index of 38.43 % while indicating the semi-crystalline nature of CTA. Morphology and elemental observation (SEM-EDX) showed small and medium rough and spongy particles within the structure of the TAC and the dominant presence of carbon (C, 87%) and oxygen (O, 13%). Lactic acid was produced after optimization of the processes of delignification by KOH and acid hydrolysis by H_2SO_4. A biomass/solvent ratio of 9.14 % and a temperature of 128 °C, resulting in a degree of delignification of 93.87%. Morphological and elemental analysis (SEM-EDX) revealed several changes within the delignified matrix and the dominant presence of carbon, oxygen and potassium elements. Infrared (TF-IR) analysis confirmed almost complete removal of lignin. Optimal hydrolysis conditions were: 26.95 min, 9.53% (w/v) biomass/solvent ratio in 4.92% (w/v) H_2SO_4, yielding 18.77 g/L of reducing sugars. The hydrolyzate obtained after concentration was used to produce LA using lactobacillus fermentum ATCC 9338 in a biofermentor. A productivity of 1.25 g/L.h at the logarithmic phase after 72 hours of fermentation, a titer of 26.61 g/L and a yield of 0.52 g/g of lactic acid were obtained from 45. 55 g/L of glucose and 12.21 g/L of xyloses.

Keywords: Cocoa Pods Husk, Lactic acid, Cellulose triacetate.

Magnetic Ball-Milled Red Mud@Peanut Seedling Straw Biochar as Hydrogen Peroxide Activator for Degradation of Tetracycline

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Magnetic red mud@peanut seedling straw biochar (BMHRBC) is a composite material made from industrial and agricultural wastes. It is prepared by a two-step process of co-pyrolysis and mechanical ball milling. In this study, we evaluated the performance and complete pathway of tetracycline (TC) degradation in BMHRBC/H_2O_2 systems. Moreover, the toxicity of TC and intermediate was evaluated. TC degradation in the BMHRBC/H_2O_2 system followed pseudo-first-order kinetics, and the removal efficiency of TC reaches 90% in 120 min (TC_0=50 ppm). Some influencing factors such as pH, catalyst dosage, hydrogen peroxide concentration, ionic strength and stirring intensity were comprehensively investigated. The electron spin resonance (ESR) analysis and free radical quenching experiments indicated that both non-radical pathway and direct electron-transfer pathway advanced TC degradation. TC was oxidized by •OH and $•O_2^-$, and •OH was the dominant active species. This work probably can be called "three birds with one stone", which not only makes industrial and agricultural solid waste resources used in the treatment of antibiotic wastewater, but also facilitated understand the reaction mechanism of biochar application of heterogeneous Fenton reaction.

Biodiesel Production from Optimal Food Waste Hydrolysis by Yeast *Rhodosporidium toruloides*

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The potential of biolipid production from the effluents of existing local food waste treatment facilities was evaluated by utilizing the oleaginous yeast *Rhodosporidium toruloides*. In addition, to increase the nutrient recovering efficiency, the conditions for food waste hydrolysis by crude enzymes produced from solid food wastes by *Aspergillus oryzae* were further optimized. The optimized hydrolysis process resulted in reducing sugar (RS) yield of 251.81 ± 8.09 mg/g_{dry} (dry food waste) and free amino nitrogen (FAN) yield of 7.70 ± 0.74 mg/g_{dry} while the waste oil was easily separated. Biomass and biolipid were increased by 41.14 and 25.85%, respectively, when the hydrolysate was diluted/mixed with domestic wastewater to have 20 g/L RS. From biolipid and waste oil, the total biodiesel yield of 229.87 mg/g_{dry} was obtained from food waste, and the properties/qualities of resultant biodiesel met the ASTM D6751 standard.

On the other hand, three different hydrolysis methods (sulfuric acid hydrolysis, industrial enzyme hydrolysis, and fungal mash hydrolysis) were assessed for their effectiveness. Under the optimal hydrolysis conditions, the ratio of reducing sugar (RS) to free amino nitrogen (FAN) obtained was 218.52, 431.89, and 34.60 for each hydrolysis method respectively, and the soluble chemical oxygen demand (SCOD) of each hydrolysate was 93,067, 103,333, and 166,667 mg/L, respectively. For the lipid production by yeast, the resultant hydrolysates were then mixed with local domestic wastewater at different mixing ratios to control the different initial SCOD concentrations (22,000, 28,000, and 34,000 mg/L, respectively). The lipid produced from these three hydrolysis methods was 6.73, 7.76, and 2.33 g per kg food waste, respectively.

Keywords: Biodiesel, Biolipid, Food waste, Food waste hydrolysate, Oleaginous yeast.

Microbial Biotechnology Approaches for Conversion of Fruit Processing Waste in to Emerging Source of Healthy Food for Sustainable Environment

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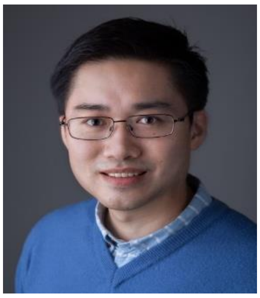
One of the most significant and difficult jobs in food sustainability, is to make use of waste in the vegetable and fruit processing sectors. The discarded fruits along with their waste materials, is anticipated to have potential use for further industrial purposes via extraction of functional ingredients, extraction of bioactive components, fermentation. As a result of its abundant availability, simplicity and safe handling, and biodegradability, fruit waste (FW) is now the subject of extensive research. It is regarded as a resource for economic development. This vast agro-industrial waste is being investigated as a low-cost raw material to produce a variety of high-value-added goods. Researchers have concentrated on the exploitation of FW, particularly for the extraction of prebiotic oligosaccharides as well as bromelain enzyme, and as a low-cost source of fibre, biogas, organic acids, phenolic antioxidants, and ethanol. Thus, this review emphasizes on various kind of FW valorisation approaches, extraction of bioactive and functional ingredients together with the advantages of FW to be used in many areas. From the socioeconomic perspective, FW can be a new raw material source to the industries and may potentially replace the current expensive and non-renewable sources. This review summarises various approaches used for FW processing along with several important value-added products gained which could contribute towards healthy food and a sustainable environment.

Keywords: Fruit waste, Sustainable food, Prebiotics, Bromelain.

Biotechnical Processes for Extraction and Recovery of Metals Value from Electronic Wastes



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Electronic waste (e-waste) refers to all electrical and electronic equipment (EEE) and its parts that have been used and discarded as waste without the intent of re-use. Globally, e-waste generation is rapidly growing at an alarming rate of approximately 2 Mt per year due to high consumption rates of EEE, short life cycles and few repair options. It is the fastest-growing part of municipal solid waste in many countries, and it has been estimated that annual global e-waste generation will reach 74.7 Mt by 2030. Along with the co-existence of various hazardous substances (e.g., heavy metals, flame retardants, persistent organic pollutants), e-waste often contains valuable and critical metals such as gold, silver, copper and other base metals, rare earth elements, lithium, and cobalt. As such, it represents a notable revenue stream, and one worth addressing to minimise the impacts associated with improper handling at the end of life. Also, considering the declining grades of primary minerals resources, developing technologies for sustainable extraction and recovery of metals from e-waste is critical to ensuring sustainable utilisation and management of resources to meet the demands of EEE.

Pyrometallurgy and hydrometallurgy are conventional technology options for recovering metals from e-waste. However, pyrometallurgy is energy intensive and demands high capital investment and supplies of large e-waste feedstock volumes to justify economies of scale. On the other hand, hydrometallurgy relies heavily on the use of strongly corrosive or oxidising chemical agents for metal leaching, rendering the process eco-unfriendly. There has been a growing interest in using biotechnical processes for value recovery from e-waste. Biohydrometallurgy is a subset of hydrometallurgy that harnesses the natural ability of microorganisms, such as bacteria, archaea, and fungi, to facilitate the extraction and recovery of metals from metal-containing solid matrices (e.g., mineral ores, e-waste) in aqueous systems. It has the potential to be a greener alternative to traditional metallurgical processes with lower energy costs and environmental impacts.

This presentation will give an overview of the research conducted at Australia's national science agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), on the development of biotechnical processes for extracting and recovering metals from two types of e-waste, namely spent lithium-ion batteries and printed circuit boards with the view of supporting sustainable resource management and the circular economy. The processes include the extraction of metals into solution with biologically generated leaching reagents (e.g., ferric iron and biogenic acid), as well as the recovery of metals from aqueous solutions by bioprecipitation with biogenic hydrogen sulfide.

Keywords: Batteries, Bioleaching, Bioprecipitation, Circular economy, Printed circuit boards.

Degradation of Emerging Eecalcitrant Contaminants in Wastes and Wastewater Using Electro-technology

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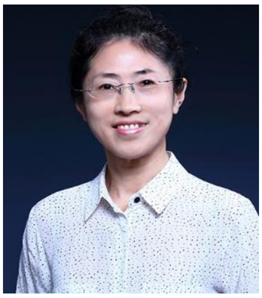
Since 20th Century, higher levels of industrialization were developed in a number of countries around the word (Canada, USA, France, China, etc.) in different sectors of activities: chemical industries, pharmaceuticals, agro-food, cosmetics, petroleum, etc. This industrialization led to the generation of effluents (industrial, municipal and agriculture effluents) more and more complexes and the appearance in environment of emergent recalcitrant contaminants (ERCs). Several ERCs (ex. pesticides, pharmaceuticals, micro-and nano-plastics, per-and poly-fluoroakyl substances, etc.) are included in the category of endocrine disruptors having toxic effects on aquatic organisms and constitute, even at extremely low concentrations, a real risk for human health. The majority of ERCs escape the conventional treatment (ex. activated sludge, bio-filtration, etc.) and can they be accumulated in biological sludge, thereby posing the problem of their valorization (agricultural spreading). To face this challenging problem of ERCs, we propose another approach for the management and decontamination of wastes and wastewater at source (before discharge back to the environment) by means of electro-catalytic processes. Electro-technologies can be considered as «green» technologies, as these techniques allow using non-polluting energy and renewable energy. The electrochemical method takes advantage of coupling chemistry (*in situ* generation of oxidant) with electronic science (electron transfer). Likewise, electrochemical treatment is generally characterized by simple equipment, easy operation, brief retention time and negligible equipment for adding chemicals. The interest of using electrochemical oxidation is based on its capability of reacting on the pollutants (such as ERCs) by using both direct and indirect effect of electrical current. Direct anodic oxidation where the organics can be destroyed at the electrode surface (owing to hydroxyl radical ($HO^{\bullet}$), and indirect oxidation where a mediator (H_2O_2, $H_2S_2O_8$, and others) is electrochemically generated to carry out the oxidation

Laboratory works dealing with electrochemical treatment of hospital wastewater were carried out. An advanced electro-oxidation (AEO) process was used as tertiary treatment (after biological treatment using membrane bioreactor). The first part of this study involved the treatment of synthetic effluents doped with four pharmaceutical pollutants, namely carbamazepine (CBZ), ibuprofen (IBU), estradiol (EE) at concentrations of 10 $\mu g.L^{-1}$ and 0.2 $\mu g.L^{-1}$ for venlafaxine (VEN). AEO process used as post-treatment allows a high elimination rate (~ 97%) of the four pharmaceutical pollutants after 40 minutes of treatment at a current intensity of 0.5 A (current density 4.4 mA cm^{-2}) by usend boron doped diamond (used as anode electrode). The scond part of this study was devoted to electrochemical treatment of real hospital effluents at source. A dozen pharmaceutical products have been selected and measured to evaluate the performance of AEO process. The results showed that AEO can be successfully applied for the tertiary treatment of hospital wastewater. Indeed, a complete elimination of ibuprofen, diclofenac, sulfamethoxazole, clarithromycin and metroxazol was obtained. A relatively high reduction rate was recorded for the remaining pollutants (hydromophone, Hydroxy-diclofenac, caffeine, claritromycin, desvenlafaxine and acebutolol), ranging from 72% to 100%, except for carbamazepine (57%) and venlafaxine (41%). The toxicity analysis of the treated effluents shows an increase in the toxicity of the effluents after the electro-oxidant treatment. This increase in toxicity may be due to the by-product generated which could be more toxic than the original compound.

Some works dealing with micro-and nano-plastics (MPs and NPs) degradation in laundry wastewater (LWW) were also carried out. Water pollution by plastics is a contemporary issue which has recently gained lots of attentions. The first part of experiments consisted to make the proof of the concept of the possibility to used electro-oxidation (EO) process for MP and NP degradation. To that end, MP and NP synthetic solutions were separately prepared with distilled water and a commercial polystyrene solution containing a surfactant. Different operating parameters were investigated such as anode material, current intensity, anode surface, electrolyte type, electrolyte concentration and reaction time. The obtained results revealed that the EO process can degrade 58 ± 21% of MPs in 1 h. Analysis of the operating parameters showed that the current intensity, anode material, electrolyte type, and electrolyte concentration substantially affected the MPs removal efficiency, whereas anode surface area had a negligible effect. In addition, dynamic light scattering analysis was performed to evaluate the size distribution of MPs during the degradation. The combination of dynamic light scattering, scanning electron microscopy, total organic carbon, and Fourier-transform infrared spectroscopy results suggested that the MPs did not break into smaller particles, and they degrade directly into gaseous products. On the other hand, the role of main reactive oxygen species (ROSs) in the electrooxidation (EO), electro-peroxidation (EO-H_2O_2), and photo-electro-peroxidation (EO-H_2O_2/UV) of NPs in water is investigated. In-situ generation of hydroxyl radicals ($^{\bullet}OH$), persulfates ($S_2O_8^{2-}$), and hydrogen peroxide (H_2O_2) were performed using boron-doped diamond (BDD) as the anode, whereas titanium (in EO process) and carbon felt (CF, in EO-H_2O_2 process) were used as cathode. In the EO process, NPs were mainly oxidized by two types of ROSs on the BDD surface: (i) $^{\bullet}OH$ from water discharge and (ii) $SO_4^{\bullet-}$ via $S_2O_8^{2-}$ reaction with $^{\bullet}OH$. In EO-H_2O_2 process, NPs were additionally degraded by $^{\bullet}OH$ formed from H_2O_2 decomposition as well as $SO_4^{\bullet-}$ generated from direct or indirect reactions with H_2O_2. Analysis of the degradation of NPs showed that EO-H_2O_2 process was around 2.6 times more effective than EO process. The optimum amount of NPs degradation efficiency of 86.8% was obtained using EO-H_2O_2 process at the current density of 36 mA.cm^{-2}, 0.03 M Na_2SO_4, pH of 2, and 40 min reaction time. In addition, 3D EEM fluorescence analysis confirmed the degradation of NPs. Advanced electro-oxidation could be the basis of a process able to degrade ERCs from different wastes and wastewater (industrial, municipal and agriculture effluents).

Fermentation of Food Waste for the Production of Clean Energy and Biofertilizer



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Food wastes are generated along the entire food processing, storage and consumption chain. The large amount of food waste from the whole process leads to not only a great economic loss but also an important environmental issue if cannot recycle potentially reusable materials. The study of food waste digestion systems, which promote its enhancement for further conversion and application to different industrial fields such as providing methane production and biofertilizer, was considered. This report discussed the biological approaches used to exploit food waste applications. The physical, chemical, biological operating parameters and factors for the process of methane and biofertilizer production are deliberated. The environmental factors and metabolites that have a major influence on digestion were analyzed. Baseline design information was discussed to develop a suitable food waste digestion system.

Keywords: Food waste; Digestion; Methane; Biofertilizer.

Enzyme Immobilization onto Clay Surface for Waste Conversion

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Enzyme immobilization techniques have been widely used to waste conversion for producing biodiesel from organic waste by biocatalytic transesterification mechanism. As highly efficient biocatalysts with high substrate specificity, selectivity, and mild reaction conditions, enzymes play a pivotal role in multiple industrial areas. However, the drawbacks of free enzymes, including high cost, poor operational stability, and challenges in recovery and reuse, have limited industrial applications of enzymes. Enzyme immobilization is an efficient route for solve these problems and improving the biocatalytic process economics by the reuse of enzyme and the enhancement of enzyme stability, thereby permitting the catalysis under harsh reaction conditions at an industrial scale. To date, a wide range of nanomaterials, including inorganic nanoparticles, nanocomposites, natural nanostructured minerals, and polymers, have been investigated as support matrix for enzyme immobilization. Studies indicate that nanomaterials can improve the efficiency of immobilized enzymes by reducing diffusional limitation as well as by increasing the surface area per mass unit and therefore improving enzyme loading. Montmorillonite (Mt) is an important smectite clay mineral that has been confirmed as a desirable phyllosilicate carrier for immobilization of enzyme due to its natural swelling lamellar nanostructure, exchangeable interlayer cations, high specific surface area, biocompatibility, and easy surface functionalization (rich silanol groups, Si-OH, on the surface, after activation by different functional groups act as attachment sites for bioactive species. In the present study, lipase was immobilized on 3-aminopropyltriethoxysilane (APTES) amphiphilic functionalized montmorillonite (Mt) support via 1-(3-Dimethylaminopropyl)-3-ethyl-carbodiimide hydrochloride (EDC) spacer. The APTES-Mt and APTES-Mt based nanostructured biocatalyst (lipase-Mt) were characterized by XRD, FT-IR, TEM, SEM and contact angle analysis. The results indicated that lipase-Mt activity was 40.65 U/mg, which was nearly 4-fold higher than that of free lipase under optimal conditions. The Michaelis-Menten constant (K_m) were found as 0.357 mM and 3.406 mM for free and lipase-Mt, respectively. The maximum reaction rate (V_{max}) for the free and lipase-Mt were calculated as 63.69 mM/(L·min) and 312.5 mM/(L·min), respectively. Further, the interfacial activation by amphiphilic surface of APTES-Mt and enlarged catalytic interface contributed to the improved activity and storage stability of lipase-Mt. Thus, this work demonstrate an economically viable method for constructing nanostructured biocatalyst for industrial applications based on covalent immobilization of enzyme onto clay minerals.

Keywords: Montmorillonite; Organoclay; Biocatalyst; Enzyme immobilization.

Technological Advances in Bio/Electrochemical Carbon Dioxide Capture & Utilization (CCU)

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Recent years have seen a sharp rise in the share of renewable energy production. This renewable power usually often leads to energy surplus. Storage (batteries, water pumping or hydrogen production) have been proposed to exploit this surplus. One of the novel alternatives is to use excess electricity to convert CO_2 into organic chemicals and fuels. Growing rapidly, currently 25% of the global electricity capacity is now comprised of renewable energy sources, thus providing great opportunity for CO_2 reduction (CO2R). As per International Renewable Energy Agency (IRENA), at the end of 2018, the installed global renewable energy generation across wind, solar, hydroelectric, was near 2351 GW. CO2R pathways have the possibility to directly use electricity in the conversion step or indirectly via other energy carriers (e.g., H_2) in the so called Power-to-X approach. Most common conversion pathways include electrochemical, bioelectrochemical, plasma and thermochemical conversion. Commercially mature non-reductive routes which are such as enhanced oil recovery, food and beverage, and concrete curing also exist. The latter though more mature, provide fewer opportunities for electricity utilization compared to reductive routes. The (bio)electrochemical CO_2 reduction provides a viable option for reducing anthropogenic CO_2 emissions, while at the same time closing the carbon cycle, by selectively converting CO_2 to fuels/chemicals. Currently**,** CO, ethylene, and formate are considered as best possible option as each has been synthesized electrochemically with partial current densities >100 mA cm^2, often considered as commercially relevant current density, at a faradaic efficiency >60%. For the indirect route, methanol and methane are at high current TRL (i.e., low technical barriers to formation) and high achievable rates of formation. In this presentation, along with a general overview of CCU, VITO's research on CO_2 conversion using bioelectrochemical and electrochemical approach will be presented.

Pre- and Co-processing of Tailor-Made Alternative Fuel

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A landfill can be reclaimed for environmental reasons (e.g., contamination of groundwater) or for economic reasons (lack of building land). After probing and breaking up the soil, hazardous and non-hazardous wastes may now be found from a variety of sources, and in varying degrees of biodegradation in unknown quantities and composition. In order to use these incompletely bio-degraded materials as alternative fuels for the cement industry, the thermal process must be understood as a manufacturing process, first. Cement is a standardized product and the upstream clinker burning process is not an omnivore! Up to a kiln-specific thermal substitution rate (TSR), the clinker burning process is indeed a well-behaved burning process that forgives fluctuations to a certain extent. However, When the TSR increases, the good-natured clinker process is strained and the pyro process becomes uncontrollable. The cement production process is divided into the mechanical raw material extraction in the quarry, homogenization and raw meal grinding. Next comes the feeding of the raw meal into the preheating and calcining process and the feeding to the rotating part of the kiln, the pyro process of the so-called clinker burning process in which the fossil fuels shall continuously be substituted. After cooling down the clinker when leaving the rotary kiln at the end of the kiln, the clinker is blend with additives such as sulfates, slag, calcined clays, fly ashes, etc. and ground to a binder that meets the standards. Consequently, the right waste processing technology now plays a key role in the production of demand oriented alternative fuels! AF preparation begins with the prior assessment of the thermal potential of the expected waste and, in parallel, with the assessment of the thermal production process. This determines both the design of the pre-processing plant and the chemical and physical specifications of the AFs. This means the number of impurities, the combustion behavior as well as the emission-relevant properties of the envisaged fuel are extrapolated and compared with the requirements of the envisaged thermal utilisation. Care must be taken to ensure that the type and quantity of impurities are identified and that they are going to be extracted by the correct treating equipment. Mistakenly, demolition waste sifters or compost drum screens are often used for this nonsense, which are not suitable for segregation of impurities. The unknown amount of glass, ceramics, metal, etc. have a direct impact on the clinker, and plays an important role in its suitability, respectively the tolerance of the pyro process as well as alkali, chlorine or water entries. Modern pyro processes in the cement manufacturing process, e.g. offer several feed points for demand-oriented AFs: low-grade RDF for the calciner, whole tyres at the kiln inlet or at the pre-combustion chamber for the coarse high calorific fraction (HCF) and at the kiln end SRF for the sinter zone burner. Basically, the thermal potential of the waste and the envisaged energetic us determine the required treatment technology and its investment. The procedure described above applies in principle to all thermal processes and should therefore also be carried out conscientiously before tendering and operating the treating plant. And during operation, a sound and continuous quality assurance system is required to ensure the advised AF qualities as well as the performance of the pre-treatment.

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Anaerobic Digestion

Factors that Limit Decomposition of Organic Fraction of Non-recyclable Municipal Solid Waste in a High-solids, Leach-bed Anaerobic Digestion Process

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Anaerobic digestion of municipal solid wastes (MSW) involves the biological conversion of organic matter to biogas, a mixture of methane and carbon dioxide. This conversion process is mediated by several groups of prokaryotic microorganisms. It is generally accepted that hydrolysis is the rate limiting step of anaerobic digestion of organic particulate matter. However, when considering the overall conversion of organic particulates of MSW to methane and carbon dioxide in a high solids bioreactor, the hydrolysis process, the availability of appropriate microorganisms, delivery of these microorganisms and the provision of optimal physico-chemical conditions for microbial growth could all affect the rate of degradation. Among the various technologies that are available for anaerobic digestion of organic fraction of municipal solid waste, the high-solids, batch, leach-bed process offers several advantages. The process does not require fine shredding of waste, does not require mixing or agitation of digester contents, and does not require bulky, expensive, high-pressure vessels as it can be operated at low (ambient) pressures. The process can be implemented in bioreactor landfills as well as in-vessel digesters. SEBAC (sequential batch anaerobic composting) is a patented high-solids, batch, leach-bed process that uses a combination of solid-state fermentation and leachate recycle to provide a simple, reliable process that inoculates new batches of waste, removes volatile organic acids and concentrates nutrient and buffer. Methanogenic decomposition is initiated in a fresh bed of waste by flushing it with leachate collected from a methanogenically stabilized MSW bed. It has been widely accepted that this operational strategy provides the fresh bed of waste with inoculum, alkalinity, micro and macro nutrients from the stabilized waste bed, thereby overcoming the limitations to decomposition. The purpose of this research was to identify the critical limiting factor among the many that impedes anaerobic methanogenic decomposition. Both biological (microbial inoculum and extra-cellular enzymes) and physico-chemical (micro and macro nutrients, and pH buffer) factors were investigated. Experiments were carried out in 200 liter insulated, 316-stainless steel vessels. These were fitted with heating tape, thermocouples, automatic temperature control, gas flow meter and leachate pumping equipment. Feedstock used was unsorted, coarsely shredded (average particle size 10 cm) municipal solid waste collected from transfer station. To minimize the effect of feedstock variability in experiments, it was collected in one grab of 1–3-ton batches and stored in a commercial freezer at -20ºC in 120-liter plastic drums. Appropriate quantities of feedstock were removed from the freezer, thawed for a day, and loaded into the anaerobic digesters. Experiments included flushing micro- and ultra-filtered leachate, and nutrient and pH-buffer solutions into the fresh MSW bed. Biogas production, methane composition, pH and concentration of volatile organic acids were monitored. The main findings were inoculation and provision of extra-cellular enzymes are not the major factors limiting start-up; the flushing of pH buffer solution resulted in rapid start up; the start-up of the degradation of a fresh MSW bed could not be initiated without the provision of pH buffer and a fresh bed of MSW was not nutrient and inoculum deficient.

Keywords: Municipal solid waste, Leach-bed, Anaerobic digestion, Biogas, Bioreactor landfills.

Biodegradability Evaluation of Plastics in Organic Solid Waste Using a Novel Volumetric Respirometer

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Knowing the biodegradability of organic matters or biodegradable material under defined conditions is crucial for both operation of biological waste treatment processes and development of environmentally friendly materials with low negative impacts on environment. Traditionally biodegradability assays have been made manually had proven problematic, providing highly variable, unreliable result. These assays are also time-consuming and labor-intensive laboratory work that requires a high skill of the personnel performing the analysis. In order to obtain reliable results, any repeated analysis should be reproducible with good accuracy. In this study, aerobic biodegradability of bioplastics that may present in organic solid waste steam is evaluated using a novel closed respirometer based on volumetric gas measuring technique. The biodegradability of four types of bioplastics sample (PHB, PLA, PLLA, PBS) in both powder, film and granule forms are tested at home composting conditions. The biodegradability assay under home composting condition has been performed over 200 days. All samples including cellulose positive control are tested in triplicate. The tests of plastics were conducted under 23-25 ºC in 1L bottle with 1.5 g of test material and 100 g of compost. The assay was conducted based on oxygen demand measurement using the volumetric respirometer for on-line and continuous measurement of oxygen consumption or depletion caused by aerobic respiration of microorganisms. The test protocol is considered to fulfil the general guideline of AS 5810 for home composting and ISO 17556 for ultimate aerobic biodegradability test in soil. Aerobic biodegradability based on on-line continuous measurement of oxygen consumption or depletion demonstrates multiple benefits against conventional methods replies on off-line manual measurement of evolved carbon dioxide. As demonstrated in the current study, the degradation kinetics of cellulose and PHB powder in the home composting condition showed the fastest initial degradation rate, and PHB powder showed the highest biodegradability. PHB powder (natural origin) shows an easily degradable property, which obtained an over 90% of biodegradation rate after 67 days and without a lag phase, and it reached to 100±10.2% after 200 days. While PHB granule with 5 mm diameter only degraded 9.5±2.0%. PBS powder shows as a difficult degrade plastic, which only degraded 26.5±4.6% after 200 days. 1cm×1cm and 0.05 mm thick PLLA film, and PLA particle with 3-5 mm of diameter can hardly degrade based on the test result. However, there is a sign of starting to degrade with an increase degradation rate after 200 days. They might be degradable if the tests last even longer. The test is considered valid as the degree of biodegradation of microcrystalline cellulose reached more than 60% in less than six months (it was 75.1±1.9% in this study) and all the blanks are within 20% of the mean at the end of the test (i.e., the standard deviation was less than 2% for all blank). As a conclusion, the oxygen demand measurement using automated respirometer demonstrates much higher measurement reliability, accuracy and precision.

Keywords: bioplastics, biodegradability, home composting, aerobic, oxygen demand, respirometer.

Deciphering Molecular Transformation Behaviour and Potential Molecular Markers in Advanced Anaerobic Digestion of Sludge by FT-ICR MS Nontarget Metabolomic Analysis

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Process monitoring is the essential way to ensure stable operation of full-scale biogas plants which often encounter process instability, but selection of an appropriate indicators relating to metabolic status for early-warning is still in its early stage and also a challenge. This study explored the DOM transformation patterns along with advanced anaerobic digestion of sewage sludge, especially, presented a novel strategy to track the potentially molecular markers of metabolic status based on Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) nontarget analysis and subsequent chemoinformatic analysis. Results showed that the molecular compositions of dissolved organic matter (DOM) presented a consistent evolution patterns among different plants, including dramatic release of N-containing molecules (accounting for 69.95%-74.93%, including CHON and CHONS), increased humification of organics with high aromaticity, and high proportion of CRAM-like compounds especially as refractory components ($O/C > 0.3$) along with industry-scale advanced anaerobic digestion. By further data mining with constructed DOM connected network, it was emphasized that sulphur containing transformation perhaps played important roles in metabolism in anaerobic digestion for its appearance with high frequency. According to the nexus of the microbe associated DOM molecules, some metabolites were recognized as potential indicators relating to metabolic status, including the known important metabolites, e.g., L-cystathionine and Coenzyme B. This study suggests that FT-ICR MS measurement coupling with further chemoinformatic analysis can explore “fingerprint” and potential molecular markers to track the DOM transformation and metabolic status in anaerobic digestion, which will assist in finding new indicators for early-warning. To our best knowledge, though the use of FT-ICS MS for characterizing DOM behaviours in biological treatment process of wastewater and biowaste is increasing, still rare works ever explored the DOM transformation especially tracked the keystone molecules and metabolites from the detected thousands of molecules. Overall, this study was the first to present the capacity and feasibility of using FT-ICR MS to explore the behaviour and roles of DOM in biological treatment process from macroscope to deep microscope for a specific molecule. These findings prove that ultrahigh resolution mass spectrometry and further data mining provides a novel way to track the important roles of DOM in biological treatment process, which will not only fill our knowledge gap but also assist in exploring new “fingerprint” and molecular biomarkers for an early-warning of metabolic status.

Keywords: Anaerobic digestion; FT-ICR MS; Chemoinformatics; Transformation; Molecular marker.

Effect of Micro-Nano Zero-Valent Iron on the Metabolic Profiles of Fermentative Bacteria

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This study evaluated the combined impact of micro-nano zero-valent iron (*m/nZVI*) (0-5,000 mg/L) and acid-treated inoculum on fermentative hydrogen production from food waste. Results revealed that *m/nZVI* concentration above and below 500 mg/L decreased H2 production rate and yield. The cumulative H2 production was 2223.4 ± 83.5 mL/L of cultural medium (or 222.34 ± 8.35 mL/g VS) with 500 mg/L of *m/nZVI* compared to 1869.04 ± 42.69 mL H2/L. Acetic and butyric acids were the main organic acids accumulated along with the evolution of H2. The genomic analysis revealed that *Firmicutes, Bacteroidota, Actinobactriota, Proteobacteria*, and *Thermotoga* were dominant at the phylum level, whereas, *Clostridium_sensu_stricto_1* and *Bacteroides* were dominant at the genus level. Overall, adding m/nZVI improved H_2 yield by 19%, possibly due to the improved electron transfer mechanism, and positively influenced metalloenzymes that catalyze H_2 production via the pyruvate-ferredoxin oxidoreductase (PFOR) pathway.

Keywords: Fermentation, Biowaste, Micro-nano zero-valent iron, Biohydrogen, Acidogens.

Regulation of Acidogenic Fermentation Through Exogenous Additives for Promoting Carbon Conversion of Food Waste in Two-Phase Anaerobic System

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Injecting H_2 to promote methane conversion is an attractive approach in anaerobic digestion (AD) system. Two-phase anaerobic digestion (AD) with gas diversion scheme using endogenous acidogenic H_2 has been proposed as a promising strategy to reduce carbon loss and promote methane recovery in an economical way. The key concern for improving carbon conversion and energy recovery in this two-phase AD system was to strengthen H_2 production in acidogenic phase. According to our previous study, H_2-producing pathway in a leach bed reactor (LBR) treating solid-state food waste (FW) was attributed to the conversion of lactate to butyrate. It can be hypothesized that shortening lactate fermentation stage and promoting lactate-to-butyrate conversion will be the key strategies to enhance methane recovery from FW in this integrated two-phase AD system. However, so far, the impact of regulating this acidogenic conversion on waste degradation and energy recovery during the whole AD process has not been illustrated.

Based on our previous study, Megasphaera, a typical lactate-consuming bacteria, was identified as the functional bacteria for the conversion of lactate-to-butyrate. In addition, acetate acts as an electron acceptor for the formation of acetyl-CoA for facilitating lactate oxidation and stimulating butyrate synthesis. Thereby, for the first time, exogenous Megasphaera elsdenii inoculum and acetate supplementation were introduced at the acidogenic phase to regulate the acidogenic fermentation pathway and assess their effects on food waste (FW) carbon conversion in two-phase AD system. These two additives significantly accelerated organic removal efficiency and subsequently increased FW hydrolysis and acidogenesis in LBR by 16% and 35%, respectively. As expected, two exogenous additives promoted butyrate fermentation during FW acidogenesis. With regard to the role of exogenous additives, both hydrogen and butyrate yields increased by over 60%. This desired enhancement resulted in a 25% increase in methane production. The overall carbon conversion from FW in this two-phase AD system was enhanced by biochemical additives, which was 1.33-fold higher than that in the control system without any additives. This study laid a foundation for the development of biochemical additives in the field-scale application of FW two-phase AD with gas diversion process, especially in the regulation of the acidogenic process.

Keywords: Acetate addition, Megasphaera, leach bed, fermentation pathway, methane.

Effect of Microaeration on Anaerobic Co-digestion of Food Waste and Sewage Sludge

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Sustainable management of food waste (FW) and sewage sludge (SS) has been a major environmental challenge in urban areas. Anaerobic digestion (AD) has long been widely adopted for the valorization of diverse organic wastes into bioenergy (methane-rich biogas) and organic fertilizer (residue following AD, also called digestate). In recent years, co-digestion of FW and SS has attracted significant research and development efforts due to their inherent merits, such as availability in proximity, proper carbon-to-nitrogen ratio, nutrients and alkalinity supplementation, and dilution of any inhibitory compounds, resulting in improved bioenergy production and digestate quality for land application. Oxidation-reduction potential (ORP)-based microaeration has emerged as a novel strategy to improve the performance of AD process, including enhanced hydrolysis of complex substrates, mitigation of volatile fatty acids accumulation through improved hydrogenotrophic methanogenesis, prevention of digestor toxicity (e.g., oxidation of hydrogen sulfide). In this study, we evaluated the effect of microaeration on methane yield and volatile solids (VS) removal during FW and SS co-digestion at different mixing ratios. Two 6-L continuous stirred-tank reactors were operated in a semi-continuous mode under mesophilic conditions at a hydraulic retention time of 20 days. Initially, mono-digestion of SS and FW was examined. SS mono-digestion reached the maximum organic loading rate (OLR) of 2.25 g VS/L·d with the methane yield of 183 NmL/g VSadded, while FW mono-digestion failed at OLR of 1.0 g VS/L·d due to VFAs accumulation. During co-digestions of FW and SS with ORP-based microaeration (ORP was maintained 25 mv above the reference ORP), microaeration resulted in significant ($p \leq 0.05$) improvement in methane yield at the mixing ratio of 60:40 (on VS basis). This could be due to the synergistic effects of the co-substrates. Higher SS (FW:SS = 40:60) could inhibit the effect of microaeration due to slow hydrolysis of SS. Furthermore, higher alkalinity level could enhance biogas production through improved digester stability. Similarly, at higher FW content (i.e., FW:SS = 80:20) microaeration did not result in significant improvement in digester performance, likely due to the rapid degradation of organic matter. Therefore, the effect of microaeration during co-digestion of FW and SS is specific to co-substrates mixing ratios.

Keywords: Co-digestion, Microaeration, Food waste, Sewage sludge, Oxidation-reduction potential (ORP).

Precise pH Control of Food Waste Biomethanation Using Granulated Activated Carbon

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Academic institutions with concentrated human populations generate food waste ranging from 400 to 1000 kg/day, which needs to be treated. Biomethanation of food waste by anaerobic digestion produces methane-rich biogas (100 m^3/ton). During biomethanation of food waste, volatile fatty acids (VFA) produced by acidogens accumulate rapidly and lower the pH, negatively impacting the process and methanogens. However, maintaining the optimal VFA concentration in the anaerobic digester that enables methane generation is imperative. Hence, this study aims to provide optimal VFA concentration by adding granular activated carbon (GAC). The addition of GAC kinetically favours the forward reaction of VFAs conversion to methane due to its large surface area, providing a porous environment for colonizing pH-sensitive methanogens. Additionally, due to their high electrical conductivity, GAC accelerates direct interspecies electron transfer (DIET) between acetogens and methanogens and improves pH buffering. The experiments were conducted in serum bottles under mesophilic conditions, and the biogas was collected in a syringe attached to the serum bottles via a rubber septum. The methane yield rate was proportional to the amount of GAC added. Hydrolytic, acidogenic, acetogenic, acetoclastic, and specific methanogenic activities were evaluated. The reducing sugar concentration was monitored using the dinitro salicylic acid method, and VFA and biogas characterization was performed using gas chromatography. The biomethane production potential study results indicated high methane generation, which proves GAC reduces acidification by utilizing VFAs during the methanogenic phase. The biogas produced minimizes the requirement for fossil fuels on campus and reduces greenhouse gas emissions and the load on the landfills, eventually mitigating climate change. Educational institutions must prioritize food waste treatment, create a sustainable living, and act as societal role models.

Keywords: Biomethanation, Biogas, Food waste, Granular activated carbon, Volatile fatty acids.

Co-Digestion of Swine-Manure and Carcass at Low Temperature: A Long Term Operation and Stability Monitoring

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Anaerobic co-digestion of agricultural residues including animal wastes for energy recovery and manure productions were considered as promising approaches to promote circular bio-economy concepts in Canada. However, co-digestion of animal wastes such as manure and carcass required special attention owing to their unique characteristics, such as high-biodegradability, pathogen distributions and nitrogen contents. In this research, we have used a lab-scale anaerobic bioreactor (~24L total volume and 20L working volume; Fig 1.) to co-digest swine-manure and -carcass under sequential batch mode under 25oC for more than 3 years. The specific organic loading rate (OLR) was 3 g.L-1.d-1 for first one year and changed it to 1.5 g.L-1.d-1 for rest of the operations. The study used 6 identical reactors and operated as duplicates under three different co-digestion conditions i.e., by keeping OLR constant but varied the ratio of manure to carcass addition. Based on the carcass loading, the systems were marked as Low, Medium and High-carcass reactors (LC, MC and HC). Each condition was tested and validated for 3 repeated cycles and mixing was done twice a week for 5 min (sampling purpose only). Biogas production, volatile fatty acids and ammonia-N accumulations were monitored from the leachate samples collected once in 7 days and compared between the treatment conditions. Acetic and propionic acids were dominant during co-digestion indicated that the three system were dominated by the microbial hydrogen consuming pathways. The pH was near neutral to alkaline in range throughout the operation for all the 6 reactors, while the total kjeldhal nitrogen (TKN) concentrations were between 5,000 and 9,000 mg/L. The cumulative biogas production was comparatively lower with the LC than in MC and HC. Overall, the total solids and volatile solids reductions were achieved between 70-85% in all the three test conditions with the high-methane recovery rate even at high TKN concentration was observed.

Keywords: Low-temperature, Swine manure, Swine carcass, Co-digestion, Sequencing mode.

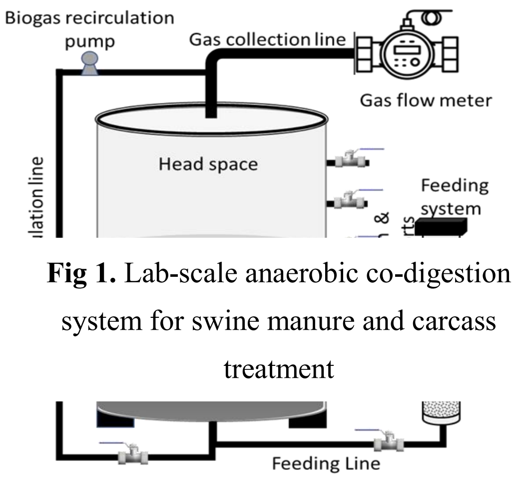

Fig 1. Lab-scale anaerobic co-digestion system for swine manure and carcass treatment

Design and Implementation of a Pilot Carbon Capture Technology to obtain Compressed Biogas (green fuel) & Compressed CO_2 from Biogas plant at NIE-CREST, Mysuru, India

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As there is an increase in air pollution by the emission of gases (such as carbon dioxide) due to burning of fossil fuels, it is instrumental for the engineering world to adopt new technologies to cope with the ever-increasing pollution aiding to the climatic crisis, where carbon capture technology is emerging as a new face of this field. To decrease the carbon footprint, capturing the CO_2 at the source is an economical option. One such source is a BIO-GAS plant. The separation of CO_2 from the BIO-GAS also increases the calorific value of BIOGAS and separated carbon dioxide can be used to produce useful products such as Clean fuel, methanol etc. A prototype is designed and developed at NIE-CREST, Centre for Renewable Energy & sustainable Technologies at the National Institute of Engineering, Mysuru India , where in a pilot plant kitchen waste is converted into Biogas by anaerobic digestion by a portable floating drum biogas plant and later the biogas generated is scrubbed to remove impurities in a Portable scrubber unit and finally the pure methane and co2 are captured separately. Working of the pilot plant: The BIOGAS which is produced in floating drum biogas plant is passed through the scrubbers. The H_2S is removed using iron filings and moisture is removed by CaCl2. The gas is compressed and then passes through the adsorption column containing adsorbent zeolite 13X/activated charcoal in a PSA scrubber. The switching operation of valves are done to capture CH4 and Co2 separately. The captured CH4 and CO2 in the cylinder is ready to be used for applications.

Keywords: Alternative fuels, Carbon capture, Biogas, Green fuel, PSA scrubber, clean fuel, Waste to wealth.

Effect of Biogas Residue Biochar on Anaerobic Digestion of Food Waste with Different Organic Loading

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To improve the methane production of anaerobic digestion (AD) of food waste (FW) with high organic loading and realize the resource utilization of biogas residue. Different organic loading gradients (0.5:1, 1:1, 2:1, 3:1, based on the VS ratio of substrate and inoculum) were set to study the effect of biogas residue biochar (BRB) on AD performance of FW. The results showed that cumulative methane production was the highest (375.5 ± 8.4 mL/g-VS) when the VS ratio was 1:1 without addition of BRB. When the VS ratio was greater than 1:1, the accumulation of volatile fatty acids (VFAs) led to systematic acidification, and the methanogenesis was inhibited. The cumulative methane production decreased with the increase of organic loading, and the lag period of methanogenesis continued to extend. BRB did not increase methane production under low organic loading (VS ratio: 0.5:1). With the increase of organic loading, appropriate addition of BRB could promote the degradation of organic matters and increase the VFAs content in the early stage of AD. In the middle and late stages of AD, it can accelerate the consumption of VFAs and promote the methane production. Also, BRB has a more significant effect on the promotion of methane production with the increase of organic loading. When the VS ratio was 3:1, the addition of 5 g/L BRB (318.5 ± 38.2 mL/g-VS) could increase the methane production by 21.37% ($p<0.05$) compared with the blank group (262.3 ± 34.9 mL/g-VS). Microbial community analysis showed that the enrichment of Clostridium_ sensu_ stricto_ 1 and Syntrophomonas may be important factor for the rapid consumption of VFAs, while the increase of methane production is mainly related to the enrichment of methanogens such as Methanosarcina.

Keywords: Food waste, Anaerobic digestion, Biogas residue biochar; Organic loading, Microbial community.

Enhanced Anaerobic Digestion of Waste Activated Sludge with Periodate-Based Pretreatment

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The potential of periodate (PI) in sludge anaerobic digestion is not tapped, although it has recently attracted great research interest in organic contaminants removal and pathogens inactivation in wastewater treatment. This is the first work to demonstrate significant improvement in methane generation from waste activated sludge (WAS) with PI pretreatment and to provide underlying mechanisms. Biochemical methane potential tests indicated that methane yield enhanced from 100.2 to 146.3 L per kg VS (VS, volatile solids) with PI dosages from 0 to 100 mg per g TS (TS, total solids). Electron spin resonance showed PI could be activated without extra activator addition, which might be attributed to the native transition metals (e.g., Fe2+) in WAS, thereby generating hydroxyl radical (•OH), superoxide radicals (•O2−), and singlet oxygen (1O2). Further scavenging tests demonstrated all of them synergistically promoted WAS disintegration, and their contributions were in the order of •O2− > •OH > 1O2, leading to the release of substantial biodegradable substances (i.e., proteins and polysaccharides) into the liquid phase for subsequent biotransformation. Moreover, fluorescence and ultraviolet spectroscopy analyses indicated the recalcitrant organics (especially lignocellulose and humus) could be degraded by reducing their aromaticity under oxidative stress of PI, thus readily for methanogenesis. Microbial community analysis revealed some microorganisms participating in hydrolysis, acidogenesis, and acetoclastic methanogenesis were enriched after PI pretreatment. The improved key enzyme activities and up-regulated metabolic pathways further provided direct evidence for enhanced methane production. This research was expected to broaden the application scope of PI and provide more diverse pretreatment choices for energy recovery through anaerobic digestion.

Keywords: Energy recovery, Anaerobic digestion, Recalcitrant organics, Free radicals.

Enhancement strategies and mechanisms of high-value medium-chain fatty acids production from waste activated sludge through anaerobic fermentation

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Medium chain fatty acids (MCFAs) production from waste activated sludge (WAS) is restricted by poor biodegradability of WAS, competitive inhibition of methanogens and low electron transfer efficiency. Therefore, the first work proposes a promising ferrate (Fe (VI))-based technique to enhance MCFAs production from WAS through accelerating WAS disintegration and substrates transformation, and eliminating competitive inhibition of methanogens, simultaneously. Results shows that the maximal MCFAs production attains 8106.3 mg COD/L under 85 mg Fe/g TSS, being 58.6 times that of without Fe (VI) pretreatment. Mechanism exploration reveals that Fe (VI) effectively destroys EPS and cytoderm through electron transfer, reactive oxygen species generation (i.e., ·OH, ·O2- and 1O2) and elevated alkalinity, resulting in the transfer of organics from solid to soluble phase and from macromolecules to intermediates. Generation and transformation of intermediates analyses illustrate that Fe (VI) facilitates hydrolysis, acidification and chain elongation (CE) but suppresses methanogenesis, promoting the targeted conversion of intermediates to MCFAs. Also, Fe (VI) pretreatment provides potential electron shuttles for chain elongation. Microbial community and functional genes encoding key enzymes analysis indicates that Fe (VI) screens key microorganisms and up-regulates functional genes expression involved in CE pathways. Overall, this technology avoids methanogens inhibitor addition and stimulates vivianite synthesis during MCFAs production from WAS. Then, a novel ferroferric oxide (Fe3O4) technique was proposed to accelerate electron transfer efficiency from substrates to MCFAs production during anaerobic fermentation of WAS. Results indicated that the MCFAs yield, and selectivity were respectively enhanced by 155.4% and 66.7% in the Fe3O4-mediated WAS. Mechanistic studies disclosed that Fe3O4 promoted substrates degradation through conducting dissimilatory iron reduction (DIR) and stimulating hydrolase activity, providing precursors for chain elongation (CE). Generally, Fe3O4 improved the key processes for MCFA production at different degrees, i.e., hydrolysis, acidification and CE. Interestingly, MCFAs yield enhancement was primarily ascribed to facilitated electron transfer rather than DIR or produced ferrous iron, which could be supported by the analyses of electrochemical properties, electron transfer system activity and morphology. Further, Fe3O4 shifted the key microorganisms in favor of MCFAs production. Overall, this strategy could improve MCFAs production, sludge dewatering and phosphorus removal, concurrently.

Keywords: Medium-chain fatty acids (MCFAs); Chain elongation (CE); Waste activated sludge (WAS); Anaerobic fermentation; Extracellular polymeric substances (EPS); Ferrate (Fe (VI)).

Sludge Source-redox Mediators Obtainment and Availability for Enhancing Bioelectrogenesis and Acidogenesis: Deciphering Characteristics and Mechanisms

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Anaerobic biological treatment was regarded as one of promising options for realizing concurrent WAS reduction, stabilization and bioenergy/bioresource recycle. But the relatively low treatment efficiency and long retention time limited its spreading application toward larger scale considerably in China. Aimed at such barrier, this study offered a novel enhancing strategy for achieving high-efficiency of bioenergy/bioresource recycle from WAS anaerobic treatment via improving bioelectrogenesis/acidogenesis using sludge source-redox mediators (SSRMs). SSRMs not only facilitated bioeletrogenesis with an increasing efficiency of 36% for voltage output and 39% for bioelectricity production efficiency, but also enhanced acidogenesis of WAS with a mean elevating efficiency of 37.5% of volatile fatty acids (VFAs) production within 5 d. Mechanistic investigations indicated that SSRMs were capable to have a potential influence on improving the protein and carbohydrate metabolisms-related genes' expression for enhancing bioelectrogenesis and acidogenesis. On the other hand, SSRMs exerted roles of electrochemical "catalysts" or as terminal electron acceptors with affecting functional proteins of complexes of I and IV in electron transfer chains for improving electron transfer efficiency. Meanwhile, the microbial community evolutions with enriching core microbes' abundance, increasing microbial diversity and community distributive evenness were triggered concurrently for carrying out superior bioelectrogenesis and acidogenesis successfully. Besides, a schematic illustration was established for demonstrating the mechanisms of SSRMs for enhancing bioelectrogenesis and acidogenesis via changing microbial metabolism functions, enhancing electron transfer efficiency, and regulating functional genes' expression of functional proteins (up-regulating cytochrome c oxidase and down-regulating-NADH dehydrogenase). This study provided an effective enhancing strategy for facilitating WAS bioconversion to bioenergy/bioresource with well-process sustainability.

Keywords: Waste activated sludge (WAS), Sludge source-redox mediators (SSRMs), Bioelectrogenesis, Electron transfer efficiency, Microbial mechanisms.

Direct Carbon Recovery from Raw Wastewater for Bioenergy Production by Anaerobic Digestion

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Wastewater is rich in carbon and normally expressed as chemical oxygen demand (COD). However, traditional wastewater treatment is aimed to remove COD mainly by biological treatment. In biological treatment, the biodegradable COD is converted to CO_2 by inputting large amount of energy (aeration) which is in fact a great wasting of resource. Recovering carbon from wastewater for biogas production would produce energy instead of spending energy. In this study, carbon was recovered from raw wastewater by flocculant and then converted to biogas by anaerobic digestion. In order to avoid inorganic flocculation impact on anaerobic digestion, bio-flocculants Chitosan was employed. It was found that chitosan quaternary ammonium salt (HACC) can remove 66.11% of total chemical oxygen demand (COD_t), 31.15% of total phosphorus in the wastewater. The trapped carbon-rich sludge was undergone anaerobic digestion. The anaerobic digestion was carried out for 45 days at temperature of 35°C. The sludge volume reduction was approximately 40% and the methane yield was 167.84 mL CH_4 per gVSS of carbon-rich sludge. It shows that the process is simple, requires low energy input, and can significantly recover energy from wastewater. It indicates that this system could be used as a novel domestic wastewater treatment model for developing countries combined with new nitrogen and phosphorus removal technology.

Iron-Rich Digestate Biochar Toward Sustainable Peroxymonosulfate Activation for Efficient Anaerobic Digestate Dewaterability

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Large amount of hazardous Fe-rich dewatered digestate from Fenton/Fenton-like treatments are becoming a reservoir of pathogens/viruses, heavy metals, and emerging pollutants, which would pose serious secondary pollution in the worldwide environment. Converting Fe-rich dewatered digestate into Fe-rich biochar (Fe-BC) for anaerobic digestate dewatering could achieve the dual purpose of waste reutilization and pollution elimination. In this study, a suite of Fe-rich biochars derived from Fe-BC were fabricated under different pyrolysis temperatures (300, 500, and 800 °C), which were firstly utilized as peroxymonosulfate (PMS) activators for promoting digestate dewaterability with wide applicability. Results showed that compared to the $Fe\text{-}BC_{300}$/$Fe\text{-}BC_{500}$ + PMS treatments, $Fe\text{-}BC_{800}$ + PMS process performed superior digestate dewaterability in which specific resistance to filtration reduction and water content reduction improved by > 12.5% and > 130%, respectively, under the optimal conditions. Mechanistic results demonstrated that in $Fe\text{-}BC_{800}$ + PMS system, HO• and $SO_4^{\bullet-}$ oxidation played a pivotal role on promoted digestate dewaterability, while HO• and $^1O_2$ oxidation was dominated in $Fe\text{-}BC_{300}$/$Fe\text{-}BC_{500}$ + PMS treatments. $Fe\text{-}BC_{800}$ containing higher Fe and C=O contents could efficiently interact with PMS to generate numerous HO• and $SO_4^{\bullet-}$ via iron cycle. These highly reactive oxygen species proficiently reduced the hydrophilic biopolymers, protein molecules, and amino acids in extracellular polymeric substances, leading to remarkable decrease in particle size, hydrophilicity, adhesion, network strength, and bound water of digestate. Consequently, the flowability and dewaterability of digestate could be significantly enhanced. The cost-benefit result indicated the Fe-BC + PMS treatment possessed desirable reusability, applicability, and economic viability. Collectively, the Fe-BC + PMS is a high-performance and eco-friendly technique for digestate dewatering, which opens a new horizon towards a closed-loop of digestate reutilization.

Keywords: Anaerobic digestate dewaterability; Fe-rich digestate biochar + peroxymonosulfate; Hydrophilic amino acids destruction; Iron redox cycle; Digestate recycling system.

Impact of salinity on hydrogen production and acidogenic bacteria for food waste fermentation

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In recent years, fossil fuel utilization has caused a significant increase in greenhouse gas emissions and global warming, threatening human health by affecting water, food, and other energy security. Hydrogen (H_2) is a carbon-neutral fuel and is considered an alternative to fossil fuels. Biological methods for H_2 production, especially via dark fermentation (DF), have multiple benefits compared to the physico-chemical processes, as simultaneous bioconversion and energy generation are possible. However, the H_2 yield under DF is lower due to thermodynamic constraints and is further affected by H_2-consuming microorganisms in

a mixed culture system. For example, hydrogenotrophic methanogens, homoacetogenic bacteria, and sulfate-reducing bacteria uptake H_2 for their metabolic processes. In addition, the H_2 production rate is affected by operating environmental conditions, i.e., temperature, salinity, pH, etc. Among all the parameters, salinity affects the microorganism as it causes osmotic stress on the microbial cells, leading to drop-in process performance and plasmolysis. In this study, we evaluated the impact of salinity (i.e., 2 to 20 g NaCl/L) on the microbial community dynamics and metabolic pattern using food waste as substrate. Genomic analysis and metabolic pattern revealed that the H_2 production was mainly through Clostridial-type fermentation under medium to high salinity levels, whereas Enterococcus-type fermentation was under low salinity levels.

Keywords: Dark fermentation, Acidogenic bacteria, Hydrogen, Salinity, Food waste.

Investigation of Microbial-substrate Interaction using Mixed Microbial Consortia for Enhancement of Biogas Production from Food Waste

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Annually, ~2 billion tonnes of municipal solid waste (MSW) are generated all over the world and 0.15 million tonnes of MSW are wasted per day in urban India, among which 34–53% is organic biodegradable waste which comprises of food waste generated from restaurants, household food waste (cooked and uncooked), animal feed waste, food industry waste, vegetable market waste, etc. The treatment of such huge amounts of waste increases the economic load on the government, which is very difficult for a developing country. Hence, only 70–75% is collected and around 20–25% is treated. Therefore, a major portion of MSW is dumped in landfill areas where it degrades naturally, causing greenhouse gas emissions (methane and CO2) and toxic leachate to mix in groundwater and make it toxic. Food waste, which constitutes a major portion of municipal solid waste, is rich in nutrients and can be used for anaerobic digestion for biogas production. Biogas production is the sequential biodegradation of organic waste routed through four steps of anaerobic digestion, such as hydrolytic, acidogenic, acetogenic, and methanogenic. Each step is governed by different microbial community groups. Most of the inoculum used for the anaerobic digestion process experiences desired and undesired microbial-microbial interaction. An efficient inoculum leads the anaerobic digestion process smoothly by following positive microbial-microbial interaction. In the present studies, a mixed inoculum for biogas production was developed by combing two inoculums (mixing sewage sludge and cow dung). The result shows that 62% soluble chemical oxygen demand (sCOD) is released in a reactor with 5g/L total solid (TS), i.e., higher than in a reactor inoculated with a single inoculum. After the screening of the inoculum, the assessment of biogas production at different organic loads was carried out. These organic loadings are 5 g/L in reactor 1, 10 g/L in reactor 2, and 15 g/L of TS in reactor 3. Total biogas production observed was 400 mL, 1100 mL, and 420 mL in reactor 1, reactor 2, and reactor 3. Lower biogas production in reactor 3 due to high organic loading leads to high volatile fatty acid production (VFAs), i.e., 9000 mg/L higher than both reactor 1 and reactor 2. High VFAs inhibit both methanogenic and syntropic bacteria. Methanogen inhibition and the breakdown of the syntropic relationship between syntropic bacteria and methanogens A decrease in the methanogenic population eventually decreases biogas production. Results suggest that an organic load with 10 g/L of total solid concentration gives higher biogas with 60-70% sCOD degradation. Further studies will be done to explore the microbial-substrate interaction in the anaerobic digestion process and its role in the enhancement of biogas production. In this study, the microbial biofilm will be developed for the enhancement of microbial-substrate interaction. Extrapolymeric substances (EPS) estimation was used as a biochemical analytical parameter for the development of healthy biofilm. In addition, activities for hydrolytic enzymes was estimated at a fixed duration to confirm the interaction between the microbial-substrate. The correlation between the enhancement of biogas production and microbial-substrate interaction were analyzed.

Keywords: Municipal solid waste, Food waste, Biogas, Microbial-substrate interaction.

Cascading Fermentation of Oleaginous Yeast Using Organic Waste for Lipid Production

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The high operating cost is currently a limitation to industrialize microbial lipids production by the oleaginous yeasts. To explore economic fermentation technology, cascading fermentation of *Lipomyces starkeyi* using yeast extract peptone dextrose (YPD) medium, orange peel (OP) hydrolysate medium, and their mixed medium were investigated for 7 days by monitoring OD_{600} values, pH values, cell growth status, C/N ratios, total carbon concentration, total nitrogen concentration, residual sugar concentration, lipid content, lipid titer, and fatty acids profiles of lipids. Results showed that two-stage fermentation with YPD and 50%YPD+50%OP medium contributed to lipid accumulation, leading to larger internal lipid droplets in the yeast cells. However, the cells in pure OP hydrolysate grew abnormally, showing skinny and angular shapes. Compared to one-stage fermentation, the two-stage fermentation enhanced lipid contents by 18.5%, 27.1%, and 21.4% in the flasks with YPD medium, OP medium, and 50%YPD+50%OP medium, and enhanced the lipid titer by 77.8%, 13.6%, and 63.0%, respectively. The microbial lipids obtained from both one-stage and two-stage fermentation showed no significant difference in fatty acid compositions, which were mainly dominated by palmitic acid (33.36-38.43%) and oleic acid (46.6-48.12%). Hence, a mixture of commercial medium and lignocellulosic biomass hydrolysate could be a promising option to balance the operating cost and lipid production. In this talk, I will cover the following several points, research background, technical route, why two-stage cascading fermentation, strategies for higher yield and productivity, and finally summary and suggestions for future studies.

Keywords: Cascading fermentation; Microbial lipids; Oleaginous yeast; Waste-to-resource.

Physicochemical and Biological Pretreatment of Municipal Wastewater against Antimicrobial Resistance for Enhanced Anaerobic Digestion

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The biopharmaceutical industry includes various unit processes, and fermentation engineering is the most popular. However, as the pharmaceutical industry grows, so does the severity of environmental contamination. High-concentrated antibiotic wastewater, which has strong quantity fluctuation, low C/N, high suspended solids and sulphate concentrations, complex composition, biological toxicity, and high chroma, is the primary source of biopharmaceutical wastewater. The high concentrations of antibiotics in the biopharmaceutical fermentation wastewater will lead to antimicrobial resistance. When bacteria, viruses, fungi, and parasites, among other microbes, can adapt and flourish in the presence of drugs negatively impacting them, antimicrobial resistance is generated. Antimicrobial Resistance has emerged as one of the most pressing risks to public health, seriously compromising the ability to prevent and cure chronic illnesses. Most pathogens are thought to be killed or rendered inactive by disinfection procedures used in wastewater treatment, and prior research has shown that disinfection efficiently renders antibiotic-resistant bacteria inactive. Even if antibiotic-resistant bacteria are completely inactive, the intact DNA may persist. Antibiotic resistance genes are often carried on genetic material that is highly transmissible, such as plasmids, integrons, and extracellular DNA. These genetic components can continue operating and pass antimicrobial resistance genes to downstream bacteria through horizontal gene transfer. Antimicrobial resistance genes are thought of being major pollutants since they have the potential to outlast their bacterial hosts. In order to address the major issues brought on by these genes, their removal or trapping should occur before disinfection or the release of wastewater treatment plant effluent into the environment. Various pretreatment techniques can be applied to increase the biodegradability of the biopharmaceutical fermentation wastewater produced. These include chemical addition, heat treatment, mechanical or ultrasonic disintegration, and oxidative, enzymatic, or microbiological pretreatment. An effective pretreatment can improve the substrate's accessibility to the anaerobic bacteria, maximising the waste's methanogenic potential and enhancing the pace and degree of degradation. Hence, this study focused on various pretreatment techniques, including physicochemical and biological methods. Thermal and pulsed electric field methods were studied under the physical methods. Poly-aluminium chloride and polyelectrolytes were used under chemical methods. The biological method involved using a Bacta-Cult powder, a specially formulated microorganism used to treat and remove BOD and COD. Kirby-Bauer's disc diffusion method confirmed these different methods' effects on antimicrobial resistance.

Keywords: Biopharmaceutical fermentation wastewater, Antibiotic resistance, Pretreatment, Anaerobic digestion, Pulsed electric field.

Evaluation of Substrate Competition for *Thermotoga Neapolitana* Fermentation

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Using fossil fuels causes climate change because of the high emission of greenhouse gases, especially carbon dioxide. Hydrogen (H_2) is considered an alternative to fossil fuels due to its low-carbon footprint. However, current H_2 production from fossil resources is cheaper but not environmentally friendly due to carbon emissions. Thus, applying biological routes to produce H_2 from organic waste can simultaneously help manage waste management issues and recover resources in terms of energy and valuable organic chemicals. In this study, we intend to understand the substrate uptake kinetics and mechanism. In this research, we used a marine hyperthermophilic strain (i.e., Thermotoga neapolitana) to evaluate its potential for H_2 and valuable organic acid production from different sugars and combinations of sugars. The experiments were carried out in 600 mL batch reactors with a working volume of 450 mL. Further, gaseous and aqueous metabolic profiles were studied by varying salinity levels and sparging gas (i.e., N_2 and CO_2). It was also observed that acetic acid was the only pathway for hydrogen production. The substrate competition studies in the batch reactors showed that glucose and xylose had similar sugar consumption patterns, and fructose and arabinose had similar consumption profiles. After analyzing the rate kinetics, the preferred sugars for T. neapolitana fermentation were glucose > xylose > fructose > arabinose under both CO_2 and N_2 sparging atmosphere.

Keywords: *Thermotoga neapolitana*, Dark fermentation, Substrate competition, Hydrogen production, Acetic acid.

Rhamnolipid Pre-Treatment of Primary Sludge Effectively Improves Short-Chain Fatty Acids Production from Anaerobic Fermentation

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Resource recovery in form of short-chain fatty acids (SCFAs) from primary sludge is restricted by the deficient sludge degradation degree and the rapid consumption of methanogens. This work reported a new rhamnolipid (RL) pretreatment method to improve SCFAs production from anaerobic fermentation of primary sludge for the first time. Experimental results showed RL pretreatment significantly improved the SCFAs production from primary sludge, and the maximum SCFAs production of 206.12 mg chemical oxygen demand (COD)/g VSS was obtained by 0.08 g/g TSS of RL, which was around 3.8-fold that of blank without RL addition (i.e., 54.14 mg COD/g VSS). Mechanism investigations revealed that RL significantly promoted the disintegration of primary sludge, under which the released protein and carbohydrate was >4 times higher than that without RL addition, thus providing more organics for subsequent SCFAs production. It was also found that the high dose of RL significantly suppressed the methane production during fermentation, leading to the accumulation of more SCFAs. Considering that studies have demonstrated that RL could be produced in situ by fermentation of sludge or digestate, this can promote the transformation of the sludge resource treatment mode from a linear mode to a circular mode, forming a “closed-loop”. But this study has not been technically optimized. This is because the purpose of this study was to evaluate the feasibility of using RL pretreatment to enhance SCFAs production from anaerobic fermentation of primary sludge. A comprehensive technical optimization and economic analysis will be required in the future.

Keywords: Rhamnolipid, Primary sludge, Anaerobic fermentation, Degradability, Short-chain fatty acids.

Role of Quorum Sensing and Quenching in Anaerobic Digestion: A Mini Review

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As the population has grown rapidly and various industries have developed, the generation of food waste (FW) and waste activated sludge (WAS) has increased significantly, leading to a substantial amount of greenhouse gases being emitted during their treatment. Anaerobic digestion (AD) is a biological process that effectively decomposes FW and WAS. These processes use anaerobic microorganisms to break down organic matter under controlled temperatures and closed conditions, producing biogas and bio-manure as byproducts. Achieving stable and increased biogas production performance requires a delicate balance between bacterial growth and metabolism. To accomplish this, it is crucial to comprehend the intricate interactions of mixed microorganisms involved in the process and apply appropriate methods accordingly. In this study, we aim to review research on the role of microbial communication in AD processes. In biological processes, bacteria communicate with each other, perceive their surroundings, react, and produce signal molecules known as quorum sensing (QS). The process involves the interaction of signal molecules with receptors upon reaching a specific concentration, leading to the initiation of group behavior among microbes. Through this process, microorganisms induce biofilm formation and bacterial aggregation and promote extracellular polymeric substance release. The formation of biofilms or granules in AD systems is a crucial factor in enhancing microbial stability and biogas production. Researchers have identified the role of N-acyl homoserine lactones (AHLs), which are one of the QS signaling molecules used by anaerobic microorganisms. Short-chain AHLs enhance treatment efficiency by promoting the growth of hydrolytic bacterial communities, and long-chain AHLs improve methane production rates by increasing the abundance of methanogenic bacteria or archaea. Quorum quenching (QQ) involves the inhibition of QS activity through the diffusion of enzymes that control and disrupt QS signaling molecules. In AD systems, controlling specific signaling molecules through QQ can alter the microbial community and, in particular, promote methanogenic activity, thereby increasing methane production. The facultative bacterium Microbacterium sp. QQ strain enhances the total abundance of fermentative and acidogenic genera and improves methane production by enhancing methanogenic activity. The application of QQ in anaerobic membrane bioreactors effectively controls membrane fouling without adversely affecting COD removal and methane yield. Gaining an understanding of the role of QS and QQ techniques can offer valuable insights into the behavior and functions of microorganisms in mixed bacterial systems. While this review contributes to shedding some light on the role of QS and QQ in AD, further intensive investigations, including aspects of metabolic engineering and genomic studies, are necessary to address the remaining enigmas and comprehend the underlying mechanisms.

Keywords: Anaerobic digestion, Bacterial signaling, Quorum sensing, Quorum quenching.

Effects of Hydrothermal Pretreatment and the Activated Sludge on Anaerobic Digestion of Food Waste

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The refectory properties of food waste and waste activated sludge inhibit their bioenergy recovery by anaerobic digestion. This paper performance, energy conversion efficiency and economic feasibility of food waste anaerobic digestion with food waste by hydrothermal pretreatment (HTP) at different temperature gradients (90, 120 and 140°C). The results illustrated that the hydrolysis of food waste was improved with the temperature increasing. It is noted that after pretreatment at 120°C, food waste digestion obtained the cumulative methane yield of 296.35± 7.9 mL/gVS add , 39.31% reduction compared to the untreated food
waste 212.72± 3.9 mL/gVS add due to the inhibition by by-products (Humic acid) formed at high temperatures. The highest cumulative specific methane yield of 324.39± 4.5 mL/gVS add was achieved by the co-digestion of pre-treated food waste under 120°C, indicating that the participation of food waste/sludge in co-digestion improve the buffer capacity of the system to relieve the inhibition. HTP significantly changed the electron transfer rate of anaerobic co-digestion. Increased relative abundances of Methanosarcina, Methanobacterium, Syntrophomonadaceae, and Synergistota were observed in pre-treated FW. In addition, the co-digestion of food waste pre-treated at 120°C obtained the maximum energy production of 11.48 MJ/t, 49% promotion compared to the mono-digestion without pre-treatment. The results of the economic analysis showed that the mono-digestion of food waste pretreated at 120 °C achieved the highest net profit. These results suggest that the co-digestion of food waste/sewage sludge can achieve the highest methane production and energy conversion efficiency.

Keywords: Food waste, Sewage sludge, Co-digestion, Hydrothermal pretreatment, Energy conversion efficiency, Economic analysis.

Enhancing Bio-Hydrogen Production in Anaerobic Reactor Through Exogenous Addition of Quorum Sensing Signals

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Excessive use of fossil-based fuels as energy sources cause severe environmental damage. Therefore, identifying alternative, clean energy sources through a biological approach is a crucial challenge for controlling environmental pollution. Bio-hydrogen is one of the most promising green energy sources, with several advantages over other biofuels. Quorum sensing (QS) is a cell-to-cell communication process based on population density, which is used to regulate group behaviors via signaling molecules known as auto-inducers. N-acyl homoserine lactones (AHLs) have been shown to have various positive effects, including an increase in microbial aggregation in the activated sludge process and promoting the metabolism of acid-fermenting bacteria. In this study, the effect of QS molecules on bio-hydrogen production was examined for the first time in a continuous stirred tank reactor (CSTR) with a working volume of 2.5L. The CSTR system used pre-treated anaerobic suspended sludge immobilized in sodium alginate beads as an inoculum and the reactor was maintained at a temperature of 35 ± 1 °C, a pH range of 5.5–6.5, and continuous stirring at 50 rpm. The reactor was continuously fed with a Modified Endo medium with a concentration of 15 g/L glucose, and a stock of N-AHLs was prepared as a cocktail (C4, C6, C8, and C10-HSL) and then diluted prior to its addition to the reactor system. Exogenous addition of AHL resulted in a 61% increase in hydrogen production rate (HPR) with a maximum hydrogen yield (HY) of 2.64 mol H2/mol glucose added, strongly signifying that it had positive effects on the hydrogen-producing microbial community during dark fermentation. Moreover, the addition of AHL also altered the structure of the microbial community during dark fermentation, specifically favouring the increase in the abundance of the genus Clostridium popularly known as hydrogen-producing bacterial group. This study suggests that QS signaling plays an important role in biological hydrogen production, and its regulation can lead to increased bio-hydrogen production.

Keywords: Bio-hydrogen; Dark fermentation; Quorum sensing; N-acyl homoserine lactone (AHL); Microbial community.

Biochar Mediated Methanogenesis from Acetic Acid and Ethanol and its Correlation with the Electron Exchange Capacity

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In order to explore the effect of straw biochar on anaerobic digestion process and whether it can promote anaerobic digestion methane production through DIET. Biochars derived from straws with different electron exchange capacities (EEC) were added to the anaerobic digestion system with acetic acid and ethanol as substrates to explore the effects of biochar on the methane production, substrate degradation and microbial community structure. The roles of direct interspecific electron transfer (DIET) in the process were explored. When the substrate was acetic and alcohol, the biogas yield of biochar experimental group was higher than that of the blank group. The performance of hydrochar group was the best, which cumulative methane production and the biodegradability were increased by 45.4% and 95.1%, and the anaerobic digestion lag period was 0.26 d, which was 45.8% shorter than that of the blank group. The percentage of hydrogen in the biogas from biochar experimental group was lower than that of the blank group. The gas production performance of the old biochar experimental group is generally higher than that of the corresponding new biochar experimental group. In the aspect of microbial community change, the dominant bacteria in the original inoculum changed, and the most important change was *Geobacter*, which could participate in DIET, and the relative abundance increased from 4.5% to 8.8%–14.8%.

Keywords: Straw biochar; Anaerobic digestion; Direct interspecific electron transfer.

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Bio-hydrogen Generation from Food waste: Effects of Microwave Pre-Treatment and Inoculum Source

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The terms green energy and carbon neutral technology has been gaining significant attention in recent years owing to their significant impact on climate change. On the other hand, global food waste generation accounts for about 1.3 billion tons annually. There is a need for a technology that can be an integrated solution to both the above-mentioned problems. Anaerobic digestion is one such technology through which bio-energy such as methane and associated products such as volatile fatty acids (VFA) could be harvested in an environmentally friendly way at a lower cost. The energy density of methane and the slow growth rate of microbes generating methane are the major points of concern. Bio-hydrogen could be an ideal energy that is much superior to methane in terms of energy density, carbon footprint, etc., that can address all the shortcomings of methane. However, the presence of competitive microbes in the seed sludge used for fermentation (methanogens majorly, lactic acid bacteria, etc.) and the amount of soluble portion of the organics in the food waste (varying between 10-30%) readily available for conversion to bio-hydrogen production are the areas of concerns that need to be addressed. This study aims at optimizing different seed sludge combinations, i.e. Combination-1: aerobic seed sludge (collected from aeration tank in a sewage treatment plant at IIT Madras) + glucose; Combination-2: anaerobic seed sludge (collected from anaerobic digester in common STP located at Nesapakkam) + glucose, and Combination-3: mixture of aerobic and anaerobic seed sludges+ glucose) for bio-hydrogen production at a glucose concentration of 3 g/L. Conventional heat treatment of the seed sludge was carried out using water bath at a temperature of 90℃ for 2 hours. The experiments were carried out in a 250 mL conical flask fitted with an airtight septum. The volume of gas produced inside the reactor was measured using water displacement method and the composition was measured using Gas Chromatography (GC). The hydrogen yield of Combination-3 was 1.48 moles of hydrogen/ mole of glucose, which was higher than Combination-1 (1.15 moles of hydrogen/ mole of glucose) and Combination-2 (1.11 moles of hydrogen/ mole of glucose), respectively. Further, Microwave (MW) pre-treatment study was carried out for Combination-3 at different MW power levels (100 W, 200 W and 300 W) to understand its effect on bio-hydrogen production. The hydrogen yield for the reactor containing mixed seed sludge treated at 100 W has produced 2.11 moles of hydrogen/ mole of glucose. The bio-hydrogen production studies with food waste as a feedstock are under progress, and significant results are obtained. Overall, MW pre-treatment could be an alternative and feasible option to the conventional heating pre-treatment technique for bio-hydrogen production.

Keywords: Anaerobic treatment, Bio-hydrogen, Pre-treatment, Microwave.

Solid Waste Biorefinery: Integrated Process Development via Hydrothermal Liquefaction and Dark Fermentation

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Municipal solid waste (MSW), an inevitable by-product of anthropogenic activities and its management has been a challenging problem. Herein, we report the catalytic hydrothermal liquefaction (HTL) of the organic fraction of MSW to facilitate thermal depolymerization to yield biocrude by employing various alkali and metal-based catalysts at 150-250^{0}C and 100 bar pressure under inert (N_2) and reducing (H_2) atmospheres with twenty-four designed experiments. The specific influence of catalyst and N_2 and H_2 conditions on bio-oil yields as well as the composition, energy recovery and by-products were explored. Catalysts with an H_2 atmosphere resulted in bio-oil with higher heating ratios (HHV) and yields by hydrodeoxygenation (H/C and O/C ratios). Among all the catalytic conditions, Pt/C under H_2 afforded more bio-oil with saturated hydrocarbon (biodiesel) content having high HHV. Further, the HTL aqueous fraction was valorised by employing dark fermentation to produce biohydrogen and bio-methane, wherein maximum biogas yield and substrate conversions were noticed under alkali-catalyzed conditions. Standalone HTL and integrated biorefinery processes were compared for sustainability by employing the lifecycle impact assessment (LCA). The biorefinery scenario depicted lesser environmental impacts and CO_2 emissions (GWP).

Keywords: Municipal Solid Waste, Catalytic Hydrogenation, Sub-critical temperature, Bio-Oil, Energy recovery, Bio-Hydrogen, Zero liquid discharge (ZLD), Circular Chemistry.

Elucidate Biorefinery Inhibition Effect on Commercially Collected Food Waste and Greener Pre-Treatment for Sophorolipids Production

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Secondary or waste organic streams have been used to produce sophorolipids (SLs) in the prospective of circular economy, and food waste (FW) is recognized as a promising feedstock. However, the quality of FW varies according to the location and seasonal changes, thereby resulting in different inhibitor's composition and interfere with the sustainable sophorolipids production. This study aimed to characterize the presence of inhibitors in a commercially collected FW, followed by designing a FW pre-treatment strategy to remove the inhibitors for sustainable sophorolipids (SLs) production. Key findings: Compare with the fresh canteen FW, the commercial FW hydrolysate had a low glucose concentration (29.40 ± 8.65 g L−1 versus 49.60 ± 2.97 g L−1), high fructose (9.73 ± 8.46 g L−1 versus 3.10 ± 0.14 g L−1), ethanol concentration (3.00 ± 2.62 g L−1 versus 2.55 ± 0.07 g L−1), lower pH (3.55 ± 0.10 versus 4.62 ± 0.12), and extra lactic acid and acetic acid of 32.10 ± 3.84 and 5.77 ± 0.21 g L−1, respectively. This was due to the facts that commercial FW was mixed and naturally fermented during collection and processing. SL bioprocess of the untreated commercial FW hydrolysate resulted in lower SL production was ascribed by low C/N ratio and inhibitory effect of lactic acid. A single factor inhibition experiment has proven a dose dependent inhibitory effect of lactic acid, at concentration relevant to the commercial FW hydrolysate (i.e., 40 g L-1), and a 98.7% and 46.7% drop in SLs and CDW observed. Further experiments indicated that increase in nitrogen concentration increased the CDW and partly improved SLs production regardless of the lactic acid concentration in the medium. To further reduce the inhibitory effect of commercially collected FW on SLs production, a washing step using deionized water was included in the pre-treatment. Although, the washing of the FW resulted in a complete removal of lactic acid and partly reduced of acetic acid and ethanol, however the washing also led to the loss of 62% ± 1.72% free amino nitrogen (FAN), despite the residual FAN was still high enough to support for SLs bioprocess. Further SLs bioprocess of the pre-treated commercial FW hydrolysate increased the SLs titre to 115.3 ± 9.3 g L-1 which is 8.5-fold higher than that of the untreated counterpart (i.e.,13.5 ± 3.2 g L-1). Conclusions: This study identified lactic acid as the major inhibitor of commercially collected FW, and a cost-effective pre-treatment method. A high FAN containing fermentation method was also provided to overcome the inhibition issue. This work strongly enhanced the actual operability of FW-based biorefinery and significantly accelerated the establishment of a circular bioeconomy.

Keywords: Food waste inhibitor, Lactic acid, Sophorolipids, Starmerella bombicola, Sustainability.

High Solid Anaerobic Fermentation of Vegetable Wastes for Propionic Acid Recovery

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Propionic acid is an important short-chain fatty acid with wide industrial applications, especially in the food industry. Currently, it is produced from petroleum-based chemicals via chemical routes. Increasing concerns about greenhouse gas emissions from fossil fuels and a growing consumer preference for bio-based products have led to interest in fermentative production of propionic acid, but it is not yet competitive with chemical production. In this study, high solid anaerobic fermentation of typical vegetable wastes, cabbage and Chinese cabbage were carried out in leach bed reactor. Results showed that the maximum yields of propionic acid in single fermentation with cabbage, single fermentation with Chinese cabbage and mixed one reached 12.50, 8.18 and 15.51 g COD/L, corresponding to 35.46%, 31.22% and 32.50% proportions of propionic acid in the total soluble products, respectively. Lactic acid was another large component in the soluble products with maximum productions of 12.47 g COD/L, 10.72 g COD/L and 16.21 g COD/L, suggesting lactic -propionic type fermentation was achieved. The operation was performed well with the volatile solid removal rate of 62.5%-73.2%. Microbial community analysis showed that *Lactobacillus* was the dominant genus in the fermentation broth. Propionic acid was mainly mediated by *Lactobacillus plantarum* using lactic acid as temporary substate. The result may pose an insight for propionic acid recovery from high solid anaerobic fermentation of vegetable wastes.

Keywords: Fermentation, Waste vegetable, Propionic acid, Leach bed reactor.

Biodiesel Production from Rice Straw using Ascomycetous Yeast *Yarrowia Lipolytica*

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Finding alternate resources is necessary to address the energy needs of the expanding population due to hydrocarbon resource depletion. As a fuel, microbial biodiesel has the potential to replace fossil fuels more affordably and sustainably. Utilizing oleaginous media, single-cell oil made of carbon, hydrogen, and oxygen is developed over lignocellulosic biomass. Triacylglycerols produced by microorganisms can be turned into biodiesel, which has qualities that are comparable to those of regular diesel. However, using lignocellulosic biomasses requires a number of low-cost pretreatment techniques. In the current study, different pretreatment methods are used to increase the biooil in the microbial production (and biodiesel properties) of rice straw hydrolysate. Based on the concentration of glucose, the pretreatment with 3 % v/v H_2SO_4 at 30 min of ultrasonication produced the best depolymerization results. The hydrolysates were injected with *Yarrowia lipolytica*. The biomass produced after six days of growth at 30 °C, 6.5 pH, and quick mixing was 14.46 g/l. The biomass was transesterified both in-situ and ex-situ to produce biodiesel. 82% of the biodiesel produced by in-situ transesterification using the magnesium zirconate catalyst. In contrast, 61% were attained with ex-situ transesterification, which involved first performing lipid extraction and then transesterifying further while using the same catalyst to produce biodiesel. When the resulting fatty acid methyl esters were exposed to FTIR analysis, the physical and chemical characteristics that were discovered were in compliance with international standards.

Keywords: Biodiesel; Transesterification; Ultrasonication; *Yarrowia lipolytica;* Rice Straw.

Cocoa Pod Husk Valorization: Acid-Alkaline Pretreatment for Microbial Lactic Acid Production

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Due to growing environmental concerns, climate change and scarcity of natural resources, there have been recent tremendous efforts to produce chemicals and materials from lignocellulosic biomass. This biomass is available in the form of organic residues and contains a high content of carbohydrates which are contained in a network consolidated by lignin, and the hydrolysis of the delignified substrate is necessary to access it. The cocoa pod husk (CPH) is an abundant and easily available lignocellulosic biomass in Côte d'Ivoire, but very little valued. Furthermore, lactic acid has attracted considerable interest due to its increasing application in many industries (food packaging, pharmaceuticals, cosmetics). The objective of this study was to produce an acid hydrolyzate of cocoa pod husk rich in fermentable sugars, after alkaline delignification with KOH and acid hydrolysis with H_2SO_4, for lactic acid production using *lactobacillus* fermentum ATCC 9338. The results showed the preponderance of the biomass to solvent ratio and the temperature on the delignification process, using a Plackett-Burman plan. Optimization of these factors using a composite central design, revealed that, the quadratic model was the most suitable for predicting delignification rate. The correlation coefficient (R^2 = 0.95) between the predicted and experimental results confirmed the fit of the model. The optimum conditions were: biomass to solvent ratio of 9.14 % and a temperature of 128 °C, which resulted in a maximum degree of delignification of 93.87 %, with 80 % solids recovered. The morphological and elemental analysis (SEM-EDX) revealed several changes within the delignified matrix and the dominant presence of carbon, oxygen and potassium elements, associated with an intensification of the Mg and K peaks. Fourier transform infrared (FT-IR) confirmed almost complete removal of lignin after delignification. Further, optimization of the acid hydrolysis process, under the conditions of low combined severity factors, of the delignified substrate, using a Box-Behnken design yielded the following optimal conditions: 26.95 min of autoclave time, biomass to solvent ratio of 9.53% (w/v) in H_2SO_4 at 4.92% (w/v), giving 18.77 g/L of reducing sugars. The acid hydrolyzate thus obtained under optimal conditions was used, after concentration, for lactic acid fermentation by *lactobacillus* fermentum ATCC 9338 in a biofermentor, in order to control the bacterial growth parameters (pH, PO_2, temperature, agitation). A productivity of 1.25 g/L.h at the logarithmic phase after 72 hours of fermentation, a title of 26.61 g/L and a yield of 0.52 g/g of lactic acid were obtained from 45.55 g/L of glucose and 12.21 g/L of xylose. A strong tolerance to fermentation inhibitors has been observed. Thus, the application of the response surface methodology to the valorization of agricultural residual biomass has been successfully demonstrated, in a context of circular economy which is becoming increasingly important.

Keywords: Cocoa pod husk, Lactic acid, Optimization, Delignification, Acid hydrolysis.

Deep Eutectic Solvents for the Pretreatment of Lignocellulosic Biomass to Enhance the Sugar Recovery

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In recent years lignocellulosic biomass has received a lot of attention in the hunt for renewable and sustainable energy. However, a pre-treatment stage is usually necessary to overcome the stubborn structure of the biomass which is mostly composed of cellulose, hemicellulose, and lignin. The conversion of lignocellulosic biomass to biofuels and chemicals has resulted in substantial research and development around the world. Deep eutectic solvents (DESs) are newly created green solvent that is inexpensive and easy to prepare. DES has the potential to selectively remove lignin from the lignocellulosic complex, resulting in a new and ecologically sustainable approach for biomass pre-treatment under mild reaction conditions. Rice husk was processed with a DES mixture of choline chloride: urea in a 1:2 molar ratio in this investigation. The influence of temperature and residence period for the most effective pre-treatment condition was also investigated. Scanning Electron Microscopy (SEM) is then used to examine the morphology of the surface of rice husk. To assess the effect of the pre-treatment on the biomass, the treated biomass is examined for crystallinity using XRD, and the functional group was analysed by using FTIR, and then the results are compared to the raw biomass. However, pre-treatment at 80 °C for 6 hours yielded the highest amount of total reducing sugar i.e., 0.694 mg/ml. The facile process used in this study has the potential to be used on a massive scale to produce fermentable sugars and other compounds.

Keywords: Deep eutectic solvent, Pre-treatment, Rice husk, Lignocellulose.

Exploration of Organic Waste for its Bioactive Pigments

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Biomass from agri-food waste is the most prevalent organic waste and has a significant potential for being valued for the creation of sustainable bioproducts. The circular economy and zero waste concepts depend heavily on the bioconversion of agri-food waste into value-added goods. Food researchers are looking for ways to use this waste for the creation of pigments and further biotechnological exploitation in functional foods or value-added goods in order to lessen the environmental load. Some of the leftover fruits and vegetables are naturally rich in colours (eg,. beet root, pomegranate, apple, banana etc.). We're going to use the organic waste in our study for its industrial uses. In Kanchipuram, Tamil Nadu, India, household kitchen garbage was collected along with waste pomegranate, beetroot, and their peels. The colour was extracted from leftover pomegranate and beets using ethanol and water as the solvent. Numerous applications, as well as antibacterial and synergistic action, were carried out in this study. The most effective ethanol extract of beetroot and pomegranate peels was observed against clinical pathogens including *Staphylococcus aureus* and *Candida albicans*. We have painted with colour and applied it to paper. The growth of the plants (black gramme) was then constantly monitored while the waste pomegranate and beetroot (after extraction) were employed as biofertilizers. As a result, there is a need for sustainable pigment synthesis using replenishable bioresources. Fruit and vegetable wastes, as well as their by-products (such as peels, seeds, or pomace), might be valued in order to meet the industrial demands of natural pigment manufacturing for prospective uses in food, medicine, and cosmetics. Natural colours such anthocyanins, betalains, carotenoids, and chlorophyll are abundant in these wastes/byproducts. These natural pigments are expected to have a substantial impact on the creation of functional foods and offer a wealth of biotherapeutic possibilities.

Keywords: Organic waste, natural pigments, Beet Root, Pomegranate and Antimicrobial activity.

Construction of A Multi-Parameter-Based Model to Simulate Lignin Fractionation Kinetics in Biorefinery Processes for Urban Waste Valorization

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Developing urban biorefinery to harvest renewable biofuels and chemicals is an environmentally attractive approach toward sustainable development. To achieve a circular bio-economy, whole biomass valorization for both sugars and lignin conversion is of a key importance, leading to both functional fermentation products to renewable aromatic chemicals at high yield. Lignin separation in the design phase is the key to tackle the goal of whole biomass valorization. Within different pretreatment approaches, diols organosolv has showed its potential in our previous studies which could induce the benzyl carbocation intermediate quenching for reducing the negative effects of lignin condensation. In this study, a series of biorefinery experiments were conducted and a novel universal severity factor: Organosolv Pretreatment Factor (OPF) was introduced. This index was developed based 1,4-butandiol fractionation of a Camellia's shell whole biomass, which covers an extreme lignin/cellulose ratio (3/1) and the unclarified lignin structure for broadening the simulation boundary. The OPF index successfully simulated the performance of hydrolysis (R2 =0.9014), lignin separation and the subsequently the degree of lignin condensation under various operational conditions (i.e., temperatures, time, types, and concentrations of acid catalysts). OPF is the first mathematical function considering and proving the relationship between polysaccharides structures and the aromatic condensation. Moreover, the model also supported that lignin separation is a stepwise process as the following order: (1) hemicellulose hydrolysis; (2) lignin is segregated from hemicellulose; (3) lignin is solvated and removed by solvent. Accurate prediction of native lignin preservation and the mechanism of lignin condensation was further revealed by combining OPF with various advanced characterizations methodologies (2D-HSQC NMR, XRD and chemical composition analysis). The model also implied that the loss of hydroxyl groups at C□□and Cγ positions in lignin polymer could be the key reason for lignin reprecipitation in alcohol based organosolv. In the establishing of continuous flow pretreatment process, OPF could help achieve high quality lignin separation with the efficiency which more than 95%. OPF may serve as an universal optimization factor in lignin-first biorefinery using municipal woody waste as biomass feedstock.

Keywords: Biorefinery, Model, Polysaccharides structures, Organosolv, Lignin.

The Role of Novel Biocarbon on The Treatment of Industrial Wastewater – A Green Concept

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The contamination of water by potentially toxic elements is considered a global problem. It calls for a safe, economic and technological approach in order to curb and prevent the devastating effect of the menace on both human and the aquatic life. This study presents the preparation of *Lawsonia inermis* biocarbon collected from the plant leaves of Henna and the biocarbon is doping with alumina particles to enhance the adsorption capacity. Chromium is one of the dangerous the toxic heavy metals in the environment and is discharged from many industrial activities. Leather industry is one which uses chromium chemicals in its process operations. The biocarbon was applied as adsorbent for the removal of Chromium (Cr) from synthetic wastewater (98.65%) and then applied in the treatment of leather industry wastewater as an economical water cleaning technology. Significantly, in leather industry wastewater, most of the heavy metals are significantly removed (Cu (II) was 81.12%, Cd (II) was 92.20%, Pb (II) was 90.74%, Ni (II) was 82.81% and Cr (VI) was 84.95% respectively. This study revealed that the biocarbon was an efficient adsorbent material for the removal of heavy metals from wastewater.

Keywords: Leather industry, Wastewater, Heavy metal, Chromium, Green adsorbent.

Study on the Effect and Potential Mechanism of Suppression on Cucumber Fusarium Wilt from Different Biogas Slurry

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Biogas slurry, the main by-product of anaerobic fermentation, can promote crop growth, inhibit soil-borne diseases, partially replace chemical fertilizers and chemical pesticides, and improve food yield and food safety. In this study, pig manure biogas slurry, chicken manure biogas slurry, distiller's grains biogas slurry and kitchen waste biogas slurry were used to investigate their effects on Cucumber Fusarium wilt caused by *Fusarium oxysporum* f.sp. *Cucumerinum* (FOC). Pot experiment, gradient sterilization experiment and biofilm experiment were carried out with the aim to find out the suitable adding ratio for different sources biogas slurry and to illustrate the relationship between the biological and non-biological composition of biogas slurry and its suppression. The results were shown below:

The biochemical properties of the four biogas slurry samples were significantly different, but they had the same influence on soil physical and chemical properties, cucumber plant dry weight, fusarium wilt incidence and FOC. They significantly increased soil pH, available phosphorus and potassium contents, but not significant influenced soil organic carbon. When the application rate was 10% and 20%, it could significantly increase soil EC value and alkali-hydrolyzed nitrogen. With the increase of application rate, the dry weight of cucumber plants increased first and then decreased, while the incidence and disease index of cucumber fusarium wilt decreased first and then increased. The abundance of cucumber rhizosphere soil FOC was significantly decreased in all treatments.

The four types of biogas slurry increased the abundance of *Bacillus*, *Sphingomonas*, *Pseudomonas*, *Chaetomium* and *unclassified_Chaetomiaceae*, while reduced the abundance of Fusarium. Application of sterilized biogas slurry significantly increased the abundances of *Bacillus* and *Pseudomonas* in the rhizosphere, and reduced the abundances of FOC and the incidence and disease index of cucumber fusarium wilt, but the inhibitory effect was significantly lower than that of non-sterilized biogas slurry. With the deepening of sterilization degree, the dry weight of cucumber plants decreased significantly, which gradually increased the incidence of Fusarium wilt (from 41.44%-46.67% to 70.34%-72.94%) and disease index (from 39.67%-43.33% to 64.00%-68.01%).

Soil bacterial community, total bacterial abundance, Bacillus abundance and Pseudomonas abundance were significantly negatively correlated with fungal community, total fungal abundance and FOC abundance. Soil pH was positively correlated with bacterial community, the abundance of total bacterial, *Bacillus*, *Pseudomonas*, and negatively correlated with total fungal abundance and FOC abundance. The fungal community composition and FOC abundance determines the degree of cucumber fusarium wilt disease, while the rhizosphere bacterial community composition of blight morbidity rate and rhizosphere FOC abundance had an adverse effect. In conclusion, application rate of 3% was the appropriate one for all biogas slurry, for they contain common biocontrol strains, which will have similar effect on soil microbial population changes and regulating soil microorganisms. Their abiotic components contribute to microbial colonization in the rhizosphere, which will help to improve the inhibitory effect on cucumber fusarium wilt.

Keywords: Diseased vegetable waste, Aerobic compost, Pathogens.

Fabrication of Food Waste-derived Biodegradable Medical Textiles via Electrospinning and Electrospraying for Healthcare Apparel and Personal Protective Equipment

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Personal protective equipment (PPE) and healthcare apparel are instrumental in the reduction of risk of viral transmission and infection of COVID-19. Since most PPE are single use items, the demand for research on the production of PPE from bio-based and biodegradable resources is high. Food waste can be valorized into value-added raw materials through a biorefinery process and converted into biodegradable polymers Polylactic acid (PLA) and Poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV). This paper will demonstrate fabrication of medical textile from food waste derived PLA/PHBV via electrospinning and electrospraying process to achieve levels of filtration, breathability and fluid resistance, which is suitable to use as new material in a highly aggressive medical environment. PLA/PHBV solution with a known concentration and different blend ratios were prepared for electrospinning. Process parameters, e.g., voltage, feed rate, needle tip to collector distance were optimized to obtain uniform nanofibers with optimized properties such as porosity, fibre diameter and thickness. Different concentrations of aerogel incorporated in polydimethylsiloxane (PDMS), polyvinylidene fluoride (PVDF) were electrosprayed over a supporting scaffold layer of electrospun PLA/PHBV membrane. The dual-layer membrane is optimized for enhanced hydrophobicity and surface roughness. Multi-spinneret electrospinner was used to carry out the electrospinning and electrospraying processes. Nanofiber and nanosphere were characterized by scanning electron microscopy (SEM). Porosity and pore size were characterized by porometer. Hydrophobicity and surface roughness were characterized by water contact angle and atomic force microscope, respectively. Polymer concentration of PLA/PHBV was investigated, with a concentration of over 30% resulting in defect-free nanofibers with high uniformity. Higher viscosity ensures an increase in viscoelastic forces for uniform nanofiber production. Different ratios of PLA/PHBV blends were investigated, with higher PLA ratios resulting in polymer solution with low viscosity and thus insufficient chain entanglement. A blend of 50:50 PLA/PHBV ratio resulted in defect-free nanofibers with mean fiber diameter of 320nm. Previous electrospraying studied concentrations of 10-50% aerogel incorporated in PDMS/PVDF. An optimized ratio of 30% aerogel in PDMS/PVDF was electrosprayed onto the PLA/PHBV to fabricate a dual layer membrane which is expected to achieve superhydrophobicity properties with water contact angle ~170°. In summary, PLA/PHBV nanofibers will form a nano-porous membrane with sufficiently small pore size to achieve good filtration and breathability properties. While the superhydrophobic PDMS/PVDF layer will further supplement the membrane with superior fluid resistance, which is crucial for new materials used for PPE and healthcare apparel.

Keywords: Biowaste utilization, Electrospinning, Electrospraying, Polylactic acid, Poly(3-hydroxybutyrate-co-3-hydroxyvalerate).

Separation and Purification of Glabridin from A Deep Eutectic Solvents (DES) Extract of Glycyrrhiza Glabra Residue by Macroporous Resin

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Glabridin can effectively inhibit antioxidant, anti-inflammatory, and tyrosinase activity. It is mainly used in the pharmaceutical and cosmetic industries. The residue of Glycyrrhiza glabra after glycyrrhizic acid extraction in industrialization still contains glabridin. Given the disadvantages of traditional extraction solvents, such as strong volatility, high toxicity, nondegradation, and low extraction rate, deep eutectic solvent (DES), an environmentally friendly, sustainable, nontoxic solvent with a high extraction rate, has been gradually developed and applied to the research of traditional Chinese medicine extraction. However, DES cannot easily achieve the separation and purification of target substances because of its high viscosity, low pH, and low volatility. In this study, DES was used to extract the glabridin from the residue of G. glabra. The extract was extracted with ethyl acetate and concentrated under reduced pressure to obtain the crude extract of glabridin. Subsequently, the macroporous resin was used for further separation and purification of glabridin. The Langmuir model, Freundlich model, intraparticle diffusion model, and kinetic model were used to study the adsorption mechanism of the resin. The adsorption and desorption conditions of the resin were also optimized. Results showed that compared with the extraction rates of 15.34, 34.44, and 194.80 μg/gwith the traditional extraction solvents of water, NaOH aqueous solution, and ethanol, the extraction rate of 317.10 μg/g with DES was the highest. The DES extract of G. glabra residue was extracted with two times the volume of DES extract by using ethyl acetate to obtain the crude extract of glabridin. The glabridin extraction rate was 91.63%. The application of 12 different resins in the separation and purification of glabridin from the crude extract of glycyrrhizae radix was studied. LSA-21 was found to be the optimal resin. The study of the adsorption mechanism showed that the adsorption process of LSA-21 resin on glabridin conformed to the second-order kinetic model and Langmuir model, the thermodynamic parameters ΔH (enthalpy change) and ΔG (Gibbs free energy) were both negative, ΔS (entropy change) was positive, indicating that LSA-21 resin spontaneously and exothermically adsorbs glabridin to form a monolayer. The separation and purification conditions of glabridin by LSA-21 resin were optimized. The optimal adsorption conditions were a glabridin concentration of 56.90 μg/mL, 16.5 bed volume (BV) sample volume, and 2 BV/h adsorption flow rate. The desorption condition was 4 BV of ethanol, the elution flow rate was 2 BV/h, and the recovery rate of glabridin was 97.80%. The recovery rate of glabridin was still higher than 90% after the resin was reused four times. Finally, the total recovery of glabridin is 89.61%. This study confirmed that macroporous resin is an effective method for separating and purifying glabridin from the DES extract of G. glabra residue.

Keywords: Glabridin, DES, Macroporous resin, Separation, Purification, Mechanism.

One-Pot Fractionation of Endocarp Waste for Sustainable High Value-added Products

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Endocarp waste, the recalcitrant and inedible part of nuts and stone fruit is a lignin rich, promising energy-dense feedstock for aromatic commodity chemicals in the sustainable biorefineries. In this study, we tested the monomer production potential of ten different phylogenetically diverse endocarp species through reductive catalytic fractionation (RCF) (Ru/C, THF, 5h, 250 °C, 40 bar H_2) and report that their aromatic monomer yield can surpass those obtained using wood up to 25-30% by dry biomass basis. We provide detailed chemical analysis of phylogenetically diverse species for better understanding of the linkages within various endocarps. Particularly striking observations include the >40% levels of Klason lignin in the nutshells from candlenut and macadamia, and lignin compositions ranging from <4% syringyl (S) in peanut to 70% to 84% S in mango and pistachio. We also observed that the seed coats of candlenut contain both S/G lignin and C-lignin, which is an ideal lignin archetype for valorization. Also, the extractive analysis done by LC-MS showed that the endocarp biomass is rich in extractives which further boost the economic and overall benefit of biorefinery. In light of our results, endocarp waste deconstructed with RCF prove to be an attractive lignin first biorefinery scheme and the detailed sustainability analysis could strengthen the shift of lignin aromatics into current petroleum dominated infrastructure to further enhance the circular economy.

Keywords: Endocarp waste, Reductive catalytic fractionation, Circular economy.

Conversion of Food Waste into Lipid by Oleaginous Fungi

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The demand for fossil fuels is increasing with increasing population and industrialization. To reduce this dependency and to mitigate the fossil-fuel based environmental pollution, development of alternative renewable fuels from renewable feedstock has received high priority in the past two decades. Biofuel production using oleaginous organisms is one the most important alternative methods. Oleaginous fungi, that can accumulate >20% lipid of their dry cell biomass, can be exploited to produce the biodiesel. In India, many studies demonstrated the possibility of growing the oleaginous fungi on an array of substrates: cheese whey, sugarcane bagasse, grape stalk, banana peel, corn cob and groundnut. Compared to other substrates, food waste (FW) is receiving greater attention recently due to the greater availability, and to eliminate the need to dispose these wastes. Food waste contains a number of organics (protein, starch, amino acids and sugar) and inorganics (sodium, magnesium, iron, calcium, phosphorus and nitrogen) that can be utilized for the growth of oil accumulating yeast. A batch experiment was conducted in culture flasks to evaluate the growth and lipid accumulation of Cryptococcus curvatus on food waste medium aiming at optimizing the growth conditions, preparation of food waste medium for the growth and lipid accumulation of yeast. Food waste, mainly composed of boiled rice, fried chapati, boiled dhal, cabbage and potato, was collected from the canteen. The food waste was analyzed for moisture content, pH, electrical conductivity, TOC (Total organic carbon) and TKN (Total Kjeldhal Nitrogen). The food waste was pretreated by different hydrolysis (acid, thermal and acid thermal) methods to increase the availability of carbon in food waste medium for supporting the growth of the oleaginous organism. Food waste medium without pre-treatment and YPD broth medium were set as controls. The experiment was conducted for 8 days. The growth of the yeast Cryptococcus curvatus on different food waste medium was monitored at regular intervals using spectroscopic method. The parameters like pH, EC, TOC, TKN and C/N ratio of the different media were analyzed at regular intervals. After 192 h of cultivation, the biomass from each treatment was harvested and analyzed for lipid content. The biomass obtained from different pretreated food waste medium was higher compared to food waste control and YPD broth medium. But comparing lipid content (%), it was higher in YPD broth medium, followed by acid treated food waste and food waste control. In thermal treated and acid-thermal treated food waste media, low amount of lipid content was obtained. Different pretreated food waste media supported only the growth of the yeast Cryptococcus curvatus. Acid treated food waste medium helpful to increase the oil accumulation.

Keywords: Oleaginous fungi, Food waste, Lipid, Cryptococcus curvatus.

Development of Low-Cost Proton Exchange Membrane (PEM) For Microbial Fuel Cells (MFC)

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Microbial Fuel Cells (MFCs) are a well-known alternative to fossil-fuel-based electricity generation and one of the most innovative bioelectrochemical approaches for the direct conversion of organic waste into electrical energy using biocatalysts. Despite its best efforts, MFC faces numerous commercialization challenges, one of which is the use of expensive membranes, which makes them unaffordable. The goal of this research is to create performance-driven, cost-effective, and environmentally friendly separators that will make MFC technology a viable option. Three different types of low-cost materials were used in MFC, i.e., clay as the nonconductive material in the single (S) chamber with a cement/sodium chloride coat as the conductive agent to replace costly carbon cloth; agar and cement as the membrane in the dual (D) chamber along with sodium chloride as the proton mobilizer to replace the costly commercial Proton Exchange Membrane (PEM) For comparison, carbon cloth in SMFC and Nafion in DMFC were used. With different combinations of low-cost materials and proton mobilizers, the simultaneous bioelectricity production and bioremediation of septic tank wastewater (STWW) in SMFC and DMFC with native microflora as a biocatalyst; sterile STWW with *Serratia marcescens* (AATB1) as a biocatalyst, and sterile STWW as a control were analyzed. In DMFCs with Nafion 117, an agar bridge with 10% sodium chloride, and a cement bridge with 10% sodium chloride, current densities of 728±10 mA/m^2,442±21 mA/m^2 and 376±16 mA/m^2, while power densities of 341±8 mW/m^2, 180±10 mW/m^2 and 148±14 mW/m^2 were obtained. Our study shows a cost reduction in terms of USD of 4.67, 0.376, and 0.0044 and power generation performance of 100%, 61%, and 52% for DMFCs with Nafion 117 (9 cm^2), an agar bridge with 10% sodium chloride (108 cm^2), and a cement bridge with 10% sodium chloride (108 cm^2), respectively. Compared to Nafion 117 in DMFC (considered at 100% cost), agar bridges and cement bridges with 10% sodium chloride used in DMFC showed reduced costs of 88% and 99%, respectively.

Keywords: Bioenergy, Bioremediation, Low cost, MFC, PEM, SMFC.

Deciphering Chloramphenicol Biotransformation Mechanisms and Microbial Interactions via Integrated Multi-Omics and Cultivation-Dependent Approaches

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As a widely used broad-spectrum antibiotic, chloramphenicol is prone to be released into environments, thus resulting in the disturbance of ecosystem stability as well as the emergence of antibiotic resistance genes. Microbes play a vital role in the decomposition of chloramphenicol in the environment, and the biotransformation processes are especially dependent on synergistic interactions and metabolite exchanges among microbes. Herein, the comprehensive chloramphenicol biotransformation pathway, key metabolic enzymes, and interspecies interactions in an activated sludge enriched consortium were elucidated using integrated multi-omics and cultivation-based approaches. The initial biotransformation steps were the oxidization at the C_1-OH and C_3-OH groups, the isomerization at C_2, and the acetylation at C_3-OH of chloramphenicol. Among them, the isomerization at the C_3-OH is an entirely new biotransformation pathway of chloramphenicol discovered for the first time. Further, we identified a novel glucose-methanol-choline oxidoreductase responsible for the oxidization of the C_3-OH group in *Sphingomonas* sp. and *Caballeronia* sp. Moreover, the subsequent biotransformation steps, corresponding catalyzing enzymes, and the microbial players responsible for each step were deciphered. Synergistic interactions between *Sphingomonas* sp. and *Caballeronia* sp. or *Cupriavidus* sp. significantly promoted chloramphenicol mineralization, and the substrate exchange interaction network occurred actively among key microbes. This study provides desirable strain and enzyme resources for enhanced bioremediation of chloramphenicol-contaminated hotspot sites such as pharmaceutical wastewater, livestock and poultry wastewater. The in-depth understanding of the chloramphenicol biotransformation mechanisms and microbial interactions will not only guide the bioremediation of organic pollutants but also provide valuable knowledge for environmental microbiology and biotechnological exploitation.

Keywords: Chloramphenicol biotransformation, Multi-omics, Interspecies interaction.

Characterization and Valorization of Marine Sediment

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Large volumes of marine sediments are dredged annually in ports, but changes in regulations will tend to restrict their disposal at sea. The recovery of part of these sediments as raw materials in the field of construction help to limit their storage and give them added value. Our study is then oriented towards the characterization and the valorization of marine sediment. This work focuses on the feasibility of using dredged marine sediment from TENES port as partial replacement of sand in mortar. Physical, chemical, mineralogy, and rheology characterization were carried out. This study revealed that the substitution of sand by sediments can be considered as a suitable option of their valorization. This solution should have a great economic and environmental interest.

Keywords: Marine sediment, Caracterization, Valorization, Mortar.

Valorization of Biowastes from Wastewater Phytoremediation Process : A Model for Constructed Wetlands Integrated Management in a South-Mediterranean Region

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Constructed wetlands (CWs) are increasingly used for effluents treatment in south Mediterranean countries, as in Tunisia. The CW treatment plant of Jougar in northern Tunisia generates considerable amounts of macrophyte biomass and sewage sludge (SS) as biowastes. Integrated management of these wastes is of great importance to CW plant sustainable functioning. Firstly, SS production by the primary treatment pond (PTP) was studied to optimize it and then to ensure downstream CWs maintenance. Dysfunction of PTP generated excessive SS amounts that could cause wetlands clogging. The GPS-X simulation software was used to perform modeling of the PTP operation. Likewise, impacts of wastewater physicochemical parameters and pumping rate on the sludge settling operation were studied, leading to different simulation scenarios. Analysis of influent physicochemical parameters database over the period 2004-2009 defined three cases: minimum, mean, and maximum. Each case could be associated to one of the year seasons. During winter and autumn, several solutions corresponding to the mean case were possible. In the summer, best alternative would be adoption of a pumping rate of 21 $m^3.d^{-1}$ over a 36-day period (minimum case). For the spring season, influent characteristics were close to those of the maximum case. Accordingly, this study recommended integration of a second PTP to enhance the primary treatment efficiency, and then to achieve a better performance of the CW system of Jougar. After PTP emptying operation, the routinely removed SS was used to reactivate macrophytes biomass composting process at the beginning step. Indeed, significant amounts of reeds and cattails' biomasses were collected from the vertical and horizontal CWs of Jougar treatment plant after harvesting operation at the end of the macrophytes' life cycle. Then, aerobic composting pile of macrophyte residues mixed with SS fraction was controlled over a four-month period through the monitoring of different key physicochemical and biological parameters. Compost maturity was assessed by C/N ratio of about 9 and germination index reaching approximately 96%. Compost application to soil with 1/3 volume proportion likely appeared to be beneficial and sufficient for soil fertilization and plant growth improvement after nutrients input. Then, valorization of CW biowastes by composting could contribute to a better management of such systems and to the fertilization of Tunisian agricultural soils continuously getting poorer in organic matter. Another way of phytomass recycling was to use it as a filter substrate to enhance wastewater treatment efficiency by the filtration technique. Annually harvested aboveground macrophyte parts composed of leaves, stems and inflorescences of reeds and cattails were crushed and dried. Then, phytofiltration assays using poly-substrate filters made with mixtures of macrophyte dead biomass and conventional inert media (gravel or brick wastes) showed a significant organic and inorganic contaminants reduction. When added to inert filter media, the new substrates of macrophyte biomass have proved to be able of improving CWs treatment performance. In conclusion, the presented integrated management model would be successfully applied to CW systems in south Mediterranean regions, as in Tunisia to ensure their sustainable efficacy and protect environment and natural resources after biowastes recycling and valorization.

Keywords: Biowastes recycling, Constructed wetlands management, Macrophytes biomass, Sewage sludge, Valorization.

Factors Influence on *Citrobacter Amalonaticus* Metabolism Towards Succinic Acid Production Through CO_2 Utilization

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Increased usage of fossil fuels has resulted in fuel shortages and higher energy prices. In order to compensate for decades of energy use, research has focused on the use of renewable energy sources towards the production of platform chemicals, with a particular emphasis on employing inorganic carbon as a substrate, such as CO_2. Succinic acid, a well-known industrial chemical, is a precursor of many important industrial compounds and consumer products. Exploiting the capabilities of microbes in enabling CO_2 biotransformation to yield succinic acid is of commercial interest and gaining prominence. Fermentative succinic acid production system, an alternative to the fossil-based production process, is well known however, little is understood regarding the specific requirement of their critical concentrations under different operating conditions such as substrate, buffer, organic loading rate (OLR), pH and temperature. This study explored the metabolism shift of isolated *Citrobacter amalonaticus* (SVMIICTSA1) towards succinic acid with eight selected parameters by employing the Taguchi design of experiment (DOE) approach. Factors such as CO_2 utilisation, pH, temperature, organic substrate, cofactors, buffer, OLR and influence of external potential/electron donor were taken into consideration. The influence of all the critical parameters driving the metabolism of *C. amalonaticus* was assessed/evaluated with bioprocess analysis, electrochemical parameters and gene expression studies. Further to evaluate the importance of $NADH/NAD^+$ ratio towards succinic acid production (rTCA cycle), cyclic voltammetry analysis and enzyme assay were performed. Overall, the eight parameters considerably influenced the metabolism of the bacteria with diverse productivity of succinic acid. Thus, the transition from fossil fuels to renewable raw materials such as CO_2 for the production of value-added products opens up great prospects for applying industrial biotechnology to create long-term CO_2 biorefineries.

Keywords: Reverse Krebs cycle, KEGG annotation, primers, hybrid fermentation, metabolic flux, CO_2 sequestration.

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Composting

Lignite Affects Active Nitrogen Gas Emissions during Poultry Wastes Composting: Insight Into the Microbial Mechanism

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Ammonia (NH_3) and nitrous oxide (N_2O) emissions are substantial contributor to nitrogen (N) loss in composting. Lignite addition can increase N retention by absorbing NH_4^+ and NH_3, and lignite dewatering could enhance NH_4^+ adsorption capacity in pure solution system. However, the results on the impacts of lignite on N_2O emissions during composting are controversial because of the lack of the study on the inner microbial mechanisms. Results obtained showed that the cumulative gas fluxes of NH_3 in lignite and dewatered lignite treatments were reduced by 46.5% and 68.4%, while N_2O emissions were increased by 48% and 7.7 times, respectively, when compared to the non-lignite control (CK). Lignite addition enhanced nitrification and denitrification, as evidenced by the significantly increased abundances of functional genes of *amoA*, *amoB*, *nirK* and *nirS* in lignite treatments in the cooling and maturity stage of composting. Structural equation models revealed that lignite and dewatered lignite may reduce NH_3 emission by increasing cation exchange capacity, promoting the growth of ammonia-oxidizers and by reducing compost pH. The increased moisture and nitrate content contributed to higher N_2O production through denitrification in lignite amendment composts. Nitrification was the main source of N_2O in CK, while nitrification and denitrification contributed significantly to N_2O production in lignite amendment composting. The findings imply that denitrification inhibition could be a promising stratagem for mitigating N_2O emission during lignite-amended aerobic composting.

Keywords: Lignite amendment; Surface modification; Methane emission; Nitrous oxide emission, Carbon dioxide emission; Poultry litter; Manure composting.

Synergistic Abatement of NH_3 and N_2O Emission from Composting Process

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Reducing reactive nitrogen (N) leakage from livestock manure management is of global concern. Aerobic composting of organic waste is an important anthropogenic source of ammonia (NH_3) and nitrous oxide (N_2O). The increasing implementation of ammonia (NH_3) mitigation measures in livestock production inevitably results in ammonium (NH_4^+) enrichment in the manure, but there is a lack of mechanistic understanding of such enrichment on N cycling and gaseous N emissions from subsequent manure management. Moreover, it is difficult to implement targeted options to mitigate emissions from this source because the dominant N_2O production pathway remains unclear. Here, combined approaches of N-form analysis, isotopocule mapping, qPCR, and Illumina MiSeq sequencing were used to differentiate N_2O production pathways and decipher the underlying microbial mechanisms during composting. Results indicated that bacterial denitrification dominated the N_2O production overall, but the major N_2O production pathway varied at different composting stages, with heterotrophic denitrification (HD) being most important at the early stage and nitrifier denitrification (ND) at the latter stage. Most N_2O was produced at the latter stage, where the production of nitrite through ammonia oxidation provides substrate for nitrifier denitrification. Quantification of the functional genes involved in nitrification and denitrification revealed that the N_2O emission rates correlated with the abundance of the amoA gene in ammonia-oxidizing bacteria (bac-amoA). The application of an electric field during composting reduced N_2O emission by 28.5-75.5%. The underlying mitigation mechanism of the electric field was attributed to ammonia oxidation inhibition, as evidenced by the observed reduction in nitrite accumulation and the abundance of bac-amoA. Sequencing of the bac-amoA gene suggested that the amoA-containing family Nitrosomonadaceae was responsible for ammonia oxidation and N_2O production, and the application of an electric field could reduce the proportion of Nitrosomonadaceae from 99% to 83% at the lower voltage and to a negligible level at the higher voltage assessed, which was attributed to their depressed competitiveness for oxygen (O_2) with heterotrophs. The application of an electric field promoted the degradation of organic matter while reducing the O_2 availability, as evidenced by the decreased free air space and O_2 concentration. The findings of this study provide evidence that an electric field could be used as an innovative nitrification inhibitor to reduce compost derived N_2O emissions.

Keywords: Composting, Ammonia mitigation, Nitrifier denitrification, Nitrification inhibitor, N_2O mitigation.

Nutrient Recovery and Treatment of Organic Waste by Vermitechnology

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Solid waste disposal and management is a challenge in developed as well as developing nations. A number of destructive methods have been proposed and practiced for the disposal of solid wastes. Scientific community is in search of non-destructive methods by which nutrients can be recovered from the solid wastes. Among various biological methods of solid waste management, vermitechnology has attracted attention of scientific community, policy makers and municipalities. It is one of the ecologically and economically sound technologies for handling biodegradable organic fraction of solid wastes. The process vermicomposting is conducted in a narrow range of temperature (25-40ºC), near neutral pH (6.5-8.5) and high humidity (60-70%) in order to sustain a large population of earthworms. It degrades the organic waste in about 2 to 4 months and the end product is odourless, disinfected and highly nutritive vermicompost which is suitable for organic manuring of agricultural soil. Moreover, it is known that the earthworms release coelomic fluids in which mucocytes, vacuolocytes, granulocytes and lymphocytes are present which kill the bacteria and parasites present in the waste, thus, making the vermicompost odour and pathogen free. Significantly, the vermicompost is considered an excellent product of homogeneous and odour-less nature, rich in microflora, and tends to hold more plant nutrients over a longer period. Vermicomposting is one such technology which can be used at small (household level) to very large (several households, village or an entire city) scale. A large variety of wastes of plant and animal origins have gainfully been vermicomposted and used as used at laboratory as well field scale.

Keywords: Vermitechnology, Earthworm, Solid waste, Organic waste.

Responds of Physiological Inheritance Mechanism on Seed Germination Under Phytotoxicity During Chicken Manure Composting

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Composting is a biotransformation environmentally friendly and potential sustainable way to convert organic waste into a fertilizer in farmland. Nevertheless, salts, ions, small organic acids and inorganic nitrogen condensation and production in composting make it a threaten for seed germination. Germination index (GI) is considered the most authoritative index for maturity evaluation of compost. Thus, seed responds to different periods of composting stress were detected during metabolism activities, such as producing certain endogenous phytohormones, invoking activities of antioxidant enzymes. Co-composting of livestock manure and straw for 42 days and the maturity and phytotoxicity were analyzed during the process. Five periods of mesophilic, thermophilic, cooling, first mature and second mature phases were clearly divided. GI increased to above 90%, other characteristics (pH, EC, C/N and so on) indicated the higher maturity of the final compost. The transcriptome and proteome are also necessary to build an available genomic resource to investigate the molecular mechanisms underlying different composting stress in seed. Comparative omics analysis showed that 14679 genes and 1091 proteins were differentially expressed in seed under initial compost stress, which were enriched in the following processes: catalysis and metabolic process. The reprogramming of transcript and protein works suggested that the induced activity of ribosome and carbon metabolism may endue seed with compost phytotoxicity tolerance, and >70% proteins in these two significant pathways were reversible with composting proceeding. With high-quality sequencing and annotation, the obtained transcriptomics and proteomics provide a robust genomic resource for higher quality and safety application of manure composts in agriculture.

Keywords: Composting, Seed, Phytotoxicity, Transcriptomics, Proteomics.

Deciphering the Dynamics of Antibiotic Resistance Genes and the Driving Mechanisms during Pig Manure, Kitchen Waste, Sewage Sludge Composting

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The organic solid wastes (OSWs) are the important hotspots of antibiotic resistance genes (ARGs), mainly including livestock manure, kitchen waste (KC) and sewage sludge (SG). Aerobic composting is a harmless recycling treatment method for transforming OSWs into organic fertilizers. However, the effects of aerobic composting on ARGs are controversial. In this study, we adopted the high-throughput quantitative polymerase chain reaction (HT-qPCR) to quantify and compare the ARGs and MGEs abundances in three raw materials composting, including pig manure (PM), KC and SG. The corresponding driving mechanisms were explored using structural equation models (SEMs). We found the dominant types of ARGs in initial materials are different, mainly including the genes resistant to tetracyclines, aminoglycosides, macrolides in PM, tetracyclines and aminoglycosides in KC, sulfonamides in SG, respectively. Interestingly, the abundance of ARGs tended to be similarity in final composts of three raw materials ($P \geq 0.05$), although there were significant differences in initial raw materials (PM > SG > KC, $P \leq 0.001$). More importantly, at the end of composting, the abundance of ARGs decreased in PM treatment (removal rate of 71%), while increased in KC (5.9-fold) and SG (1.3-fold) treatments. In addition, the rebound of ARGs abundance in maturation period happened in all treatments, which should be taken seriously owing to the increasing resistance risk of compost products. The network analysis indicated Firmicutes, Proteobacteria and Actinobacteria were the important potential hosts of ARGs. Notably, several genes should be taken seriously, including tetW, aadA, aadE, tetX, strB, tetA, mefA and intl1, intl2 in final products. Finally, according to the SEMs, we concluded the different driving mechanisms of ARGs variations in three treatments, including “microenvironment-ARGs” in SG compost, “microenvironment-ARGs” and “microenvironment-microorganisms-ARGs” in PM compost, “microenvironment-microorganisms-ARGs” and “microorganisms-HGT-ARGs” in KC compost, respectively. This study provided a systematic and deep insight of ARGs dynamics during PM, KC and SG composting.

Keywords: Antibiotic resistance genes, Dynamics, Driving mechanisms, Different raw materials, composting.

Effects of Reflux of Mature Compost During Perishable Waste Composting

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With the growth of population and the development of economy and society, the increasing production of perishable organic solid waste has become a restrictive factor for the green and high-quality development of cities and towns in China. Aiming at the problems of low bioconversion efficiency and serious secondary pollution of urban perishable waste and based on the technical idea of microbial intraspecific inoculation, the study took kitchen waste as the research object to investigate the effects of reflux ratio (10 %, 15 % and 20 %) and reflux mode (mixing and mulching + mixing) on the process of compost fermentation, the emission of NH3, CH4 and N2O. In this experiment, the kitchen waste (food waste and vegetable waste were mixed together at a ratio of 1:1 by wet base), rapeseed straw and sawdust were mixed together at a ratio of 3:1:1 (dry base), with the combined addition of VF20F0020 microbial agents at 3 ‰ (dry base) and pH modulator (CaO and CaCO3 mixed together at 1:1). According to different treatments, the main results were shown below: i) With the increase of the proportion of clinker reflux, the maximum temperature increased during composting; of all the treatments, the temperature raised fastest and peaked at 72 ℃ on the second day when the clinker ratio was 20 %, in which the GI value is close to 50% on day 7, more than 60 % on day 9, and more than 80 % on day 21. In the thermophilic stage, the temperature of the mixing and covering process is slightly higher than the pure mixing process all the time. At the end of composting, the pure mixing process had the greatest GI value of 94.3 %, while the control was 68.7%, which reached basic maturation only. ii) The clinker ratio of 20% had the best emission reduction effect on NH3, CH4 and N2O, respectively, which decreases by 26.7 %, 31.5 % and 30.62 % compared with the control. The mixing and covering of the clinker were more conducive for emission reduction. Mixing 15 % mature material and covering 5 % mature material had a better emission reduction effect on NH3 and CH4. Mixing 15 % thermophilic material and covering 5% mature material had a better emission reduction effect on N2O. In conclusion, refluxing clinker at a ratio of 20% prolonged the thermophilic stage and accelerated the fermentation process of compost, which also had the greatest emission reduction effect on NH3, CH4 and N2O. The pure mixing process was more conducive to the improvement of GI value, while the mixing and covering of the clinker had better insulation effect and was more effective in reducing pollution gas emissions.

Keywords: Compost, Odorous gases, Perishable wastes, Clinker reflux.

Examination of Feasibility and Effectiveness of Earthworm in Degradation of Kitchen Refuse

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Earthworms pledge to provide incredible solutions to several social, economic, and environmental problems plaguing the human society. Earthworms can safely manage all municipal and industrial organic wastes including sewage sludge and divert them from ending up in the landfills. Since past many years earthworms and species of it are used in degradation of different types of waste. The study examined the ability of the earthworm species *Eisenia foetida,* in the vermicomposting of Kitchen refuse. In these treatments, the vermicompost materials were analysed the micro and macronutrients to understand the impact on the bioconversion of waste into compost. Experiments were conducted for 60 days, after 15 days of pre-composting, Pre decomposition of 15 days and subsequent vermicomposting of 60 days indicates the role of this species in vermitechnology. The efficiency of kitchen waste degradation with earthworm was evaluated after mixing in different ratio with the help of saw dust and cow dung in compost trial pits in various proportions. The sampling was done once in 5 days. Analysis of physical and biochemical parameters was done during period of 60 days. After the completion of maturation period the compost and earthworms will be recovered from each trial pits. Samples were dried and sieved through 2.5mm sieve and then analysed for the final characteristics. The protein rich earthworm biomass is being used for various application like ‘nutritive feed materials’ for fishery, dairy & poultry industries. The study is aimed at scientifically monitoring vermicomposting process and to understand the optimum management requirements to improve the operation of an institutional scale worm farm. The investigation of earthworm species with waste helped to improve the knowledge base to influence and support urgently needed solutions aimed at improving waste management system.

Keywords: Kitchen Refuse, Potential Earthworm species, Vermicomposting, Waste degradation.

The Role of Different Types of Biochar in Food Waste Digestate Composting

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Anaerobic digestion is gradually recognized as green technology to deal with the everlasting food waste problem, due to the limited landfills, climate mitigation policies, and environmental awareness. Food waste digestate (FWD) is a by-product of this process and its generation is globally increased along with a boost of anaerobic digestion plants, being estimated to ~180 million tons per year. Without the proper treatment of the elevated FWD generation, the loop of the circulated economy cannot be closed. In addition, the FWD is characterized by high NH_4^+-N (10000-12000 mg/kg dm), high moisture content (75-80%), and low C/N ratio (5-7), and also be regarded as a valuable recycling resource. Hence, a state of the art of technology can achieve valorization of FWD, replacing 5-7% inorganic fertilizer globally, in order to satisfy green recovery as well as a circular economy. Composting is a potential treatment Jonathan W. C. Wong way to realize the circular economy, which can recycle FWD as a biofertilizer. However, under normal conventional composting conditions, because of high NH_4^+-N, emissions of unwanted odorous NH_3 and greenhouse gas, N_2O is inevitable. In addition, high NH_4^+-N inhibits the nitrification process and hastens nitrogen loss through NH_3 and N_2O emissions leading to low agronomic compost. To overcome the issues of FWD composting, improved in-situ technologies should be adopted other than the conventional approach. Biochar, a pyrolyzed carbonaceous material has attained recent attention as a physical additive in composting due to its unique characteristics such as high surface area, high cation exchange capacity, and porous volume. Due to these characteristics, biochar could play a pivotal role in ammonium rich FWD composting. The significance of using biochar as a physical additive is demonstrated in this work. The superior adsorption quality of biochar significantly reduces the inhibition of high NH_4^+-N on FWD composting by adsorbing onto the surface thereby reducing the NH_3 emission as well. By biochar addition, the resourceful nitrogen could be conserved in the compost which will further act as a slow-nutrient releasing biofertilizer in agricultural applications. However, the extent of mitigation of NH_3 emission and nitrogen loss during biochar-assisted FWD composting depends on the pyrolytic temperature as well as the feedstock used for biochar production. In our studies, the biochar produced from tobacco, bamboo, and coconut biomass at pyrolytic temperatures 450 °C, 600 °C, and, 900 °C respectively showed varied effects on FWD composting at 10% dosage (dry weight basis). The coconut and tobacco biochar displayed higher cationic exchange and adsorption capacity and resulted in the mitigation of NH_3 emission by 58% and 64%, respectively, whereas bamboo biochar could reduce NH_3 emission by only 48% compared to the control without biochar. Furthermore, the presence of different types of biochar significantly impacted the N_2O emission during FWD composting. The coconut and bamboo biochar reduced the N_2O emission by 48% and 31%, respectively whereas tobacco biochar induced the N_2O emission by 53% compared to the control without any biochar. Overall, the coconut, bamboo, and tobacco biochar could significantly reduce nitrogen loss by 57%, 53%, and 29%, respectively, during biochar-assisted FWD composting. These results clearly indicated that the presence of biochar significantly affected the nitrogen transformation process during FWD composting and the changes are dependent on the type of biochar used.

Keywords: Food waste digestate, Composting, Biochar, Compost quality, Greenhouse gas emission.

Different Composting Technologies and Raw Materials Induced Microbial Dynamics and Core Microbiomes

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Composting technologies is the best way to recycle the organic wastes and make them into organic fertilizers or composts, to increase the rate of recycling. However, which process or raw material was the best choice unclear. For evaluating which was the preferable method for recycling, the research was choosing three main composting process, pile, bed and reactor, and three livestock manures, swine, cow and chicken manure through analysing by physicochemical indices and bacterial 16S rRNA gene amplicons. Compared to pile and bed, reactor process was better to reduce moisture content, especially swine manure, this process could reduce moisture content 9.15% per day. For reactor process, the moisture content of swine, chicken and cow manure reduced to 25.97%, 21.13% and 23.09%, respectively. For ammonia emission, bed process was the best, there was 18.61 g/m3, 17.38 g/m3 and 34.90 g/m3 in swine, cow and chicken manure, respectively. On the contrary, the average of ammonia emission content was above 200 g/m3. The germination index of three processes were above 70%, and followed the Chinese standard, it means that all these three processes were good for recycling livestock manure. This study also revealed that microbial dynamics among different processes and raw materials had significance difference, the variance was 7.38% and 8.15%. The relative abundance of phylumn during these treatments were different, for all composting processes, the main phylumn was Firmicutes. Nevertheless, there were difference among three composting processes, for reactor, the second was Actinobacteria, while for pile and bed, when the raw materials were chicken or swine manure, the second was similar like reactor progress. While when the raw materials were cow manure, the second was Bacteroidetes in bed progress and was Deinococcus-Thermus in pile process. Core microbiomes with these processes and raw materials were distinct. Bacillus and Actinobacteria were higher in reactor progress, Thermomicrobia and Thermotogae were important in pile progress, while Deinococci, Sphingobacteriia and Methanomicrobia were predominant in bed process. In conclusion, this study provides basic assessments of these processes and raw materials in compost.

Keywords: Composting process, Raw materials, Physicochemical indices, Microbial dynamics, Core microbiomes.

Mature Compost Promotes Biodegradable Plastic Degradation and Reduces Greenhouse Gas emissions during Kitchen Waste Composting

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Biodegradable plastic (BP) degraded under specific conditions is an option to decrease the environmental effects of plastic waste. Composting provides a controlled environment for transforming biodegradable plastic to compost. It is reported that mature compost addition could shorten the composting period and reduce the greenhouse gas (GHG) emissions. However, the degradation of BP during composting with mature compost addition is not clear. This study explored the effects of mature compost on BP degradation, GHG emissions and bacterial community succession during co-composting of kitchen waste and polybutylene adipate terephthalate (PBAT), in which two treatments were set as adding 20% compost of high temperature phase (MC) and no addition (CK). The goals of this study were to: 1) assess the enhancement of bioplastic degradation in composting by mature compost addition; 2) investigate the influences of mature compost on GHG emissions and composting process; 3) determine the role of mature compost to drive bacterial community succession, identify the dominant bacteria and discuss their relationship with environmental parameters. Mature compost addition prolonged the duration of high temperature (above 60 ℃), from 6 to 11 days. PBAT in MC treatment began to rupture on day 10, while the time was longer in CK. CH_4 is emitted throughout the composting process in all treatments, the cumulative emission of CH_4 in MC reduced 15.73 % compared with CK. Over 21 days of composting, the cumulative N_2O emissions of CK and MC were 23.82 $g \cdot kg^{-1}$ DM and 18.23 $g \cdot kg^{-1}$ DM, respectively. Mature compost reduced total GHG emissions (kg CO_2-eq t^{-1} DM) by 23.5 % eventually. Cracks appeared on the surface of PBAT on the day 21 in both CK and MC by SEM micrograph, and deeper cracks appeared on the surface of PBAT in MC. This is consistent with the results shown in the photos. PCoA with the PCoA1 and PCoA2 axes (explained 48.89% and 26.7% of total variation in bacterial community, respectively) revealed that significant variation in bacterial community was directly related to composting stage, and the difference in microbial community between treatments was most significant on day 0. In MC, Firmicutes and *Thermobifida* were dominant bacterial communities at the phylum and genus levels on day 0, respectively. These bacteria played an important role in rapid rise of heap temperature and reduce nitrogen loss. The VPA showed that the bacterial community succession was mainly attributed to nitrogen components which contributed 42.35% of the observed variation. In conclusion, mature compost addition could increase the bacteria related to organic matter degradation and nitrogen fixation (mainly Firmicutes and *Thermobifida*), therefore promote PBAT degradation and GHG emissions reduction during composting.

Keywords: Biodegradable plastic, Kitchen waste composting, Mature compost, Greenhouse gases, Microbial community.

Effect of Mature Compost as Additive During Municipal Solid Waste Composting

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One of the most serious problems is the safe treatment and disposal of municipal solid waste (MSW). Composting is one of the solid waste management methods in which the organic component is biologically decomposed under controlled conditions. Tirunelveli City corporation is operating micro-composting facilities in which dry leaves collected from the streets become the major bulking agent. However, the quantity of dry leaves is not adequate resulting in inadequate thermophilic temperature or very short thermophilic periods which eventually affect the compost product. Therefore, this study aimed at investigating the effectiveness of mature compost (MC) from the micro-composting facilities as additional bulking agent along with dry leaves. Mature compost (MC) is an inexpensive bulking agent that aids in the composting process. By combining mature compost with raw materials, it can improve inter-particle voids in a composing pile and increase air permeability. It could be used as a different source of microbial inoculants. Mature compost was collected from a micro-composting facility operated by the Corporation. MSW was mixed with mature compost (MC) along with dry leaves (DL) or sawdust (SD) as follows: Treatment 1 -MSW+SD+20%MC, Treatment 2 -MSW+DL+20%MC, Treatment 3 -MSW+DL+30%MC (w/w, dry weight basis). The temperature of the compost piles was monitored every day and the moisture, pH, electrical conductivity (EC), total organic carbon, total Kjeldahl nitrogen, extractable ammonium, and C/N ratio were analyzed every week. The phytotoxicity of the compost was assessed using the seed germination index (SGI). The mixtures were composted for 42 days in 25-L homemade composters. The results revealed that in all treatments, the thermophilic phase was maintained for three weeks. At the end of the composting process, the pH of treatments was slightly alkaline and ranged from 7.62 to 8.07 while the EC was less than 3 mS/cm in all treatments. Total organic carbon contents ranged 35.6-38.0% while the TKN content ranged 1.77-1.89%. The treatment with 30% MC+DL had the highest TKN concentration. The C/N ratio was 21.51, 20.06 and 18.95 in treatments 1,2 and 3 respectively. Treatment 3 showed the highest seed germination index (122.58%), followed by Treatment 2 (117.60%) and Treatment 1 had the lowest SGI (105.42%). Mature compost addition, particularly 30% mature compost addition treatment MSW+DL+30% had a long thermophilic period, a high nutrient content, a high degradation rate, and high seed germination index compared to other treatments. Therefore, MSW+DL with 30% mature compost addition is an optimal mixing ratio for improving the MSW composting process and increasing the quality of the finished compost.

Keywords: MSW, Dry leaves, Mature compost.

Controllability Improvement of Food Waste Composting Quality: A Comparative Study of Control Strategies

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Composting of food waste to produce organic fertilizer is considered an effective strategy for clean organic waste treatment and its conversion into high value-added products in developing countries. In this study, the effect of regulating key parameters (temperature, agitation frequency and aeration frequency) in the composting process using different intelligent regulation strategies on enhancing the controllable level of fertilizer output quality was investigated through a comparative validation experiment. To improve the reproducibility of the experiment, a 7-day rapid composting control strategy meritocratic experiment was conducted using food waste standard samples (high oil and high salt samples (HOAS)). The results showed that there were differences in seed germination index, maximum fermentation pile temperature, and the number of days with fermentation pile temperature ≥ 50°C for the fertilizers produced using different intelligent control strategies for composting process. This study helps to improve the controllability of the quality of kitchen waste composting, thus improving the standardization of composting products, as well as to select an intelligent control strategy for composting process with low energy consumption and excellent reaction rate. It provides a reference for further development of clean treatment technology and waste resource utilization.

Keywords: Food waste, Composting, Composting control strategy, Seed germination index

Study of the Three Common Vermicomposting Species on Cyclical Utilization of Swine Manure in Organic Farmland

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The pig industry is the largest livestock industry in Taiwan, however, it derived much pig manure to be treated. Many studies indicate that the livestock's manure can be effectively treated and turned it into a high added-value compost in an environmentally friendly pathway particularly by vermicomposting, and earthworm can also be used as a raw material feeding other animals. Although the vermicomposting species are commonly known as #2 Tai-pin (red earthworm), they are actually three common species as Eisenia andrei and Perionyx excavates and Eudrilus eugeniae. The present study aims to explore the utilization and substitution of feed material by vermicomposting to achieve a cyclical resource use in Taiwan. The three main vermicomposting species in Taiwan were reared them respectively in spent mushroom substrate (SMS) which was commonly used and field soil from an eco-farm nearby in which the latter for evaluating the possibility of alien species invasion. A total of nine earthworm farms were investigated in this trial and confirmed the main three vermicomposting worms, however only one farm with all three species. Furthermore, we found the body sizes($P<0.001$) and cocoon number of three species ($P<0.01$) were significantly different. No significant differences were found with the survival rate between those cultured in field soil and spent mushroom substrate. Eisenia andrei with a lower survival rate reared in SMS than that of field soil, confirmed that the common vermicomposting species may have the opportunity to survive in the wild. The vermicomposting earthworms used as a feed raw material by proximate analysis of the three earthworms species. The results showed after vermicomposting with pig manure, the nutrition composition of three earthworm species all with high nutrient, hence they all have opportunities as feed material. Particularly Perionyx excavates is the best among the three species with a crude protein 69% and crude lipid 16%. However, the body size of Perionyx excavates being too small to be a good candidate ready for fresh fed living organisms. We recommend the other two species also with high nutrient can be used together with Perionyx excavates on replacing fish meal. Overall, the three vermicomposting species in the present study have good opportunities treating pig manure in Taiwan, they all possess high nutrient and good potential to replace feed material after vermicomposting pig manure. Therefore, the cyclical use of the waste into resource by vermicomposting has feasibility for further development.

Keywords: Vermicomposting, Eisenia andrei, Perionyx excavates, Eudrilus eugeniae, feed substitution.

Preliminary Risk Assessment of Decentralized Composting Systems for Source Separated Biodegradable Wet Waste from Households

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Decentralized composting is recommended as a potential treatment method for source separated biodegradable organic waste from households to reduce waste transport and processing costs at the centralized location. Composting is an aerobic microbial activity which results in air-borne emissions to the surrounding environment. Hence, it is prudent to assess human health risks associated with the activity in decentralized mode. Further, suitable measures should be taken to avoid any such risks. Hence, the present study is an attempt to identify and compare the risks involved with the operation of decentralized composting systems in India and the UK. To achieve the objectives, three types of decentralized composting systems, i.e., rotary drum (RD), plastic drum (PD) and basket (BT) with capacity ~160 L, 140 L and 4.5 L, respectively, were operated for the treatment of household wet biodegradable waste (HWBW) at Mumbai, India for 50 days. The HWBW added to the three systems was 100 kg, 25 kg and 2-2.5 kg, respectively. The RD and PD systems were operated in continuous mode with daily addition of 2.5 kg/day for 10 days while the waste was added only once to the BT system. Several important attributes such as air emissions, leachate generation, exposure to operators and nearby residents were considered qualitatively to evaluate the severity of risk. Subsequently, risk ranking was assigned to each attribute based on the local conditions. The seasonal variations and meteorological conditions have significant impact on the nature of risk. Gaseous emissions such as odour, methane and ammonia are expected from the systems though these may pose low risk to the surrounding residents. However, the risk to systems operators may be higher. In monsoon season, the emissions may be considered much higher compared to those in summer and winter seasons in India. Due to the low moisture content in the HWBW and setting up the composting facility away from receptors, the risks involved were considered relatively lower in the UK as compared to the Indian conditions. One of the recommendations may be the selection of proper location for the decentralized systems. A secluded confined location with proper ventilation may be found for such systems. Further, proper guidelines to place and operate the decentralized systems in developing nations should be formulated. The findings from the presented initial study can be useful for the policy makers to formulate a guidance document on immediate need basis. Whereas the interested researchers can perform rigorous risk assessment study to obtain more detailed and quantitative information.

Keywords: Decentralized composting, Household biodegradable waste, Risk identification and assessment.

Patterns of Heavy Metal Resistant Bacterial Community Succession Influenced by Biochar Amendment During Poultry Manure Composting

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The purpose of this study was to investigate the heavy metal resistant bacteria (HMRB) community succession and bacterial activity in poultry manure composting. Five different concentration of chicken manure biochar (CMB) at 0 %, 2 %, 4 %, 6 %, and 10 % on a dry weight basis was applied with initial feed stock (poultry manure + wheat straw) and indicated with T1, T2, T3, T4 and T5. In addition, high-throughput sequencing, principal coordinate analysis, and correlation analysis were used to analyze the evolution of HMRB communities during composting. The study indicated that crucial phyla were *Proteobacteria, Actinobacteria, Bacteroidetes* and *Firmicutes*. The bacterial diversity in the CMB amendment treatment was higher than in the control treatment, and T4 treatment was the highest in all CMB treatments. Moreover, results from CCA indicated that T4 and T5 treatments quickly enters the high temperature period, which is maintained for 5 days, and is significantly positively correlated with *Proteobacteria,* and *Actinobacteria*. These findings offer insight into potential strategies to understand the succession of HMRBs during poultry manure reuse. Overall, above results show the addition of 6% biochar (T4) was potentially beneficial to enrich the abundance of bacterial community to improve composting environment quality and composting efficiency. In addition, effective to immobilize the heavy metals and HMRB in end product.

Keywords: Heavy metal resistant bacteria, Chicken manure biochar, Poultry manure, Community succession.

Effects of Fungal Pathogen and Assistant Materials on Composting Process of Infected Vegetable Wastes

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Vegetables are easily infected with various soil-borne diseases, which will produce infected vegetable wastes carrying many phytopathogen and may cause pathogen transmission and environmental pollution. Thermophilic aerobic composting is a useful method for killing the pathogens. However, it is uncertain whether the high concentration of pathogens in vegetable wastes will inhibit the composting process and real be removed in the process. With the aim to judge the safety of composting products and provide a theoretical basis for their harmless treatment and utilization, a composting experiment of cucumber plants infected with Fusarium oxysporum f.sp. Cucumerinum (FOC) was carried out to investigate the influence of fungal pathogen and assistant materials (sawdust, bagasse and Chinese medicine slag) on the composting process, and to illustrate the change of pathogen quantity during the composting process. The composting experiment used cylindrical composters with the effective volume of 8 L and under the aeration intensities of 0.20 L kg−1 DM min^{-1}, which lasted for 21 days. Fluorescence quantitative PCR was used to determine the number of pathogens in composting process. The main results were as follows. The heating rate of the vegetable wastes without pathogens was faster than that containing pathogen, which reached 68℃ only after 0.5 days since the start of composting. Its highest temperatures was 70.31°C, lower than 73.05℃ that reached in the treatment of infected vegetable wastes. Sawdust and Chinese medicine slag lasted prolonged the duration above 55℃, shown as 8 days and 13 days, respectively. Meanwhile Chinese medicine slag significantly reduced the ammonia emission. The final seed germination rate in all treatments reached the basic standard of decomposition. After composting, the number of pathogens in the treatment with sawdust, bagasse and Chinese medicine slag was 70.8 CFUs/g, 467.6 CFUs/g and 266.3 CFUs/g. Compared with the initial value, the removal rates of the treatment with sawdust and Chinese medicine slag were 80.3% and 35.6%. In conclusion, pathogens in raw materials would not inhibit the normal process of composting. Different assistant materials had different removal effects on pathogens in composting, in which sawdust and Chinese medicine slag were better. Further verification is needed for safely utilization of vegetable wastes with pathogens in agriculture.

Keywords: Diseased vegetable waste, Aerobic compost, Pathogens.

Bacterial Dynamics and Functions Driven by Fermentation Material Backflow to Reduce Environmental Burden During Food Waste Composting

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Globally, 30%-50% of food is wasted. To reduce the adverse climate impact caused by more than 1.3 billion tons of food waste, composting is receiving increasing attention from countries around the world. Control of pollutant gas emissions in food waste composting is a matter of global sustainable development. In order to clarify the effect of mature compost backflow on the pollutant gas emissions of composting process and its cyclic reinforcing effect on the structure and metabolic function of indigenous bacterial. Food waste were used as raw composting materials, rape straw and sawdust as auxiliary materials in this study, and composted under the initial conditions of C/N of 30 and moisture content of 60% with non-backflow (CK) as the control, and investigated the effect of different fermentation periods of materials such as backflow of thermophilic material (GW), cooling material (JW) and mature material (FS) on the pollutant gas emissions and bacterial community structure. High-throughput sequencing was integrated with functional Annotation of Prokaryotic Taxa (FAPROTAX) to decipher the mechanism of the above effects. Results show that the accumulative emissions of N_2O in GW was reduced by 20.7%, which could be ascribed to the higher abundance of the genus *Bacillus* in the phylum *Firmicutes*, which accelerated organic biodegradation and promoted higher temperatures. The genus *Pseudoxanthomonas* and *Acinetobacter* was a typical group of denitrifying bacteria and unfavourable to high temperature and therefore N_2O emissions were reduced. FS reduced the accumulative NH_3 and CH_4 emissions by 21.54% and 24.03%, and nitrogen losses by 56.32%, which was closely related to the decrease of pH and the enhancement of methane oxidation in composting. Results reported here show that backflow of thermophilic material has obvious effect on N_2O emission reduction. Backflow of mature material reduce the NH_3 and CH_4 emission and reduce nitrogen losses. Therefore, it is possible to shorten composting period and reduce the pollution gas emissions by changes in bacterial dynamics and functions driven by fermentation material backflow.

Keywords: Food waste, Composting, Fermentation material backflow, Gaseous emission, Bacterial dynamics and functions.

Effects of Biochar, Superphosphate and Magnesium Sulfate as Additives on Gaseous Emissions during Chicken Manure Composting

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This study used a laboratory-scale system to investigate the effects of biochar (BC), superphosphate (SP), superphosphate and magnesium sulfate (SP+MS), and a combination of three additives (BC+SP+MS) on gasous emissions and antibiotic degradation during chicken manure composting. The results showed that after 35 days of composting, all treatments met the maturity requirements, with a GI of 99%-122.8%.

For N-containing gas emissions, neither BC nor SP had the effect of reducing NH3 emission, while the treatments with MS (SP+MS and BC+SP+MS) reduced NH3 emission by 38.8-47.9%. But all additive treatments increased N2O emissions.

For the emission of sulfur-containing odor gases, all additive treatments reduced the total gas emission by 51.3%-72.0%, and the effect of BC+SP+MS was the best. Specifically, SP+MS and BC+SP+MS reduced H2S emissions by 34.4%-35.3%. BC had the best emission reduction effect on Me2S, with a reduction rate of 92.76%. BC+SP+MS had the best emission reduction effect on Me2S2, and the emission reduction rate reached 97.0%.

A total of 23 different classes of antibiotics (tetracyclines, sulfonamides, quinolones) were detected throughout the composting process. During this period, 82.8%, 82.21% and 92.05% of tetracycline, sulfonamide and quinolone antibiotics were removed, and the thermophilic period of the first 14 days of composting was the main period of antibiotic degradation. However, some of the sulfonamide antibiotics were also enriched, so that the detected concentration after composting was higher than that in the original chicken manure. Different additives had little effect on the degradation of antibiotics, and the total removal rate of antibiotics in BC treatment was slightly higher, reaching 95.25%.

Keywords: Composting, Biochar, Superphosphate, Magnesium sulfate, Gaseous emission.

Influence of Different Bulking Agents on Municipal Solid Waste Composting

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Composting is an effective and low-cost treatment method for the treatment of municipal solid waste (MSW), especially in developing countries. Municipal solid waste composting at the community level suffers from sourcing adequate and ideal bulking agents to obtain an effective composting process. Mainly, the dry leaves collected from the streets become the major bulking agent; however, the quantities are not adequate. The bulking agents enhance the composting conditions and the quality of the compost product in terms of composting temperature, porosity, water retention, particle-size distribution, pH, electrical conductivity (EC), nitrogen losses, humification indices, microbial numbers, enzyme activities, macro- and micro-nutrient contents, and toxicity to germination seeds. Therefore, this study aimed at investigating the influence of sawdust (SD), woodchips (WC), dry leaves (DL), and paddy straw (PS) as bulking agents in composting MSW. Four treatments were included in the study as follows: MSW+WC+SD (1:0.5:0.5), MSW+SD (1:1), MSW+PS (1:1), and MSW+DL (1:1), the mixing ration was in w/w dry basis. The mixtures were composted for 42 days in 25-L homemade composters. The temperature of the compost piles was monitored every day, while the moisture, pH, electrical conductivity (EC), total organic carbon, total Kjeldahl nitrogen, extractable ammonium, and C/N ratio were analyzed every week. The phytotoxicity of the compost was assessed using the seed GI.

The results revealed that in all treatments, the thermophilic phase was maintained for two weeks. The pH range at the end of composting was 6.45 to 7.86; and the electrical conductivity was less than 4 mS/cm in all treatments. When compared to other treatments, the MSW + DL treatment had the highest NH4+-N content, nitrogen content, and seed germination index. Results indicate that use of dry leaves as bulking agents in a 1:1 ratio with MSW significantly improved compost quality and reduced the composting period to six weeks.

Keywords: MSW, Bulking agents, Dry leaves, Paddy straw, Sawdust.

Control of Nitrogen and Odor Emission during Chicken Manure Composting with A Carbon-Based Microbial Agent Inoculation and Biotrickling Filter

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The large-scale and intensive development of the livestock and poultry breeding industry has resulted in large amounts of untreated organic waste, causing serious environmental and social problems. Composting is widely used in the centralized treatment of livestock and poultry manure because of its advantages, such as low production cost, efficient processing, and high-quality products. However, odor is one of the challenges in the aerobic composting of poultry manure, which generally contains ammonia (NH_3), hydrogen sulfide (H_2S), and total volatile organic compounds (TVOCs). The emission of these odorous gases causes harm to the human body and the environment. Moreover, it causes the loss of nitrogen, sulfur, and other essential elements in products, resulting in a decline in product quality.

In this study, the modified corn straw biochar was used as a carrier additive to select and cultivate nitrifying bacteria with high efficiency and easy survival. Based on the optimal proportion, the efficiency of carbon-based microbial agent on nitrogen fixation in the chicken manure composting process was studied to reduce nitrogen loss and odor production. The biotrickling filter (BTF) treatment technology was combined to reduce odor emission further and recover effective elements in odor substances.

Results showed that adding a carbon-based microbial agent accelerated the heating time of the compost, shortened the high-temperature period, increased the putrefaction period, reduced the volatilization of ammonium nitrogen in the pile, and accumulated a large amount of nitrate nitrogen. Moreover, the compost product obtained a high maturity degree. The addition of carbon-based microbial agent reduced the odor intensities of NH_3, H_2S, and TVOCs in the stack by 25.06%, 18.28%, and 13.50%, respectively. The deodorization effect of BTF was stable, and the removal rates of NH_3, H_2S, and TVOCs reached more than 90%, 96%, and 56%, respectively. Compared with the control group, the group with added carbon-based microbial agent exhibited a high NO_3^--N content and a total nitrogen retention preservation rate increased by 36.59% and 14.60%, respectively, after composting. Microbial sequencing showed that carbon-based microbial agent effectively changed the microbial flora in the compost, protected the ammonia-oxidizing microorganisms, including *Thaumarchaeota*, *Crenarchaeote*, *Nitrosospira*, and *Nitrosomonas*, from the menace of high temperature, and strengthened the nitrification of the compost. In addition, the abundance changes in denitrifier groups containing *nirS*, *nirK*, and *nosZ* denitrifier genes were also investigated. The nitrifying and denitrifying microorganisms dominated by *Pseudomonas*, *Pusillimonas*, and *Paracoccus* were more active in the cooling period than they were in the thermophilic period. Moreover, the denitrification effect was weak in the addition of carbon-based microbial agent system. Thus, a large amount of nitrogen was retained in the carbon-based microbial agent system.

The outcome of this study confirmed that the carbon-based microbial agent could accelerate the composting process and promote the activity of nitrifying microorganism, thereby reducing odor emission and increasing nitrogen accumulation.

Keywords: Chicken manure composting; Odor; Nitrogen; Biotrickling filter; Carbon-based microbial agent.

Dynamics of Oxytetracycline, Sulfamerazine, and Ciprofloxacin and Related Antibiotic Resistance Genes during Sewage Sludge Composting

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Understanding the dynamics of antibiotic and related antibiotic resistance genes (ARGs) during sewage sludge composting is crucial in assessing the environmental risk of antibiotics, which could effectively reduce their impact in natural environments. This study investigated the dissipation of oxytetracycline (OTC), ciprofloxacin (CIP), sulfamerazine (SM1) and related ARGs during sewage sludge composting. These antibiotics were together pre-spiked into the sewage sludge at two concentration levels. The results indicated that the removal efficiency of antibiotics by composting were >75%, except for the SM1 in low antibiotic concentration level treatment. Compared with the relative abundance depletion rate of ARGs (27.54%) in the control treatment, the high and low antibiotic concentration level treatments can greatly enhance the reduction of ARGs, which the depletion rates of ARGs were up to 64.33% and 48.52%, respectively. Statistical analyses indicated that the behaviour of these class antibiotics and ARGs were controlled by microbial activity (such as *Proteobacteria, Bacteroidetes and Chloroflexi*) and significantly influenced by environmental factors (mainly pH, TOC and moisture) throughout the composting process.

Keywords: Antibiotic; Antibiotic resistance genes; Sewage sludge, Composting, Bacterial community.

Co-composting of Food Waste with Organic Materials: Impact of C/N Ratio

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With the rapid increase of the population and industrialization, vast amounts of food waste is being generated. Food waste is the most abundant organic component of the municipal solid waste. Globally, more than 1.3 billion tons of food goes as waste each year. Food waste is the largest fraction of waste reaching landfill. Once landfilled, degradation especially anaerobic, contributes to greenhouse gas emission and global warming. Current major uses of food waste as a substrate include: animal feed, composting, anaerobic digestion, incineration. Composting is a bio-oxidation process, in which microorganisms breakdown organic matters into hygienic and humus rich stable product. Composting is receiving increased attention as an alternative organic waste management practice due to increased pressure from community to reduce the impact on the environment. The nitrogen loss due to NH_3 emissions is a key reason for reducing the compost quality. This study aimed at investigating the use of organic materials such as neem cake (NC), peanut cake (PC) and sesame cake (SC) as co-composting substrates with food waste to increase the compost quality.

Food waste was mixed with sawdust as bulking agent and mixed with the above-mentioned organic materials and composted in lab-scale reactors for 42 days. The physicochemical parameters like pH, electrical conductivity, temperature, extractable ammonium, total organic carbon, total Kjeldahl nitrogen, and C/N ratio were evaluated regularly. The results indicate that neem cake resulted in higher nitrogen content of the compost when compared to other materials.

Keywords: Food waste, Organic materials, Co-composting, Neem cake.

Nitrogen Retention and Emissions during Kitchen Waste and Fallen Leaves Aerobic Composting Covered with A Semi-Permeable Membrane

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Aerobic composting is an effective method for the treatment of kitchen wastes. However, this method also has some disadvantages, mainly reflected in that the composting process will release a large amount of NH3 and a certain amount of greenhouse gases, which not only reduces the fertilizer quality, but also causes secondary pollution to the air. In recent years, the new technology of aerobic composting covered with semi-permeable membrane has performed well in reducing gas emissions. The membrane-covered aerobic composting system itself will form a micro-high-pressure inner cavity, which makes oxygen flow and distribution in the material better, can significantly accelerate the ripening process of the material, and reduce the population and abundance of anaerobic microorganisms. This study is the first time to apply the membrane-covered system to the aerobic composting of kitchen wastes. In the experiment, fresh kitchen waste from school canteen was used as raw material, leaves were added as filler to adjust moisture content and C / N ratio, and non-membrane-covered aerobic composting was used as control. The composting performance, nitrogen retention and release and bacterial community succession characteristics of kitchen waste under membrane-covered aerobic system were studied systematically.

The composting experiment lasted 35 days. During the whole cooling period, the experimental group (EG) maintained a higher composting temperature than the control group (CG), which indicated that the experimental group experienced a more thorough process of organic matter degradation. At the end of composting, the NH4+ concentration in EG group decreased to 5.34 g/kg, which was 28.06% higher than that in the CG group (4.17 g/kg).At the end of composting, NO3− and NO2− concentrations reached 1.92 g/kg and 0.20 g/kg in EG group, and 0.93 g/kg and 0.13 g/k in CG group, respectively. The semi-permeable membrane effectively controlled the release of NH3. Compared with CG group, the emission of NH3 outside the membrane in EG group decreased by 48.50%. Compared with CG group, the N2O emission of EG outdoors decreased by 44.05%, and the EG inside also decreased by 31.46%. During the whole composting period, the TN concentration (dry matters) of EG group and CG group increased from the initial concentration of 17.8 g /kg to 21.22 g /kg and 20.64 g /kg respectively. From high temperature period to the end of composting, the TN concentration in EG group was higher than that in EG group

($P<0.05$). The higher retention and less emission of nitrogen in EG is significantly relevant to the bacterial community. More ammonia-oxidizing archaea and ammonia-oxidizing bacteria were found in EG in the thermophilic stage, these strains contributed to the retention of nitrogen by transforming nitrogen to nitrate and nitrite.

The results show that the use of membrane-covered aerobic composting technology to treat kitchen waste can promote the maturity of the compost, increase the nitrogen rate of the compost, which is an effective means to improve the emission of pollutants in the composting process of kitchen waste.

Keywords: Membrane-covered; Aerobic composting; Gas emission；Bacterial community.

Chicken Manure Composting: Effect of Initial Carbon / Nitrogen ratio

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Chicken manure is one of the important valuable resources as a soil fertilizer, providing a high content of macro- and micronutrients for the plant growth. The untreated chicken manure can cause very serious environmental problems such as emission of toxic greenhouse gases, leaching of nitrates, groundwater pollution, human and animal risks, etc. Composting is an effective, inexpensive alternative method for stabilizing the chicken manure. In this study, the physicochemical and biological parameters were examined to assess the effectiveness through stability and maturity indicators during the composting of chicken manure (CM) with different amount of sawdust (SD) at different initial C/N ratio of 20, 25 and 30 at lab-scale.

The composting process was monitored through the analysis of selected physicochemical parameters at regular intervals. The composting mixture with the initial C/N ratio of 30 showed prolonged period of thermophilic phase and maintained the temperature exceeding 60°C for more than 7 days which would be effective for the destruction of pathogens. But the composting mixtures with initial C/N ratio of 20 and 25 did not meet that requirement. The final electrical conductivity values of the composting products were 4.22, 4.10 and 3.75 mS/cm respectively while the total organic carbon values were 30.61%, 31.51% and 35.46% in the composting mixtures, respectively. The results of ammoniacal-N of the composting mixtures indicated that the transformation of ammoniacal-N into nitrate by nitrification activity. Three different crops, maize, sorghum and tomato were selected for assessing the compost stability and maturity. The composting mixture with C/N ratio 30 showed the seed germination 50-84%, and biomass 37-64% in the selected crops. The results of this study suggested sawdust used as bulking agent at the optimum C/N ratio 30 for the composting of chicken manure was ideal to achieve the rapid degradation of organic matter and great retention of essential nutrient elements.

Keywords: Chicken manure, Sawdust, C/N ratio, Compost, Nutrient transformation, Compost maturity.

Potential of Carbon Emissions Avoidance from Food Waste Composting in Higher Education Institution (HEI)

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Globally, the amount of food waste is estimated to be about 1.3 billion metric tons per year (FAO, 2011). The environmental impacts of food waste are substantial (FAO, 2013a). In 2013, the Food and Agriculture Organization (FAO) of the United Nations determined that the amount of greenhouse gas emitted annually due to food waste in landfills is almost equivalent to the total emissions of Cuba (about 3.3 billion tons of CO2e/yr). Among all the treatment technologies, composting is most recommended because it able to reduce waste disposal in landfills, while simultaneously recycling organic materials by converting them into a beneficial product. This study aims to calculate the potential carbon avoidance by using carbon footprint assessment via case study of an established composting system at Universiti Malaya from year 2012 until 2021. The avoidance of carbon emissions are calculated from the avoidance of food waste degradation in landfill and transportation of food waste to landfill, and saving of diesel used for the transportation. The result shows that composting of food waste has great potential in carbon avoidance. The finding from this study addresses climate change in a comprehensive way and promoting a sustainable solution that is easier to start and manage to reduce food waste from being disposed to the landfills from HEIs.

Keywords: Food waste; Carbon avoidance; Composting; Carbon footprint assessment; Sustainable.

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Biowaste Valorization

Insect-based Biorefinery for Organic Wastes Valorization

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Food security is at the forefront of the critical global concerns due to increased population growth, rapid urbanization, increased occurrences of climate-related disasters (e.g., extreme heat, droughts, floods, and storms), and pandemics like COVID-19. Growth in population and affluence is likely to increase the global food demand by over 50% by 2050. The conventional agricultural practices for producing food and feed are highly resource intensive (high use of fresh water and synthetic agrochemicals including fertilizer and pesticides), leading to eutrophication, soil degradation, greenhouse gases emissions, biodiversity loss, among others. At the same time, over a billion metric tons of food is being wasted each year, accounting for 17% of total food produced for human consumption. Moreover, organic waste management has been a long unsolved issue elsewhere, especially in low- and middle-income countries. In the context of environmental, economic, public health, and food security issues associated with the ever-increasing and non-sustainable way of using limited resources for food and feed production, coupled with the generation of large amounts of organic wastes, insect farming on organic wastes has gained significant research and development interest as one of the emerging industries for valorizing different organic wastes to high-quality food, feed, fertilizer, and bioproducts. Such interest is also reflected in the increased investment in the sector (insect industry for food and feed application), which is expected to increase from about US$ 1 billion in 2020 to over US$ 3 billion by 2025, while market value and market volume of the insect for food and feed industry is projected to reach US$ 9.6 billion and over 3.1 million metric tons by 2030, respectively. This presentation critically discusses the current state-of-the-art of bioconversion of organic wastes into food, feed, fertilizer, and bioproducts via insect farming; identifies the research gaps; and highlights the challenges associated with development and commercialization of the insect technology.

Keywords: Organic wastes, Insect farming, Bioconversion, Biorefinery, Bioproducts.

Integrated Genomic and Field Level Evaluation of Agricultural Waste Enriched Potential Streptomyces UP1A-1 for Plant Growth Promotion and Disease Control

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This study was designed to investigate the cultivable rhizosphere Streptomyces associated with disease control and their plant growth promoting ability. The potential Streptomyces UP1A-1 was previously isolated and tested for their ability to control bacterial wilt and promote growth of solanaceae crops in-vitro and in-planta. Further, the current study planned to utilize the agricultural waste materials farmyard manure enriched talc-based Streptomyces UP1A-1 to evaluate the plant growth and bacterial wilt disease control of tomato and eggplant in different agricultural field conditions. In both field conditions the bio-formulation Streptomyces UP1A-1 was recorded the least disease incidence of 8.32 and 3.32 plant disease index in tomato and eggplant, respectively. Similarly, the FYM enriched bio-formulation Streptomyces UP1A-1 recorded the highest total yield of tomato and eggplant fruits by recording 39,387 kg/ha and 29,489 kg/ha of tomato and eggplant, respectively. The genome sequence of the strain UP1A-1 was obtained using an Illumina HiSeq 2000 sequencing system using the paired-end sequencing. Predicted and annotated gene sequences were analyzed for similarity with the Kyoto Encyclopedia of Genes and Genomes enzyme database. The results show that the Streptomyces UP1A-1 genome has a total of 8,252,902 bp with 72.42% G + C content. PGP conferring genes such as siderophore production, indole-3-acetic acid (IAA) biosynthesis, phosphate solubilization, nitrogen metabolism and pottasium metabolism were determined. Similarly, genes putatively responsible for disease control including chitinase production, peroxidase, superoxide dismutase, catalase, proline biosynthesis and glucose dehydrogenase were determined. Moreover, genes putatively responsible for resistance to other stress factors including oxidative stress response GABA production, osmotic stress alleviation, cold shock protein, phenazine production, trehalose metabolism and heat shock protein were also observed in the UP1A-1 genome. These genes reveal the genetic adaptation of UP1A1 to versatile environmental conditions and the effectiveness of the isolate to serve as a biotic and abiotic stress controller.

Keywords: Agriculture waste, Farmyard Manure, Streptomyces, Whole genome sequencing, Plant growth, Disease control.

Investigation of Morphological Characteristics of *Abelmschus esculentus* During Terrestrial Weed Compost Amendment in Soil

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Terrestrial weeds pose the greatest threat to agricultural ecosystems, wreaking havoc on nearby plants by impeding fruit production and weakening the leaves. In the current study, compost prepared from terrestrial weeds such as *Ageratum conyzoides*, *Parthenium hysterophorus* and *Lantana camara* was high in nitrogen (3.2, 2.47 and 2.74%), accessible phosphorus (3.62, 4.34 and 4.42 g/kg), and potassium (32.5, 51.5 and 34 g/kg). The compost to soil ratio was varied from 5, 10, 15, 20, 25, 35, 45, and 100% in a 10 L pot with a height of 50 cm and an upper diameter of 30 cm. Germination, quantity of leaves and fruits, and plant height of *Abelmoschus esculentus* were all monitored. Compost percentages ranging from 15 to 25% resulted in high germination rates ranging from 80 to 100%. The potassium content in the fruits was higher at 45% compost amended soil ranging between 750 to 1050 mg/kg. The heavy metal content such as lead in the fruits was higher than the permissible limit (0.1 mg/kg) ranging between 1.8 to 2.5% from 5 to 100% compost amendments. The 25% compost composition could be feasible composition in growing horticulture crops compared to edible crops as compost contains more lead content.

Keywords: Terrestrial weeds, Abelmoschus esculentus, Nutrient rich, Composting, Macronutrients.

Odor Characterization and Health Risk Assessment of Food Waste Bioconversion By Housefly (Musca Domestica L.) Larvae

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Bioconversion of food waste by insect is drawing increasing attention in recent years, due to the increasing food waste generation, growing protein demand, and promotion of source separation of municipal solid waste. Bioconversion by housefly (*Musca domestica* L.) larvae is a novel technology for reducing and recycling food waste. In this study, the odor characteristics and health risks of gaseous pollutants from food waste bioconversion by housefly larvae were investigated and compared with other treatment technologies for the first time. The air samples were collected from different areas in a full-scale food waste bioconversion facility (50 t/d), and their chemical compositions were quantitatively and qualitatively analyzed. Based on which, the odor contribution and annoyance were assessed with the odor activity values (OAVs) and their sum (SOAVs), and the health risks (carcinogenic and non-carcinogenic risks via inhalation and other risks) were evaluated. The total concentrations of volatile compounds were significantly higher in the breeding and biodegradation areas than in the other areas. The air composition in the breeding area was the most complex. Ethanol was the dominant odorant in the unloading, pretreatment, substrate storage, and breeding areas, while that was ammonia in the biodegradation and product areas. The SOAVs in the breeding and biodegradation areas were the highest (1171 and 756, respectively) with trimethylamine as the key odorant. Carcinogenic risk in the breeding area was unacceptable with acetaldehyde as the key carcinogen, and possible carcinogenic risks existed in the other areas except for the substrate storage area. Non-carcinogenic risk existed in the order of breeding area > biodegradation area > product area > pretreatment area with acetaldehyde, ethyl acetate, hydrogen sulfide, and ammonia as the dominant contributors. Corrosive, irritant, acute toxic, and health hazardous substances were detectable in all sampling sites. Odorants can form secondary pollutants, such as particulate matter (<2.5 μm) and ozone, which cause health risks. The breeding area was considered as the priority area for carcinogenic and non-carcinogenic risk control, followed by the biodegradation area. The bioconversion technology showed different odor characteristics and health risks from other treatment technologies. In terms of reducing sulfur compound emissions, insect-based bioconversion is favorable due to the enhanced oxygen transfer effect. Odor control and health protection measures should be taken based on the odor and health risk evaluation. The principle of similarity was proposed for the design of odorous gas collection, and health risks, SOAVs and major odor contributors were suggested to be considered for the design of ventilation rates and gas treatment methods. The findings provide a scientific basis for odor control and health protection in food waste bioconversion facilities.

Keywords: Odor, Health risk, Food waste, Bioconversion, Housefly larvae.

Bio-Waste Valorisation As Sorbent For Removal Of Methylen Blue From Aqueous Solutions

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Our objective is to prepare low-cost, environmentally friendly adsorbents for green chemistry by recovering waste from the agri-food industry, and to assess their capacity in water treatment. In this work, agro-wastes coming from sunflower seed shells are used as low-cost biosorbents to remove methylene blue (MB) from aqueous media. Batch experiments are performed under different experimental conditions investigating the effects of biosorbent amount and pH. The properties of sunflower seed shells were identified through characterization by different method namely: dosage of surface functions by the Boehm method and by infra red spectroscopy (IR), pH of point zero charge (pHpzc), iodine index, phenol index, methylene blue number. The characterization results show that this adsorbent has an acid character according to the three tests (IR, Boehm the existence of the dominant acid functions and pHpzc=4.9), In order to assess their adsorption capacity and develop a mathematical model describing the process and also to minimize the number of tests, we were interested in modelling the adsorption of methylene blue by the powder of sunflower seed shells (PSSS), using an experimental design, considering pH and mass as variables. The modeling results indicate that under optimal conditions of pH=10 in the pH study interval (between 4 and 10) and adsorbent mass = 0.5g in the study interval (between 0.5 and 1g), sunflower seed shells have significant capacitie of MB adsorption, it is of the order of QMB=1.15 mg/g. Finaly we can say that this adsorbent can retain and eliminate macro and micro molecules, it has an acid character therefore, it is favorable to the basic medium pH 10, and that the optimal mass of adsorption is equal to 0.5g.

Keywords: Adsorption, Adsorbent, Optimization, Experimental design, Methylene blue.

Potential of Bio-Risks in MSW Management System

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Microbial (bacteria and fungi) community structures and their distributions in urban household municipal solid waste (HMSW) were characterized in a sampling campaign in 38 cities of China covering 5 climatic zones. All these HMSW samples were collected from garbage containers in residential communities in winter (11 to 26 January) of 2022. A total of 110 species of bacteria belonging to 247 genera, 110 families and 22 phyla were identified among the samples. Firmicutes (44.3%), Bacteroidetes (33.77%) and Proteobacteria (21.54%) were the top 3 dominant phyla, and Arcicella (33.11%) and Leuconostoc (21.87%) were the dominant genera. Meanwhile, 234 species of fungi belonging to 124 genera, 84 families and 7 phyla were detected. Ascomycota was the most dominant phylum, with an average relative abundance of 77.31%. Hanseniaspora (24.03%), Debaryomyces (13.47%), Candida (12.18) and Cystofilobasidium (9.95%) were the top 4 dominant genera. Alpha-diversity index analysis showed that the species richness and diversity of bacterial and fungal communities of HMSW samples belonging to different climatic zones did not differ significantly. Correlation analysis between microbial community structure and local climatic showed that the microbial communities were more similar between HMSW samples from temperature and subtropical monsoon climatic zones, while those from temperature continental climatic zones were different. Nonmetric multidimensional scaling (NMDS) analysis demonstrated that climatic had an effect on microbial communities but did not show a significant correlation. In addition, the study identified 13 bacterial and 16 fungal species as pathogenic. The most abundant pathogenic bacteria and fungi detected were Pseudomonas putida (0.25%) and Sclerotinia sclerotiorum (2.12%), respectively. These findings provide valuable data for the prevention and control of biological risks associated with municipal solid waste (MSW) facilities.

Keywords: Municipal solid waste, Bacteria, Fungi, Biological risk.

Ecological Effects of Organic Fertilizers Produced from Agrowastes with Different Carbon-Nitrogen (C/N) Ratios on Corn Growth, Soil Chemical Properties and Earthworm Behavior

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Organic amendments in the form of compost, manure, and several other agricultural wastes are a source of plant nutrients that also improve soil quality. Currently, many existing composting technologies aim to convert raw materials into organic fertilizers that can be used in agriculture effectively. However, in most cases, organic fertilizer production has been restricted at higher C/N ratios of agrowastes. There should be a proper balance of C and N if decomposition is to proceed rapidly. An experiment laid out in a split-plot in a completely randomized design was conducted to determine the recovery and chemical properties of organic fertilizers produced from the decomposition of raw agrowaste mixtures with different C/N ratios and its effect on corn growth, soil chemical properties, and earthworm behavior. The preparation of different C/N ratios of poultry manure mixed with shredded rice straw and poultry manure mixed with carbonized rice hull was based on the moisture content, organic carbon, and total nitrogen analyses. To attain the 15:1, 20:1, 25:1, 30:1, and 35:1 C/N ratios of the mixture of two materials to be mixed, the determination of organic carbon, total nitrogen through chemical analysis, and moisture contents through oven drying were conducted. The organic carbon (C), total nitrogen (N), and moisture content data were plugged into the formula adopted from Cornell Waste Management Institute, Cornell University. For the seedling emergence test, the seeds were placed in pots in contact with soil treated with fertilizers derived from agrowastes with different C/N ratios. The effects were evaluated for 21 days after seedling emergence in the control group and all treated media. Endpoints were determined as visual assessment of seedling emergence, biomass measurements, shoot height, and the visibly damaging effects on different parts of the plant. The test was conducted to determine the dose-response curve, or at one concentration/rate as a limit test. Also, the earthworm avoidance behavior assay (ISO 17512-1:2008) was conducted as a rapid screening method for assessing the influence of contaminants and chemicals on earthworm behavior. Results show that increasing the C/N ratio increases the recovery rates of compost. Although the chemical properties of composts are considerably high, increasing the C/N ratio lowers the pH, organic carbon (OC), total phosphorus (P), total potassium (K), and total NPK. It is worth noting that its application significantly enhances corn growth and improves soil chemical properties such as pH, % OC, available P, available K, and CEC. No toxicity was found based on the earthworm avoidance test. Application of organic fertilizer to acid soils, a common problem in the Philippines, is recommended as it increases soil pH.

Keywords: Organic fertilizer, Ecological, Decomposition, Earthworm, C/N ratio.

Carbon Emissions in Treating Food Loss and Waste in China Based on Life Cycle Assessment

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More than 30% of food is transferred into loss and waste in the process of food supply chains. Treating food loss and waste (FLW) would consume a large amount of energy, generating obvious carbon emissions. Thus, the treatment of food loss and waste should be paid attention to, in order to mitigate carbon emissions. In this study, carbon emissions features of FLW treatment were identified in a life cycle assessment (LCA) framework. This study focused on the following stages of FLW treatment: (1) crop planting and livestock breeding; (2) food supply; (3) food production; and (4) food consumption. The following related waste treatment technologies were also incorporated in the system boundary: composting, incineration, anaerobic digestion, biomass reuse, and landfilling. In consideration of multiple uncertain conditions (i.e., FLW treatment, and food consumption), experiment design methods (e.g., copula sampling, Monte carlo simulation, and Latin hypercube sampling) were proposed. The results demonstrated that a large amount of carbon emissions in FLW treatment was generated in the production and storage stages. Alternative solutions in FLW treatment (e.g., such as biomass reuse) can mitigate a certain proportion of carbon emissions. Reducing food loss at consumption stage was also significantly important for mitigating carbon emissions. This study provided a nexus approach for analysing and quantifying the carbon emissions in treating FLW in China. The finding of this study can serve as a theoretical basis for setting reduction carbon targets and formulating mitigation measures in food management.

Keywords: Food loss and waste, Waste treatment, Life cycle assessment, Carbon emissions, Uncertainty analysis.

Environmental Evaluation of Emerging Bakery Waste Oil-Derived Sophorolipids Production by Applying Dynamic Life Cycle Assessment (dLCA)

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Sophorolipids (SLs) are promising biosurfactants that have attracted the attention from both academia and industry due to its enhanced properties in comparison to their petroleum-derived surfactant counterparts. Increasingly, researchers are utilizing the waste streams as feedstocks to reduce the economic cost and meet the requirements of sustainability and green chemistry. Although such waste valorization minimizes the use of first-generation substrates, the systematic environmental impacts must be assessed by considering the different materials and processes to improve the sustainability of the process. For this reason, the dynamic Life Cycle Assessment (dLCA), due to its iterative nature, is applied to identify the tradeoffs between potential environmental impacts early on in the research and development phase. Our previous dLCA traversal has demonstrated that food waste hydrolysate (FWH) is a promising hydrophilic carbon source, while oleic acid as the 1st-generation hydrophobic carbon source, should be a significant pollution source. Hence, this work evaluates the environmental performance of using bakery waste oil (BWO) as a hydrophobic feedstock. The 4th and 5th traversal of the dLCA showed that although BWO brought more environmental pollution than the pure first-generation substrate, proper pH regulation could effectively reduce its environmental burden. In the 6th traversal, the further comparison showed that if SLs production is applied batch fermentation, using BWO as substrate was more environmentally friendly than using FWH. This paper suggests that multi-technique incorporation, such as feeding with FWH and BWO together equipped with fed-batch fermentation and in-situ separation, may further reduce environmental impacts, meanwhile providing a clear direction for the experimentalists.

Keywords: Life cycle assessment, Sophorolipids, Biosurfactants, Bakery waste oil, Environmental impacts.

Preparation and Characterization of Cellulose Triacetate from Cocoa Pod Husk (CPH)

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The valorisation of agricultural residues into a high value-added product is necessary to respond to the global environmental concerns caused by the pollution of agricultural waste. The objective of this study was to shed light on a new way of value-added use of CPH for the synthesis of cellulose triacetate.
Cellulose was isolated from CPH by alkaline pre-treatment with an aqueous solution of NaOH 5 wt% followed by bleaching with 2 wt% hydrogen peroxide. The extracted cellulose was produced in 54% yield. Cellulose triacetate (CTA) was synthesized by acetylation reaction of extracted cellulose in the presence of acetic acid, acetic anhydride and sulfuric acid. The CTA obtained had a degree of substitution of 2.87 and a percentage of the acetyl group of 43.75%.
The cellulose and CTA produced were characterized by Fourier transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD) and scanning electron microscopy (SEM) combined with X-ray energy dispersive analysis (EDAX). The FTIR result showed the appearance of ester group (C=O) and acetyl group (C-O) stretching, indicating the formation of cellulose acetate. The XRD showed that the crystallinity index of the cellulose of CPH was 38.43% while indicating the semi-crystalline nature of the CTA produced. SEM morphology observation showed that the synthesized CTA was in the form of small and medium-sized rough and spongy particles. EDAX spectra showed that the CTA consisted mainly of carbon (C, 87%) and oxygen (O, 13%).
This study thus reveals that CPH represent in this work a very important source of biomass of cellulose and its derivatives.

Keywords: CPH (Cocoa pod husk), cellulose, Cellulose triacetate, acetylation, Degree of substitution.

Valorization of Cocoa Pod Husk in High Value Added-Products

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Cocoa pod husk (CPH) is a carbohydrate-rich lignocellulosic biomass, and it is abundant and readily available in Côte d'Ivoire for the production of materials and bioproducts. The present study aimed to produce cellulose triacetate (CTA) and microbial lactic acid (LA) from this residual biomass.

CTA was produced after isolating cellulose from CPH, by alkaline pretreatment with 5% (w/v) NaOH and bleaching with 2 % (v/v) hydrogen peroxide. A yield of 54 % (w/w) of cellulose was obtained. Then, TAC was synthesized by acetylation reaction of the extracted cellulose in the presence of acetic acid and anhydride catalyzed by sulfuric acid. A degree of substitution of 2.87 and an acetylation percentage of 43.75 % were obtained. FTIR results confirmed the formation of cellulose acetate by the appearance of ester group (C=O) and acetyl group (C-O) stretching. XRD gave a cellulose crystallinity index of 38.43 % while indicating the semi-crystalline nature of CTA. Morphology and elemental observation (SEM-EDX) showed small and medium rough and spongy particles within the structure of the TAC and the dominant presence of carbon (C, 87%) and oxygen (O, 13%).

Lactic acid was produced after optimization of the processes of delignification by KOH and acid hydrolysis by H_2SO_4. A biomass/solvent ratio of 9.14 % and a temperature of 128 °C, resulting in a degree of delignification of 93.87%. Morphological and elemental analysis (SEM-EDX) revealed several changes within the delignified matrix and the dominant presence of carbon, oxygen and potassium elements. Infrared (TF-IR) analysis confirmed almost complete removal of lignin. Optimal hydrolysis conditions were: 26.95 min, 9.53% (w/v) biomass/solvent ratio in 4.92% (w/v) H_2SO_4, yielding 18.77 g/L of reducing sugars. The hydrolyzate obtained after concentration was used to produce LA using lactobacillus fermentum ATCC 9338 in a biofermentor. A productivity of 1.25 g/L.h at the logarithmic phase after 72 hours of fermentation, a titer of 26.61 g/L and a yield of 0.52 g/g of lactic acid were obtained from 45. 55 g/L of glucose and 12.21 g/L of xyloses.

Keywords: Cocoa Pods Husk, Lactic acid, Cellulose triacetate.

Extremophile Extracts from Microalgae and Vegetals for the Food Industry

E. Cicala

Project manager, Journalist, Italy

The EE4FI PROJECT aims to create a pilot plant for the production of microalgae and plant extracts to be used in the food industry TO FIGHT MALNUTRITION: A) Consolidation of research and development activities carried out by scientific and industrial partners B) Analysis of nutritional needs, with particular reference to the populations C) Elaboration of nutritional models with the aim of improving and balancing nutrition – Models E) Identify the biocomponents necessary to improve the nutritional characteristics of the food – Identification F) Develop production processes on a pilot scale to extract biocomponents from microalgae and plants – Development G) Realization of pilot line of cultivation, production and extraction - Design and Implementation H) Market analysis and study of packaging for distribution in the nuraceutics and food channels – Marketing I) Validation of nutritional models, screening of patient samples under medical supervision – Validation L) Processing of results – Dissemination.

Biotransformation of Sorghum Syrup Derived HMF to FDCA Using Novel Rhodococcus Qingshengii C27

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The 2,5- Furandicarboxylic acid (FDCA) is one of the 12 uppermost chemical building blocks which can be synthesized from the biomass. FDCA is a desirable alternative to petroleum-derived terephthalic acid for the synthesis of biodegradable polyesters. In this study, biocatalytic approach was adapted for the conversion of sorghum syrup derived HMF to FDCA. The biotransformation of HMF to FDCA was carried out using whole cells of novel isolate Rhodococcus qingshengii C27. In the batch mode biotransformation, 6 mM of FDCA was yielded from 8mM of HMF concentration under optimal conditions (72 hours, 30 °C and pH 7.0) with the complete HMF utilization. In the fed-batch mode biotransformation initially in shake flask followed by scale up in the fermenter, the FDCA yield was further improved from 8.32 mM to 13.45 mM. Later through the repeated batch biotransformation and media recycling, the total FDCA yield was 26.76 mM from 39.46 mM of HMF. Also the strain could tolerate up to 240 mM of HMF. Finally, the produced FDCA was recovered and purified using synthesized PS-DEA resin mediated adsorption and NaOH mediated desorption. Further work will be aimed at the life cycle analysis of the complete process.
Importance: The discussed process of biomass derived HMF to FDCA using a highly HMF tolerant novel biocatalyst, R. qingshengii C27 is a state of the art approach with the promising environmental friendly operations for the green future.

Spent Mushroom Substrate and Fruit Waste Bioconversion by Black Soldier Fly Larvae (Hermetia Illucens): Effect of Cow Dung Biochar Addition

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Food waste has emerged as an issue of global concern due to its high amount of production and poor handling and disposal practices, which led to several serious environmental issues. Bioconversion through black soldier fly (*Hermetia illucens*) larvae (BSFL) feeding could be a valuable approach to convert such wastes into larval biomass and bio-manure for sustainable agriculture practices. This study aimed to investigate the bioconversion of spend mushroom substrate (SMS) and fruit waste (FW) mixtures spiked with cow dung biochar (BC) using BSFL. SMS was mixed with FW in different proportions 30, 70, and 100% along with 5% BC and fed to BSFL until the emergence of adult fly and changes in waste physicochemical quality was analyzed. BSFL feeding caused a decrease in total organic carbon, NH_4^+-N and C/N ratio while an increase in NO_3^- -N, electrical conductivity, total phosphorus and total potassium. Fourier transform infrared spectroscopy suggested significant changes in the chemical composition of waste mixtures after BSFL feeding. Waste mixture 70% SMW + 30% FW showed better results of waste mineralization and BSFL growth. The waste reduction, feed conversion ratio (FCR), bioconversion ratio (BCR), growth rate, and larval weight showed better results in BC-amended setups of SMS and FW. The germination index study supports the potential use of frass (residual waste) in plant production. In summary, results suggested that BSFL could be a valuable tool for converting food production and processing wastes into multiple products: protein-rich larval biomass for animal feeding and biosolid (frass) for soil fertility management under a circular economy approach.

Keywords: Fruit waste, Spent mushroom substrate, Black soldier fly larvae, Biomanure.

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Bioplastics and Microplastics

Microplastics Pollution in Food Waste Biological Treatment

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Plastic pollution is ubiquitous in the present world as it is affecting the aquatic and terrestrial ecosystem. Around 300 million tonnes/year of plastic is produced globally that is nearly the entire human population weight. Due to the mismanagement of plastic waste, approximately 8-9 million tonnes per year of plastic is entering the oceans causing serious threats to aquatic life and ecosystem. In Hong Kong, plastic waste accounts for 21% of total municipal solid waste (MSW). An average of 9,684,741 plastic bags are disposed of every day which accounts for ~768 tonnes (7% of total MSW) causing the increase in micro plastics by 11 times in the past 3 years. The fate of mis-managed plastics in the natural environments are caused by several physicochemical activities which eventually leads to the formation of macro (> 5 mm), micro (< 5 mm) and nano (< 1 µm) plastics. It is estimated that humans are consuming a credit card of plastics in a week through water and food. Eventually, the plastics are ending up in food waste as well. The inevitable plastics pollution in food waste causes its further biological treatment processes such as anaerobic digestion (AD) and aerobic composting. The current mode of food waste collection in plastic bags followed by its mechanical breaking to remove the food waste is causing the microplastics contamination on food waste. In the food waste treatment facilities, the current practices do not have sufficient machineries to completely remove the plastics in food waste. The food waste contaminated with microplastics entering the anaerobic digesters and affecting the process performance. It is reported that the microplastics from the conventional plastics such as polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP), polystyrene (PS or styrofoam) and others affect the microbial activities and affect the methane production in AD process and reduce the compost quality in composting process. In this study, the abundance and impact of microplastics on food waste treatment technologies, i.e., AD and composting will be addressed.

Keywords: Microplastics, Food waste treatment, Anaerobic digestion, Composting.

Deciphering the Mechanism Shaping Bacterial Community in Plastisphere and Kitchen Waste Composting with PLA/PBAT Blends

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Biodegradable plastics has aroused increasing concern for reducing the negative environmental impact of plastic waste, however, the impact of biodegradable plastics mixed into kitchen waste (KW) on composting remains poorly understood, especially focusing on bacterial communities in the unique "plastisphere". Here, KW composting for 120 days with adding poly lactic acid / poly butylene adipate-co-terephthalate (PLA/PBAT) plastics were conducted to reveal the dynamics of bacterial composition, succession, and assembly process in different ecological niches (compost and plastisphere). Results showed, after composting with 80% degradation of PLA/PBAT, there were prominent divergences of bacterial compositions between plastisphere, composts with PLA/PBAT and control. Co-occurrence network showed that PLA/PBAT plastisphere exhibited greater network complexity and stronger cohesion than those in compost, and PLA/PBAT increased bacterial module hubs, connectors, and network hubs in composting compared to control, but might enrich pathogens. Phylogenetic bin-based null model analysis indicated that stochastic processes critically shaped the communities on PLA/PBAT plastisphere, but compare to control, PLA/PBAT plastics increased the relative importance of deterministic processes on composting bacterial community assembly. These findings deeply understood the assembly processes and diversity patterns of plastisphere and composting processes, laying down a foundation on applying biodegradable plastics under the classification of domestic garbage.

Keywords: Biodegradable plastics, Composting, Co-occurrence network, Microbiome, Assembly processes.

Bioprocess Robustness of Newer Polyhydroxyalkanoate Producers as Sustainable and Persistent Industrial Strains

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Polyhydroxyalkanoates (PHAs) are naturally occurring ester-polymers synthesized by several microbes as carbon reserve and protectants against environmental stress. Owing to their exceptional multifaceted properties like insolubility in water, non-toxicity, environmental compatibility, biodegradability, piezoelectricity, and thermoplasticity, these polyesters are gaining huge attention over known biodegradable polymers. The current market for biodegradable PHA based plastics is 25.3 metric-tons per year and is expected to increase fourfold by 2021, but the progress to meet the production demand is still limited. *Cupriavidus necator* has traditionally been considered as the primary polyhydroxyalkanoate producing microorganism however its non-growth dependent PHA synthesis, highly stringent nutrient requirements and presence of immunogenic factors such as lipopolysaccharides hinder its suitability for a (i) large-scale polyhydroxyalkanoate production, and (ii) low cost nutrient rich feedstock utilization. These bottlenecks in turn make PHAs lag towards becoming a part of sustainable and circular economy due to 3–4 times higher cost in comparison to conventionally available polymers. The high cost is mainly accredited to the microbial incompetence towards carbonaceous raw materials (>45%) and polymer recovery process (>26%). This can be overcome by identifying efficient PHA producers with elevated substrate utilization capacity and potential to accumulate high amounts of PHAs. Numerous studies in the past decade have reported that new and promising PHA producers can be found in various environments. However only a few have been isolated from samples like wastewater and sludge ecosystems. These competitive nutrient limiting environments tend to harbour a huge diversity of microbes with potentially high PHA synthesis ability. To solve these problems, our research aims to isolate newer efficient PHA producers from various environmental niche. Though a rigorous screening process on a whole-cell level, we have recently isolated a strong growth dependent PHA accumulating strain from food waste hydrolysate. The potent isolate is identified as *Bacillus cereus* IBA1 which synthesizes poly(3-hydroxybutyrate) in presence of glucose. Experimental optimization of *B. cereus* IBA1 for batch fermentation, showed 2 folds higher PHA yields. Biomass of 9.7 gDCW L^{-1}, PHA yield 5.7 gPHA L^{-1} and PHA content of 58.3% was achieved. With this quantitative understanding of growth behaviour and metabolism, we would aim at establishment of a stable fermentation system with low-cost nutrients and study their effects on PHA synthesis at a cellular level. Further research in this direction will enable the quantitative understanding of biochemical and cellular aspects of PHA production which (i) form potential set-screws to allow the process to be positively manipulated and (ii) enable the development of high productivity process which can be adopted to industrial scale.

Keywords: Biopolymers, Metabolic regulation, Process behaviour, Fermentation, Waste valorization.

Metabolic function under in PHA accumulation different alkaline conditions

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Waste activated sludge has been frequently used as mixed substrate to produce polyhydroxyalkanoate (PHA). However, insufficient research on microbial metabolism has led to difficulties in regulating PHA accumulation in mixed microbial cultures (MMCs). To explore the variation of functional genes during domestication and the effect of different alkaline conditions on metabolic pathways during PHA accumulation, MMCs were domesticated by adding acetate and propionate with aerobic dynamic feeding strategy for 60 days. As the domestication progressed, the microbial community diversity declined and PHA-producing *Brevundimonas*, *Dechloromonas* and *Hyphomonas* were enriched. Through bacterial function prediction by PICRUST, the enrichment of *rpoE* involved in starvation resistance of bacteria was found after the domestication. Untargeted metabolomics exhibited that neutral and weak alkaline conditions could promote the up-regulation of significant differential metabolites, while higher alkaline conditions caused the inhibition of metabolic activity. Functional annotation showed that weak alkaline conditions significantly affected Pyrimidine metabolism, resulting in an increase in PHA production. Regarding the pathways of PHA biosynthesis, acetoacetate was found to be significant in the metabolism of hydroxybutyric, and the weak alkaline condition could restrain the conversion from hydroxybutyric (HB) to the acetoacetate to protect PHB accumulation in MMCs compared with neutral condition. Taken together, the present results can advance the fundamental understanding of metabolic function in PHA accumulation under different alkaline conditions.

Identification and Removal of Microplastic Pollutants in Soil-like Materials from Landfills

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The huge amount of plastic waste accumulated in landfills has caused serious microplastic (MP) pollution to the soil environment, which has become an urgent issue in recent years. In the present work, the MPs in landfill soil were identified by pyrolysis-gas chromatograph/mass spectrometer (Py-GC/MS). To remediate the contaminated soil, a dielectric barrier discharge (DBD) system was applied to remove MP pollutants from the soil due to its strong oxidation capacity. The soil-like materials with severe MP pollution were sampled from a non-sanitary landfill in China. The procedure of flotation-digestion was adopted to extract MPs from the soil sample, which visually proves the MP pollution in the landfill soil sample. MPs observed under the stereomicroscope were divided into five types in terms of morphology: fragments, fibers, films, foams, and pellets. The indicator compounds corresponding to each MP polymer were selected. The Py-GC/MS results showed the soil samples contained four common MP pollutants, including polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyvinyl chloride (PVC) with sizes ranging from 50 to 1500 μm. The contaminated landfill soil was treated in a DBD device, and MP pollutants were rapidly removed under the action of reactive oxygen species (ROS) generated by DBD plasma. The maximum remediation efficiency represented by mass loss reached over 95% after 30 min treatment, realizing almost complete innoxious treatment. Compared with nitrogen, when air was used as the carrier gas, the remediation efficiency increased by 97%. The increased applied voltage could also promote the removal of MP contaminants. Sufficient air supply was conducive to thorough degradation. However, a higher air flow rate would shorten the residence time of ROS, resulting in reduced remediation efficiency. Gas products (mainly COx, accounting for ~90%) and liquid by-products were analyzed. The possible remediation mechanism was put forward: long-chain fracture, oxidation of substituent groups by ROS, decomposition into small molecular acids, and mineralization into carbon dioxide and water. This study provides initial evidence of MPs pollution characteristics in soil-like materials from landfill, and the results will foster the understanding of MPs fates in landfill systems. The proposed DBD plasma treatment showed superior energy efficiency and remediation performance, which provide a potential solution to solve MP pollution in the soil environment.

Keywords: Landfill, Microplastic pollution, Soil remediation, Plasma oxidation.

Aerobic Degradation of Deca-brominated Diphenyl Ethers (Deca-BDE): Novel Indigenous Microbes, Mineralization, Dehalogenation, Metabolites and Degradation Pathway

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Polybrominated diphenyl ethers (PBDEs), a group of persistent organic pollutants (POPs), and emerging contaminants (ECs) have raised the concern for human health due to their persistent nature, bioaccumulation potential and toxicity. Therefore, developing eco-friendly and sustainable remediation technologies for the removal of PBDEs from the environment is the need of the hour. In the present investigation, three novel bacteria having the potency to degrade and use BDE 209 as a sole carbon source were isolated from a PBDE polluted municipal waste dumping site in India. The bacteria were found to have 99.93%, 99.23%, and 99.23% similarity with the *Lysinibacillus capsici*, *Bacillus subtilis*, and *Lysinibacillus macroides* using 16S rRNA gene sequencing technique. These novel bacterial strains were named *Lysinibacillus capsici* strain BDE S2, Bacillus subtilis strain BDE S3, and *Lysinibacillus macroides* strain BDE S4. Genetic sequences of strain BDE S2, BDE S3, and BDE S4 were submitted to GenBank and their GenBank accession no. is MZ470736, MZ474476, and MZ474477, respectively. 94.35%, 84.31%, and 85.89% carbon content utilization and 66%, 60%, and 55% of initial BDE 209 concentration were removed by strain BDE S2, BDE S3, and BDE S4, respectively, within eight days of the incubation period. Also, 11.88%, 15.17%, and 11.67% debromination was observed by the strain BDE S2, BDE S3, and BDE S4, respectively. Hexa, penta, tetra and tri-BDE were detected as metabolic intermediates, which were further converted into non-BDE products with the possibility of generating CO2 and H2O as an end product. As per the analysis of metabolic intermediates, dehalogenation, breakdown of diphenyl ether bond, and cleavage of the aromatic ring were reported as probable breakdown pathways for BDE 209 by the screened bacterial strains. The present study is the first of its kind study reporting the screening and use of indigenously isolated bacteria for the aerobic breakdown of deca-BDE, which can provide new insight for removing these toxic flame retardants from the contaminated matrices.

Keywords: Polybrominated diphenyl ethers, Aerobic degradation, Bio-degradation, Efficiency, Pathway, Debromination.

Near-Infrared Spectroscopy Based Method for Rapid Detection of Microplastics/Plastics in Complex Environment

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Due to the abuse of plastics and loose waste management system, waste plastics are accumulated in the environment and resulting in white pollution. Besides, due to weathering, external forces and other factors, plastics in environment will be decomposed into small-scale plastics/microplastics, which will exist stably in nature. Many studies have found that microplastics can act as accessible vectors of organic contaminants or heavy metals to promote the transfer of pollutants in environmental media. The identification of microplastics has become a global concern. In this study, three machine learning classification models (random forest classifier, extreme gradient boosting (XGBOOST) and partial least square discriminant analysis (PLS-DA) models) and Hyperspectral imaging (HSI) technology are combined to identify microplastics directly on different media without complex separation steps. The commonly used plastic and rubber samples were used to train the models and reduce the possibility of being wrongly classified as other materials with similar spectra, and 11 household plastic items were collected as the external test set to verify the effectiveness of the model. The influence of transparency, color, roughness and background media on the identification of plastic materials were investigated. Most of the practical samples can be correctly classified by the model. However, the additives for achieving various material properties in some practical samples may result in the difference of their compositions compared with those of standard samples (plastic and rubber resin), leading to huge classification errors in the model. In order to make the model more widely applicable, more spectra of practical samples should be included for model learning. Spectral pretreatment can solve the problem of color and material surface wear and achieve high classification accuracy. Identification of fully transparent plastic materials is still a challenge, and environmental interference is a main factor. The identification of opaque plastic samples is basically independent of the background, and the identification of translucent and transparent plastics will lead to classification errors due to different background information. PLS-DA model can better identify the characteristic spectrum of transparent plastics superimposed with background information and achieve the best classification effect. The combination of spectral pretreatment and two-stage model recognition method is proposed to identify plastics in different backgrounds, which has excellent classification effect (with accuracy more than 95% for XGBOOST, 99.99% for PLS-DA). The combination of hyperspectral technology and machine learning classification model shows the potential of feature screening as a means of micro plastics classification.

Keywords: Hyperspectral imaging, Plastics, Machine learning, Classification.

Concomitant Production of Value-Added Co-Products During Polyhydroxyalkanoate (PHA) Production: Approaches for Building Circular Bioeconomy in PHA Process

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Polyhydroxyalkanoates (PHAs) are attractive alternatives to petro-plastics as they are biobased-biodegradable polymers produced by microbes. PHAs can be produced by variety of microbial strains using pure and renewable substrates under certain unfavourable conditions like availability of carbon, limitation of nitrogen, oxygen, or phosphorus. However, their penetration in market is still limited due to their high production cost. The ability to generate PHA from renewable and inexpensive materials such as lignocellulosic feedstock, cheese whey, waste lipids, crude glycerol can make the process cost-effective. During PHA production process, various value-added products can also be simultaneously produced such as microbial proteins, extracellular polymeric substances (EPS), lipases etc. Recovering useful biomaterials can further help in reducing the PHA production costs, improving the waste management and resource efficiency which is important for maintaining the circular economy in the process. In conventional PHA process, these value-added products are not targeted which end up as organic wastes in the liquid streams generated in the process. In this study, cheap waste substrates such as activated sludge, waste cooking oil and crude glycerol were studied for the simultaneous production of PHA, microbial proteins and EPS. Both PHAs and microbial proteins are intracellular products and fed-batch fermentation resulted in 25 g/L PHA (60% w/w) and 6-8 g/L proteins (13-15% w/w), respectively, at the end of fermentation. The microbial proteins were released in the supernatant obtained after cell disruption/pre-treatment conducted for PHA release outside the cells. Therefore, various protein precipitation methods were used for recovering the soluble microbial proteins from the supernatant/waste stream generated during the PHA downstream processing. The produced EPS (extracellular co-product) was further characterised in terms of flocculation activity, dewaterability, protein-carbohydrate content and structural analysis. Sludge volume index and protein precipitation was carried out by the produced EPS to understand its application prospects. After fermentative PHA production and downstream processing, various liquid streams (such as waste stream generated after treatment of PHA-rich biomass and wash waters) are released which are generally discarded. Various recycling strategies were developed for these streams to be used in the subsequent PHA production process. Therefore, the research aims at providing strategies to reduce the cost of PHA production by recovering high value-added co-products as well as minimizing the ecological risks by recycling precarious waste streams generated during the process in more than one fashion thus, maintaining circular bioeconomy.

Keywords: Polyhydroxyalkanoates, Biopolymers, Microbial proteins, Circular bioeconomy, Exopolysaccharides.

Production of PHA from Pineapple Residues by *Cupriavidus Necator*

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Nowadays, petrochemical plastic waste pollution is a global challenge due to its adverse effects on the environment and human health. Therefore, companies are interested in biobased and biodegradable thermoplastics such as polyhydroxyalkanoates (PHA). PHA are effective substitutes because they have a multidimensional use like conventional plastics but also a very short life cycle and complete elimination in the environment. This approach uses well-defined and efficient methods for PAH production. The use of pure substrates (carbon sources) for PHA production is complex and affects the production economics. Therefore, there is a requirement for replacing them with the cheaper waste substrates. New studies have been conducted to develop more cost-effective PHA production processes. These processes are based on a microbiological technique mixing a pure microbial culture of bacteria with agri-food waste (pineapple skin). Microorganisms, thanks to their ability to adapt to complex substrates such as agri-food waste, are excellent accumulators of PHA. This would allow the production of bioplastics using renewable waste as a carbon substrate while minimizing the cost of obtaining PHA. In this study, the production of PHA is based on the use of juice from pineapple waste as a fermentation substrate and *Cupriavidus Necator*. The pineapple waste was ground, pre-treated at 50°C for 30 min and filtered to obtain a substrate rich in reducing sugar (RS) and minerals for PHA accumulation. Experiments were performed for 96 h at 200 rpm at 30°C with pH 6.8 adjusted with 4N NaOH and 4N H_2SO_4. The initial concentrations of SR tested were 10, 15, 20 and 25 g/L in 2 L erlenmeyer flasks with a working volume of 300 mL. Several feeding models (batch and fed batch) on PHA production were also studied for 96 h. The batch mode was conducted in a 5 L total capacity bioreactor with a working volume of 3 L. The fed-batch mode was conducted in a 7 L total capacity bioreactor with a working volume of 4 L. It started in batch mode for 24 h and continued in fed-batch. The bioreactors are equipped with control systems for dissolved oxygen, pH, defoamer, turbine speed, aeration rate and temperature. Experiments reveal that the maximum suspended solids (SS) concentration obtained in erlenmeyer flasks was 10.78 g/L and the maximum PHA content was 90.1% with an initial SR concentration of 19.41 g/L and a C/N ratio (SR/NH_4Cl) of 20. Among the different fermentation modes that were evaluated, the fed-batch mode was found to be better. Indeed, with a constant fed-batch of the substrate of initial concentration SR of 26.85 g/L and a C/N ratio of 20, the maximum concentration of SS was 23.47 g/L and the maximum PHA content reached was 74.2%. The PHA synthesized were polyhydroxybutyrates (PHB) with a content of 99.3% and polyhydroxyvalerate (PHV) with a content of 0.7%. The results of this study show the efficiency of pineapple waste to produce high value-added products. This approach contributes to the waste management problems and constitutes a new economically profitable source.

Keywords: PHA, Pineapple waste, *Cupriavidus Necator*.

Dissolved oxygen impact on PHA production with kitchen waste as carbon source

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The massive use petrochemical-based plastics has led to increasingly serious environmental problems. Polyhydroxyalkanoates (PHAs) are biodegradable polyesters that has great potential to replace traditional petroleum-based plastics, but high production costs have been a barrier to their commercial adoption, with the cost of the carbon source accounting for about half of the total production cost. The production of PHAs using volatile fatty acids (VFAs) from the fermentation of organic wastes such as kitchen waste and wastewater sludge as a carbon source as it leads to reduction on the PHA production cost. However, it was found that the cost needs to be further reduced by increasing the PHA productivity and reduce the energy input. Dissolved oxygen concentration has been revealed as a crucial factor in PHA accumulation and it is highly related to energy input, but the mechanism of the effect of dissolved oxygen has not been elaborated. The aim of this study was to investigate the effect of DO concentration on microbial growth, substrate utilization and PHA production capacity during the production of PHA from VFAs obtained by microbial fermentation of kitchen waste as a carbon source. A lab isolated PHA producing microbe was employed and it was found that the PHA accumulation content was increased by 50% when the DO concentration was reduced to less than 1 mg/L from 4 mg/L, and the yield of PHA was increased around 20%. In terms of energy consumption, least 35% energy saving could be obtained in per kg of PHA production by reducing DO concentration. Based on the study, the optimal oxygen supply pattern would be provided to enhance PHA productivity and reduce energy input.

Keywords: Polyhydroxyalkanoates, Dissolved oxygen, Volatile fatty acids, Mechanisms.

Bioplastics: An Emerging Blue Technology Contributing to Green Economy

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India is covered by three side waters and delineated to the great Himalayas on the northern side which makes it a peninsular region. This geographical location contributes to the fact that the country can make humongous contribution to the blue economy and has been doing so in past decades. The aquaculture is proportional to the diversified oceanic water. With a developing economy and democratic nation, India has vividly developed new initiatives to uphold the ocean and its aquatic life. Out of 700 species of marine algae found across the Indian coast, 60 species are of utmost significance. Blue economy is one of the building blocks of a green economy leading to a sustainable future.
Marine seaweed also popularly known as macroalgae are the photosynthetic eukaryotes whose properties differ from plants with lack of vascular tissue. The seaweed are the algal species found in the ocean with multifunctional abilities like carbon capture, maintaining balance in ocean life etc. The natural polysaccharides like carrageenan, agar and alginate are extracted from the algae with a wide range of applications in medicines, food and beverage industry etc. With the current ongoing plastic pollution, the ban on its usage is soon going to be implemented on a larger scale. Hence the need for a substitute has hit a peak. Bioplastics is one of the emerging technologies with seaweed as a raw material. The polysaccharide extracted from each species of seaweed differ in yield or compositions. Seaweed farming is another important technique adopted across coastal lands generating revenues at a larger scale and met a production scale of 6,00,000 tons in the year 2000. Algae has soon become the commercial crop of every fisherman out there in the country. This in turn is compensating revenue losses of the monsoon periods and increasing living standards of fishermen. This foreseeable 3rd generation of bioplastics shall exponentially draw down the generation of solid waste and enhance the blue economy. The current research on bioplastics in different regions is carried out based on the different species of seaweed and till date the pilot scale of work done is to produce thin sheets. Further study is to produce it on a commercial scale and make it a perfect substitute fit for plastics. This can revolutionize the entire face value of plastics and take it to an eco-friendly platform keeping in mind the faster degradability rate.
The current paper aims to comprehensively review the 3rd generation of biodegradable plastic produced using seaweed from the species available across the coast of India. The research further gives some insights on the bioplastics contribution and the study done so far in India. It also highlights the statistical scenario of seaweed farming contributing to the economic status of the country. The future scope of work is to produce a firm plastic shaped into a product.

Keywords: Seaweed, Bioplastics, Blue economy, Polysaccharide.

Polyhydroxyalkanoates Production by Mixed Cultures Acclimated from Wastewater Sludge with Food Waste as Carbon Source in Continuous Fermentation

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The great concern on the use of petroleum plastic has driven bioplastic production. Polyhydroxyalkanoates (PHAs) is one of the most potential bioplastics due to its excellent biocompatibility, biodegradability, and thermal processing properties. Currently, PHAs production is mainly in batch or fed batch fermentation, which requires frequently start-up and ending. Continuous fermentation is easy to cope with other downstream processing and easy to operate. In this study, wastewater sludge was used as the seed of PHAs producing microorganism. Organic acids with chemical oxygen demand (COD) 610 mg/L were used as carbon source and its compositions was stimulated according to food waste anaerobic digestion. The process consists of two reactors, anaerobic reactor and aerobic reactor. During the PHAs producing microbe accumulation stage, 5 L of sludge with suspended solids (SS) concentration of 3000 mg/L was filled into anaerobic reactor and carbon source was added with a flow rate of 25 mL/min. After 4 h, the sludge was transferred to aerobic reactor and aerated for 6 h, then sent back to anaerobic reactor again. After 16 d, the PHAs content was increase to around 55% g/g MLSS. Thereafter, the continuous fermentation was performed. The flow rate, carbon source addition rate, cell recycling rate were optimized. This study will provide a new insight of PHAs production by continuous fermentation.

Fate and Impacts of Bioplastics during Food Waste Anaerobic Digestion

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The unprecedented use of plastic materials is one of the major reasons for fossil fuel exploitation and severe environmental pollution. Over the decades, extensive efforts have been undertaken to alleviate persistent plastic waste and subsequent environmental pollution. Recently, European Union and other countries including United States, China and India completely or partially banned the single-use persistent plastics to encourage use of recyclables and invigorate development of alternatives. Consequently, the adoption of biodegradable plastics is forced by different national regulations as alternative to single use plastics. Being classified as biodegradable and compostable, a major part of these materials is often collected with the organic fraction of municipal solid wastes, basically due by food waste (FW), and sent to biological treatment plants such as composting and anaerobic digestion for bioenergy recovery or their combination. Given enhanced recognition an untapped resource worldwide, anaerobic digestion of FW is a particularly promising approach for its treatment and energy recovery. This study summarizes the progressive altercations in bioplastics properties and its simultaneous impacts on FW anaerobic digestion. The experimental investigations on FW anaerobic digestion were performed with compostable, oxo-degradable, polylactic acid (PLA) based and polyethylene (PET) bioplastics in under mesophilic (35°C) conditions using the Automated Methane Potential Testing System (AMPTS-II) (Bioprocess control, Sweden). The compostable or starch-based bioplastics demonstrated quick consumption of assimilable organic matter followed by slower degradation of polyester fractions. The type of bioplastics affected the kinetics of FW anaerobic digestion based on respective chemical composition and hindrance or disruption of microbial cells. Moreover, surface deterioration and chemical composition altercations confirm degradation of bioplastics. Selective application of bioplastics in FW Anaerobic digestion could be sustainable approach, following circular economy principles, drawing energy recovery, and reducing bioplastic wastages.

Keywords: Food waste, Bioplastics, Anaerobic digestion, Biomethane, Biomethane potential test.

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Sustainable Waste Management

Comprehensive Recycling of Fresh Municipal Sewage Sludge to Safely Fertilize Plants and Achieve Low Carbon Emission

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Recycling nutrients in municipal sewage sludge (MSS) to soil would support sustainable development. In this study, a comprehensive recycling using specific plants able to grow in the fresh MSS and an indirect application technique was developed. Fresh MSS was placed in permeable containers next to *Handroanthus chrysanthus* plants to provide indirect fertilization. Sludge treatment plants (*Alocasia macrorrhiza* and *Pennisetum hybridum*) were grown directly on the Fresh MSS to produce plant biomass and treat MSS. The basal diameters of the *H. chrysanthus* plants were markedly increased by the treatment. Nutrients were extracted from MSS more readily and more biomass was produced by the *P. hybridum* than the *A. macrorrhiza* plants. The heavy metal contents of the soil did not increase significantly and not generate potential ecological risk, but the organic matter, nitrogen, and phosphorus contents increased markedly. The fresh MSS leachate met the relevant fecal coliform and heavy metal irrigation water standards. At the end of the treatment, the MSS mass had markedly decreased and the treated MSS was used as a substrate for two garden plant seedlings. The net carbon emissions from the comprehensive recycling are estimated as -15.79 kg CO_2e (CO_2 equivalent) per ton fresh sludge, in contrast, the emissions from composting treatment are estimated as 8.15 kg CO_2e. The method allows nutrients in MSS to be recycled without causing heavy metal pollution and without net carbon emission, while gives plant products with commercial value.

Keywords: Sewage sludge, Indirect application, Sludge treatment plant, Garden plant, Greenhouse gas emissions.

Energy Economics of the Municipal Solid Waste Process

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With increasing needs and moderation, the generation of municipal solid waste (MSW) is growing exponentially. In this study, MSW physical characterisation was carried out for six months of a MSW management plant, the average percentage of plastic, rubber, wooden, clothes, glass, metal, stone, sand, bone and organics were 11.67 %, 3.52 %, 10.82 %, 11.08 %, 1.84 %, 0.14%, 5.16%, 1.58%, 0.24%, 2.69%, and 52.38% respectively. Moreover, the efficiency of mechanical pre-treatment of mixed MSW into organic fraction of municipal solid waste (OMFW) at the waste management facility is evaluated, as well as the average amount of biogas produced per tonne of feed, compost production, compost quality, dry matter generation, calorific value of dry waste. This study also evaluates the energy economics and operational economics of the bioenergy plant. MSW generated per tonne requires 13.07 KW of electricity for treatment, and the amount of electricity generated per tonne is 64.26KW. About 20,000 units of electricity are produced each day, of which about 4,000 are used for captive consumption. For processing MSW costs around ₹ 328 per tonne and compost production costs around ₹ 1950 per tonne. The selling price of loose compost is ₹ 2800 to 3200/tonne while the selling price of packaged compost is ₹ 4200-4500/ tonne. On the basis of the overall economics, operating the MSW seems to be economically feasible.

Keywords: Energy Economics, Municipal solid waste, Anaerobic digestion, Biogas, Compost.

Separation of Low-Grade Phosphate Ores by Novel Semi-Through Hydraulicbarrier Hydrocyclone

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With the decrease of high-quality phosphate ores ($P_2O_5 \geq 30$wt%), the use of low-grade phosphate ores ($P_2O_5 \leq 20$wt%) is becoming more and more emergent. Hydrocyclone was one of the common equipment for separation of mixing ores in aqueous media, with the advantages of high separation efficiency and low cost. There still existed some problems in traditional hydrocyclone such as the particle dislocation, the "fishhook" phenomenon, the low separation efficiency, etc., due to the phenomena as the particle entraining, the random fluctuation in multiphase flow, and the high short-circuit flow (>10%), etc. Herein, a novel semi-through hydraulicbarrier hydrocyclone was suggested for the separation of low-grade phosphate ores. The fluid dynamics simulation showed that compared with the conventional hydrocyclone, the adaptation of the semi-through hydraulicbarrier hydrocyclone led to the reduce of the short-circuit flow rate from 13.3% to 7.17%, the increase of the separation efficiency from 92.3% to 97.5%, the increase of separation accuracy from 0.88 to 0.95, and the elimination of the fishhook effect. The influences of pressure, velocity, turbulent kinetic energy, the air core and the multiphase streamline on separation processes were discussed in detail. The experimental results indicated that the novel semi-through hydraulicbarrier hydrocyclone was effective for the separation of low-grade phosphate ores, leading to the increase of the P_2O_5 contents in phosphate ores from 17.5wt% to 23.6wt%.

Keywords: Hydraulicbarrier-hydrocyclone; Separation of low-grade phosphate ore; Simulation and experiments.

Designing Low-Carbon Cements for Stabilization/Solidification of MSWI Fly Ash

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Low-carbon and high-efficiency binder is desirable for safe disposal of municipal solid waste incineration fly ash (MSWI FA). In this work, CaO or MgO was used to activate ground granulated blast furnace slag (GGBS) to form calcium silicate hydrate (C-S-H) and magnesium silica hydrate (M-S-H) gel for stabilization/solidification (S/S) of hazardous MSWI FA. Experimental results showed that the potentially toxic elements (PTEs, e.g., Pb and Zn) significantly inhibited the formation of reaction products in CaO-GGBS system due to the complexation between $Ca(OH)_2$ and PTEs, whereas PTEs only had insignificant inhibition on transformation from MgO to $Mg(OH)_2$ in MgO-GGBS system, resulting in lower PTEs leachability and higher mechanical strength. Stabilization/solidification experiments demonstrated that MSWI FA (70 wt%) could be recycled by MgO-GGBS binder (30 wt%) into blocks with desirable 28-day compressive strengths (3.9 MPa) and immobilization efficiencies for PTEs (99.8% for Zn and 99.7% for Pb). This work provides mechanistic insights on the interactions between PTEs and CaO/MgO-GGBS systems and suggests a promising MgO-GGBS binder for the low-carbon treatment of MSWI FA.

Keywords: Waste incineration fly ash, Hazardous waste treatment, Low-carbon stabilization/solidification, PTEs leachability, Sustainable waste management.

Process Optimization for the Pretreatment of *Lantana Camara* Using Combined Acid and Deep Eutectic Solvent for Sugar Production

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The supply of fossil fuels is limited and their usage is creating havoc on the ecosystem. There is a need for renewable energy sources that have a lower environmental effect. Recently, lignocellulosic biomass is becoming increasingly popular as a renewable energy resource for producing biofuels. Invasive weeds can be used as feedstock for producing biofuels because of its high holocellulose content. However, pretreatment is a prerequisite step for increasing the enzymatic digestibility of biomass. Therefore, in the present study the potential of *Lantana Camara* as a feedstock to produce fermentable sugar was explored. The biomass was sequentially pretreated with sulphuric acid (H_2SO_4) in the first stage and for the second stage acid pretreated biomass was further pretreated with DES (Choline-chloride/Urea). The biomass was pretreated with 1:2 molar ratio of ChCl/U for (1h, 3h, and 6h) at 80 ℃. Further, SEM, XRD, FTIR, and TGA analyses were employed to study the structural and functional changes in biomass after pretreatment. A combination of 1% H_2SO_4 and 1:2 ChCl: U for 3h at 80℃ yielded the highest amount of reducing sugar i.e. 2.69 mg/ml. In conclusion, *Lantana Camara* can be a potential raw material to produce fermentable sugars for bio refineries that can be further converted to biofuels and other value-added products.

Keywords: Lignocellulosic, Sequential pretreatment, DES, Reducing sugar.

Effective Utilisations of Discarded Reverse Osmosis Post-Carbon for Dye Adsorption

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The common contamination in the distribution network of municipal water treatment plants urges the re-treatment of treated natural water resources. In common practice, the re-treatment can be done via advanced purification technologies like membrane-based technology. Out of the relative multitude of membrane technologies, Reverse Osmosis (RO) is a technology that is well known for both its ability to purify water and for some of its drawbacks, such as the generation of concentrated liquid streams and post-carbon that is typically dumped in an open environment. The post RO-carbon contributes toward the improvement of water quality by removing extra fine dirt, sand, silt, rust and thus, discarded RO-carbon has several inorganics and volatiles adsorbed onto it. It has been extensively documented in the literature that adsorbed inorganic and volatiles are effective in improving the surface morphology of the material due to the release of various gases that diffuse through already existing pores. Thus, the discarded post-carbon can be a viable candidate for wastewater treatment. This study has considered the deployment of post RO-carbon as a sorbent for dyes removal. The post RO-carbon was thermally activated at 900^{o}C (RO900) and the material thus obtained exhibited high surface area *viz.* 753 m^2/g. In the batch system, the maximum adsorption capacity of RO900 for Methylene Blue (MB) and Methyl Orange (MO) were found to be 223 and 158 mg/g respectively. The comparatively higher MB adsorption was attributed to the electrostatic attraction between sorbent and MB. In addition to electrostatic interaction, the dye adsorption was the outcome of various other interactions like π-π, and n-π, H-bonding, dipole-dipole, and lewis acid-base interactions. The thermodynamic findings revealed the process as spontaneous, endothermic, and accompanied by entropy increment. Additionally, real wastewater containing dyes was treated, and 87.5 % of the methylene blue was successfully removed. To simulate an industrial perspective, methylene blue adsorption onto RO900 was carried out in continuous mode as well. The initial dye concentration, effluent flow rate, and bed height were among the process parameters that were optimized using the continuous mode of operation. Further, the experimental data of continuous mode was fitted with Adams- Bohart, Thomas, and Yoon-Nelson models. The cost and low toxicity associated benefits of discarded RO-carbon over other sorbents reveal the significance of the present study.

Keywords: Adsorption, Dye removal, Kinetics, Reverse osmosis carbon.

Enhancing Compressive Strength of Rubberised Concrete with Sodium Hydroxide Coupled with Microwave Devulcanization Treatment

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Every year, 14-17 million tons of used tyres are produced worldwide. One of the ways of valorization of this waste developed by the researchers is the use of used tire aggregates as a partial replacement for natural aggregates in the composition of concrete. These studies have shown that the adhesion of tyre aggregates to the cementitious matrix is low; This significantly reduces the mechanical properties of the materials developed. To overcome this problem, research is directed towards methods of treating tyre rubbers to improve the strength of the bonds at the tyre/cement interface and thus improve the mechanical properties of the concrete developed. For our study we treated rubber aggregates with NaOH solution on the one hand and on the other hand with NaOH coupled with microwave devulcanization to improve the compressive strengths of rubberized concrete. The rubber aggregates of size 0/5mm were immersed in a NaOH solution of 10% concentration for 60 min. Then the aggregates are removed from the NaOH solution and washed with tap water until the pH of the water is 7. Finally, the aggregates were dried at room temperature in the laboratory before being used as a partial replacement of sand by volume with a content of 10% in the formulation of rubberized concrete. The second treatment consisted in devulcanizing the aggregates treated with NaOH in the microwave for 30s before incorporating them into the formulation of rubberized concrete. Ordinary concrete and concrete incorporating untreated rubber aggregates were developed and used as references. SEM, FTIR and contact angle analyses were performed on the rubber aggregates to evaluate the effect of the treatment on their surfaces. The different concretes were characterized by the determination of their compressive strength at 28 days using a Matest type compression press with a maximum load of 1500kN according to standard NF EN 12390-3. The results obtained initially show a decrease in the compressive strength of rubberized concrete incorporating untreated aggregates of 30.28% compared to ordinary concrete. After treatment with NaOH and NaOH coupled with devulcanization, the compressive strength reduction at 28-day were 23.76 % and 21.83 % respectively compared to normal concrete strength. Both treatments improve the compressive strength of rubberized concrete. However, the best result is achieved with NaOH treatment coupled with microwave devulcanization.

Keywords: Concrete, Compressive strength, Rubber, Surface treatment, Used tyre.

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Waste Management Practices:

Countries Perspective

The Impact of COVID-19 on Quantification and Characterization of Solid Waste in the Bagmati River Corridor of Kathmandu Valley, Nepal

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The main aim of this study was to quantify, characterize the solid waste (SW) and evaluate the impact of COVID-19 on the status of household SW. A stratified random sampling technique using a cross-sectional survey questionnaire was used to collect data from three municipalities: Kathmandu Metropolitan City (KMC), Lalitpur Metropolitan City (LMC), and Kirtipur Municipality (KM) of the Bagmati River Basin (BRB), Nepal. A total of 400 households (HH), 100 institutions/offices, and 100 commercial establishments (shop/hotel/restaurant) were studied in the survey, and data were analysed using SPSS and Excel spread sheet. Given the limited resources, one-day sampling was undertaken. Enumerators collected the SW by the next day to determine the quantity (on a wet weight basis) of the nine separate components. The categories were biodegradable, plastic, paper/cardboard, rubber, textile, glass, metals, sanitary pads/diapers, and others. As per the survey, the total HH SW generation is 0.21 kg/capita/day, out of which biodegradable waste generation is 0.16 kg /capita /day, and the remaining, is non-degradable waste. Combining household, commercial and institutional waste, the average per capita MSW of the study area is 0.396 kg/day. Unit HH waste generation in KMC, LMC, and KM seems to have increased by about 10 % between 2012 and 2021. Overall, MSW production was not decreased though most commercial and institutional establishments were not fully operational due to the fear of the COVID-19 pandemic, which led to a shift of SW production from commercial to household. After COVID-19, people followed the government's stay-at-home order, worked from home, and moved less outside the house for eating due to fear of transmission of the virus. More frequent home cooking and eating raised HH waste. The main fraction of HH waste (77.5%) is biodegradable in the study area. The COVID-19 pandemic not only increased HH waste but also increased the biodegradable fraction. A recent study conducted by the KMC during the COVID-19 pandemic reported similar findings. Rooftop and backyard farming increased to produce more vegetables at home, which raised more organic waste in the HH. Moreover, the shift from eating out to online food delivery services led to increasing food waste due to the order of excessive amounts of food without adequate meal planning and management. The higher percentage of biodegradable waste in the study area shows the higher potential to manage it at its source through HH composting. As the interest in rooftop gardening and urban farming is increasing, composted waste can be used, which helps to manage the main fractions of waste at sources to create resources by activating the community, which ultimately prevents littering and improve the environment of the BRB. The source-segregated clean recyclable materials are another source of livelihood for the urban poor in the study area. Moreover, the findings will help to develop SWM benchmark indicators and design community-based capacity building initiatives and infrastructures.

Keywords: SW generation, Biodegradable waste, SWM benchmark indicator, Composting.

Evaluating Circular Economy Applications for Plastic Waste Management in Hong Kong

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Plastic waste constitutes a major challenge for global waste management (WM) systems: According to estimations of the Ellen MacArthur Foundation, the production of plastics increased twenty-fold over the last 50 years from 15 million tons in 1961 to 311 million tons in 2014. Hereof, consumer goods packaging constitutes the major fraction of plastic discards at around 40% or 78 million tons, of which only 8% are recycled. This in turn puts the spotlight on the nexus between production and consumption and raises questions on mitigation strategies. In order to address the challenge of plastics via a WM approach, the concept of the circular economy (CE) and the application of its R-principles has gained substantial traction. The CE envisages transforming traditional, linear (take-make-dispose) into circular (take-make-recycle-process again) systems that centre on resource-efficient utilisation and material conservation. In Hong Kong, where plastic packaging waste is on the rise particularly since COVID-19 and mostly ends up in landfills, the CE offers a broad range of alternative and more sustainable approaches. In regard to managing plastic packaging waste in Hong Kong, the central questions of this contribution are as follows: (1) To which extent have CE applications been implemented; (2) how well have these performed quantitatively and qualitatively in terms of R-principle effects (e.g. refuse, reduction, reuse, recycling); and (3) to which degree can such practices relieve capacity pressure of existing recycling structures. To methodologically tackle these questions, the research employs an evolutionary-institutional model in combination with a recycling network analysis. Functionally, the framework explores quantitative performances of Hong Kong's recycling system on the basis of institutional (rule- and routine-based) practice patterns. Here, routinised practices and official regulations together with their evolution over time are the essential determinants for quantitative outcomes, such as recycling rates of plastic waste streams. As for topic selection, the paper will analyse plastic-based food and beverage containers (FaBCs) and investigate patterns of consumption, treatment and CE-related substitution by consumers, recyclers and circular businesses in Hong Kong. In regard to materials, the study uses (a) field research findings (interviews and quantitative measurements) from a project on beverage container recycling, (b) desk research on institutional developments, (c) two consumer surveys on the CE (n>5,500) and (d) individual interviews with circular businesses. The results of the analytical framework show that: (1) CE applications have been piloted and are explored by different practitioners, albeit in temporarily and spatially limited contexts with insufficient legal embedding; (2) consumer and practitioner responses indicate that CE approaches are well received and adopted, particularly if economic incentives are included; (3) quantitatively, field data shows that economic incentives induce substantial improvements in material recovery and extrapolations demonstrate significant CO_2 emission reductions.

Keywords: Plastic packaging waste, Circular economy, Hong Kong, Institutional evolution, Recycling system.

Sustainable bioenergy, economic, and environmental impacts of resource recovery from organic fraction municipal solid waste in Penang, Malaysia

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Rapid increment in the global municipal solid waste production with time raises up the concern in terms of environmental impacts including greenhouse gas emissions, landfill issues, and water quality deterioration. Thus, this study focuses on the potential bioenergy and resource recovery from organic domestic waste using anaerobic digestion and its economic, and environmental impacts in Penang, Malaysia. Accordingly, approximate and elementary analyses of organic solid waste samples were carried out to estimate the potential production of biogas and bio-fertilizer. The economic and environmental benefit analysis was investigated. It was found that 534748.5 t/year of total domestic waste was collected from Penang island and 1,143,995.00 t/year was collected from Penang mainland. Anaerobic digestion of organic domestic waste has the potential to produce electricity with a total amount of 250390.34 kWh/day and bio fertilizer with a total amount of 211413.95 kg/day, reducing the land used for landfilling by 233.27 m^2 /day, and avoid the production of 99.37 m^3/day. The cumulative revenue of RM 1337 million/year can be generated within 3 years, whereby the project return of investment (ROI) requires 3 years 5 months with initial capital expenditure. The results are promising and can motivate investors and decision-makers to recover resources from organic solid waste.

Keywords: Municipal solid waste, Bio fertilizer.

Transition towards Circular Economy: Policy Insights from a Developing Country

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As an alternative to the linear economic model of "make-use-dispose", the circular economy is a system that seeks to keep resources in use for as long as possible, extract the maximum value from them while in use, then recover and regenerate products and materials at the end of their useful life. Although the circular economy often viewed as a waste management and disposal strategy, the economic opportunities it presents are far wider and more diverse. The circular economy is an integral part of sustainability agenda and it contributes to global agenda such as the Paris Agreement and the Sustainable Development Goals (SDGs). The circular transition is not only vital to protecting social and environmental wellbeing and mitigating the climate change, it also offers economic opportunities by reducing waste, stimulating business growth, and creating jobs. Increasingly, with demographic shift and growth as well as urbanization, countries around the world make an economic, environmental, and social case for the circular economy. Many developed economies have widely accepted and transitioned to a more resource efficient and circular economy. These economies have developed policies and national strategies for sustainable materials management, resource productivity or the circular economy. The circular economy practices in these countries have also been researched extensively, thus leading to the discovery of solutions and innovations that accelerate the transition to a circular economy. It is increasingly recognized that the transition towards circular economy is not only urgent for developed countries, but also for developing countries including Malaysia. Developing countries face similar challenges in addressing their environmental and social sustainability issues and in mitigating the impacts of environmental degradation and climate change. Sustainable development approach has been the focus of Malaysia's socioeconomic development since the 1970s. In recent years, Malaysia has stepped up its green growth efforts and has implemented several green growth initiatives to accelerate the country's transition towards a more resilient and low-carbon circular economy. This study attempts to provide an overview of policy trajectories under a green growth and sustainable development paradigm in Malaysia. A comparative benchmarking analysis is also conducted to review existing strategic frameworks, best practices, monitoring indicators that are implemented, particularly in developed countries against those currently being put in place in Malaysia.

Keywords: Circular economy, Green growth, Sustainable development goals, Sustainable production and consumption, Circular practices.

Understanding, Consensus, and Willingness to Implement Solid Waste Management Policy of Citizens in Municipalities of Vietnam

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Municipal solid waste is forecasted to rapidly increase due to population growth, industrialization, and modernization. If no solution is found, the overloading of waste will become a threat to humanity because of waste pollution and its effects on human health. Citizens play an important role in implementing waste management activities. Therefore, it is necessary to propagate national policies and strategies on waste management to encourage people to understand and support waste management activities. The more people know about waste management regulations and policies, the more they show their interest in waste pollution issues. However, very little research has been done on people's understanding of solid waste management policies in developing nations that are facing waste pollution. This study aims to find out how well people in three municipalities of Vietnam including Hanoi, Da Nang, and Ho Chi Minh know about waste management policies. In addition, consensus with regulations, willingness to participate in waste management activities, and sharing their knowledge and interest in local environmental issues are also found through the in-depth interview methods for a total of 346 respondents. Survey results were cleaned and statistically processed using SPSS v. 29.0.0.0 through descriptive and inferential statistics. The results showed that 85% of people shared they had never heard of national waste policies, while this figure for the understanding of local regulations was 44%. There are three main pieces of information that people know including waste disposal location, collection time, and collection fee. 78% of citizens agree with the solid waste collection, transportation, and treatment method of local authorities. The waste classification regulation is the most objectionable one, with up to 66% of respondents disagreeing. The difficulty of the classification (56.4%), the lack of synchronization between the classification and the collection (20.3%), and the lack of time (12.3%) are the primary causes of disagreement. In addition, the results revealed that 52% of respondents stated that they had never attended a local waste management propaganda program, while 32% stated that they had known them. However, only 11% of respondents were able to participate at a level ranging from frequent to always. Finally, 78.9% of people in the three municipalities rated that waste pollution had serious effects on the environment and their health, and 55.8% of people rated the management of local authorities as mediocre. This research results also support the development of a comprehensive plan for the implementation of the national waste management policy, the issuance of sanctions to deal with violations, and the strengthening of the organization of propaganda programs in solid waste management are important tasks for resolving the current issues. In order to fully comprehend the issue and support a national solid waste management strategy at the same time, similar studies should be extended to urban and rural areas. Sustainable solid waste management is a complicated endeavour that necessitates society-wide attention, support, and participation.

Keywords: Citizen’s understanding, Consensus and willingness, Municipal solid waste, Policy implementation.

The Challenge of Plastic Beverage Container Recycling in Hong Kong - Perspectives and Performances of Local Recyclers

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Recycling is an effective strategy to mitigate environmental pollution caused by the excessive consumption and discarding of plastic beverage containers. In Hong Kong, plastic beverage container collection and recycling mostly relies on individual, often non-registered stakeholders. Yet, given the containers' low market value in the city, collection and recycling rates have been relatively low. What complicates matters is the absence of an encompassing waste management (WM) regime and particularly an Extended Producer Responsibility (EPR) scheme for plastic beverage containers. Such regulatory shortcomings leave key WM responsibilities unallocated and render recycling operations solely dependent on market dynamics.

The aim of this paper is to first highlight the qualitative (operational) and quantitative performance of local plastic recycling (collection, pre-processing, and downstream transfers). These findings are then used to identify international best practices and finally juxtapose these against upcoming measures planned by the Hong Kong government.

In terms of analytical framework, the paper proposes a multi-disciplinary approach that combines value-chain analysis, material flow accounting and institutional economics to explore qualitative and quantitative elements of Hong Kong's plastic recycling system. The data used for the study stems from field research in the city during September and October 2021. Over this period, we conducted over 40 in-depth interviews with collecting and pre-processing stakeholders involved in post-consumer waste recycling. Additionally, over 470 instances of recyclable waste transactions were documented to explore the quantitative dimension of the local recycling value chain.

The results indicate that policy intervention and measures are inevitable to achieve a sustainable, circular plastic WM system in Hong Kong. First, international WM regime comparisons show that an EPR system with high container unit deposits is feasible and indeed needed to enable an effective reverse logistics structure. Second, general taxation and insufficient subsidies are critical challenges for recyclers to maintain economically viable operations. Third, costs and usability of as well as storage space related to infrastructure create uncertainty and impair capacities of stationary pre-processing stakeholders. What on the other hand works well is the synchronisation of how operational routines between waste collecting and waste pre-processing stakeholders. The smooth interaction among these stakeholder groups in fact proves that plastic recycling in Hong Kong can benefit from a reliable network structure, which may with relatively low economic incentives (1.4 HKD/ kg of plastic beverage container) realise a sustainable, more circular system. Limitations of the study are the relatively short survey period, which renders further long-term observations and additional interviews with a broader stakeholder base critical for exploring the shortcomings of plastic beverage container recycling in Hong Kong.

Keywords: Hong Kong, Plastic beverage containers, Recycling, Reverse logistics, Collection.

Municipal Solid Waste Management in West Bank/Palestine (Challenges And Solutions)

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Currently, Solid waste (SW) is one of the most pressing issues around the world , as the world population is growing at a fast pace (11 million tons per day in 2100).Since More than 3.5 million tons per day in 2010, global waste generation will reach 6 million tons per day by 2025 and probably about 11 million tons per day in 21006 (According to The World Bank's specialists).As a negative effects, increasing the pollution of soils and water and potentials for health crisis will face many countries, on the other hand it is most probable that developing countries will suffer the most from unsustainable waste management policies.

In west bank (Occupied Palestinian Territory (OPT)), solid waste management is also a crucial issue: the rapid growth of the population and consumption, the limited area of land, water resources and the climate conditions are important factors to be taken in consideration for any future sustainable solid waste management. In addition to the modest capacity of the municipalities in terms of expertise and at the technical and financial levels makes these municipalities in a state of great confusion in dealing with this sector in an appropriate manner.

The Municipalities are the main managers of the solid waste generations in west bank, since the poor Municipal management will lead to unstable on the national level. The common way of waste management in (Occupied Palestinian Territory (OPT)) is disposal at random landfills where the 3R principle (reduce, reuse and recycle) is still not applied nor forced by legislations. Therefore, the municipal situation should be improved on the levels of finance, technical and social awareness.

This paper aims to give an overview about the role of the municipalities in the current situation of solid waste management and in West Bank (WB), at the legislative, technical, financial and social levels . The research examines first the inter ability of the municipalities to manage the SW sector in their areas and second, the municipal solid waste, i.e. the waste collected by or on behalf of municipalities, that is generated by households, and by commercial, industrial and institutional activities, similar in nature and composition of household's waste. In addition, the management of some of the hazardous and infectious waste, which can be present mainly in industrial, commercial and health care activities, is described and takes into account the fact that, in the Occupied Palestinian Territory (OPT), this type of waste is not systematically collected and treated separately.

There are many challenges facing municipalities in managing solid waste sector in West Bank/ Palestine, but on the other hand, there are many qualitative proposals to address these challenges, as the most prominent of these proposals is the Public–private partnership (ppp) principle to reduce solid waste production and raise the social awareness in the communities and raising the ability of the municipalities by improving performance and allocating appropriate financial budgets to this sector.

The study relies on collecting information directly from the municipalities and from some experts in this field at the local and national levels.

Key words: Solid waste management, Ability of Municipality, Social awareness, West bank.

When and How Solar Photovoltaic Waste Would Become a Burden for Hong Kong? and the Actionable Insights for Effective Management

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Hong Kong's first solar photovoltaic (PV) installation dates back to 1985 as the power source for weather stations in remote locations. Later a PV system was installed on the remote island of Hei Ling Chau to power the drug addiction treatment center. Following this, with the government's push towards renewables, many small and conventional stand-alone applications-based PV installations and the most advanced installation types, including Building Integrated Photovoltaic (BIPV) on high-rise buildings and Floating Solar Photovltiaics (FSPV) on water reservoirs, have become popular. Recently, environmentalists and other stakeholders' started expressing concerns about aging solar PV panels due to the lack of end-of-life (EoL) regulations specific to solar panels. Given the existing issues with the city's e-waste management and favoring feed-in tariff policy that is taking the solar installations in a fast-paced manner, we aim to investigate 'when and how solar photovoltaic waste would become a burden for Hong Kong with evidence-based, actionable insights for effective management'.
For this, we first applied a data-driven approach for identifying and mapping solar PV installations in and around Hong Kong to estimate the exact time for different installations' aging for further quantification of possible e-waste. Second, the consequences of not having a regulation leading to various environmental risks are estimated.
The results show that many government-owned solar PV installations have already reached EoL 12 years back from the referenced year 2022, and the first installed non-government solar PV installations will reach EoL in the coming two years (i.e., 2024). The observed environmental risks include the metal's leaching potential, cadmium exposure, and potential chances for water contamination. It is also observed that the existing e-waste guidelines of Hong Kong and the type of material recovery units at Hong Kong's eco-park can potentially recover valuable materials from the EoL solar panels if regulation and infrastructure support
are provided, thus promoting local recycling. Overall, this study offers an aging timeline for solar panels and secondary material inventory when solar panels are recycled under various methods, suggesting the Hong Kong government take immediate action on formulating EoL regulations for solar panels.

Keywords: Photovoltaic waste, E-Waste in Cities, Solar in Hong Kong, Material recovery, Solar waste regulations.

Cross-border Industrial Symbiosis Over in-City Industrial Symbiosis for Hong Kong City's Circular Dream

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In the last five years, Hong Kong's waste disposal rate has snowballed, and it is expected to grow further. But the resource recovery rates from the generated waste have remained consistently low due to a lack of effective waste management centers for all kinds of generated waste. Thinking of solutions, a globally more recognized solution, i.e., the circular economy, is believed to facilitate better resource utilization and waste reduction. But for a city to become more sustainable and circular, effective waste management under the principles of industrial symbiosis (IS) is needed. IS is a process where the waste of by-products produced by one company becomes a valuable material for another, facilitating a reduction in the consumption of virgin materials, water, and energy. So, this study aims to investigate the role of IS in Hong Kong city's circular dream. For this, a data-driven approach is explored considering various resources coming into and going out of Hong Kong city along with manufacturing facilities and available waste management industries. Later, these are mapped with the IS principles to see the possibility of establishing in-City IS. The investigation outcome suggested that in-City IS for Hong Kong is difficult at this stage. But a close look at EcoPark tenants and their waste inputs and recovered outputs suggests that in-City IS is impossible unless major regulatory changes and a diversity push happen. The results also suggest that IS geographic extension leading to cross-border IS could be another best option for achieving Hong Kong city's circular dream.

Keywords: Circular economy, Cross-border industrial symbiosis, International industrial symbiosis, Waste management regulations, Hong Kong circularity.

Solid Waste Management in Different Economic Settings: A Case Study of uMsunduzi Catchment, South Africa

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South Africa is faced with water quality challenges which are mainly associated with waste management that introduces pollutants into the water resources. Insufficient management of solid waste is a palpable cause of stress to the environment, budget processes, community participation challenges, institutional arrangements, finance issues and unsustainable waste disposal. According to the United Nations, ~11.2 billion tonnes of solid waste is collected worldwide and almost all of it comes from humans alone. South Africa is one of the major contributors of solid waste generation globally with an estimated 108 million tonnes of waste contribution; 59 million tonnes of which was classified as general waste. Therefore, it is important to find ways how to manage this waste and come up with strategies that will sustainably manage such waste. Understanding and education about the waste end-results are fundamental but not equally distributed between different economic backgrounds, with the communities from rural and peri-urban areas not fully understanding the impact of solid waste.

UMsunduzi catchment, in South Africa, suffers from poor water quality as well as flooding during the rainy season. Solid waste is only collected and disposed of properly in urban areas of this catchment. The rest of the communities are left to handle their waste and most of it finds its way to stormwater management systems thus impacting their functionality and therefore contributing to flooding and impairment of freshwater systems. As part of the non-structural best management practices (BMPs), it is important to educate the communities on waste management. To lay the foundation, this study aims to explore how well do people in different economic backgrounds within this catchment handle their solid waste and their understanding of its impact. In so doing, using random quantitative sampling methods, communities from rural, urban, and informal settlements will be interviewed to gauge their views on solid waste management and current practices. Overall, this study will highlight the necessity of communities' involvement in the design of BMPs of the catchment and possible adaptation for other catchments with similar problems.

Keywords: Best Management Plans, Environmental Pollution, Solid Waste Management.

Zero Waste Management Community adapted in Karaikudi, Tamil Nadu, Environmental Problem Solving, and Sustainable Development

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The Zero Waste Management Community (ZWMC) initiative was launched in India with the goal of enhancing waste disposal and village cleanliness in transhipment hubs that had been identified. Communities around ZWMC's manufacturing facilities are targeted. The main components include door-to-door waste collection, lane and road cleaning, waste separation, composting of wet waste, and awareness raising. Solid waste disposal is a widespread problem in many developed and developing countries. In the Indian state of Tamil Nadu's Sivagangai district, Karaikudi is a Greater Municipality. According to figures from the 2021 census, it is the 21st largest urban agglomeration in Tamil Nadu.The town is administered by the Karaikudi municipality, which covers an area of 100 km2 (39 sq mi) and contains 32 wards with 628 streets. The town had apopulation of 3,17,041 as of 2021, with 1,55,690 males and 1,61,303 females. Land filling, The most common and mature waste disposal technologies are incineration and composting by the Karaikudi municipality. Traditional methods of transporting solid waste include the use of three types of vehicles: fuel-type vehicles, electric-type vehicles, and man-powered tricycles.There are many types of waste generated that are organic, inorganic, degradable, non-degradable, plastic, metal, rubber, and glass, and these are mostly separated as wet and dry waste. In Karaikudi, approximately 48 metric tonnes of waste are generated per day along this line. Municipal trash Collection is a major part of waste management, including the collection of household waste; this allows waste to be transferred from its original location to the location of its treatment. This includes source reduction and reuse, animal feeding, recycling, composting, fermentation, landfills, incineration, and land application. The residential level of waste secretion is higher. when compared to others. Residential waste is the primary source of waste leakage in Karaikudi. The other important sources are commercial waste, including waste from markets, hotels and restaurants; institutional waste, including waste from schools, colleges, and universities; and government offices; medical waste from hospitals and clinics; and construction and demolition waste. And particularly on the weekends like Sunday and Monday, waste accumulation is higher than on other days. The initial aim is to minimise the waste, starting at the house level. In this study, we analyse the people knowledgeable about garbage disposal and their handling methods in-house. This study is to observe the current system of collection, segregation, and treatment of municipal waste in Karaikudi and create an efficient system of processes at every level that will sustain itself in the future. For example, collecting and glass waste one or two days per week will help in the segregation process and prevent the dry and wet waste from becoming contaminated. And to reduce the burden for the municipality, Alagappa University can handle campus waste on its own using an organic waste management system. It will minimise the waste accumulation on the university campus and produce the compost that will be used in the garden.

Alagappa University assisted in the completion of this project in Karaikudi, Tamil Nadu, India. The Alagappa University launched the Clean Transport initiative with the goal of enhancing waste disposal and cleanliness in Karaikudi, a designated transshipment hub. Customers in transportation hubs have their demands met by ZWMC. The main characteristics include door-to-door rubbish pickup, lane and road cleaning, waste segregation, composting of wet waste, and the establishment of end-of-life spaces is a significant project that the government has initiated. Over 500 individuals used the ZWMC and an excellent to prevent their disposal in landfills.

Keywords: Zero Waste Management Community, segregation, , composting, Solid waste disposal, fermentation, landfills, incineration.

An Analytical Study on Management of Bio-medical Waste in Selected Hospitals of Patna Municipal Ward: A Northern City of India

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The World Health Organization (WHO) considers health as a “state of complete physical, mental, and social well-being and not merely the absence of diseases or infirmity”. In the last few decades, the rapid growth in the urban population with better living standards and demands for better endorsed medical facilities led outnumbering of hospitals in the town without proper planning and management of bio-medical waste (BMW). Large amounts of potentially infectious and hazardous wastes are generated from these hospitals. Indiscriminate disposal and exposure of these BMWs without specific norms like segregation, storage, and management is a serious threat to the environment and human health. The non-availability or shoddy data is a major concern for chalking out appropriate procedures for the remediation of BMW. To investigate the existing bio-medical waste management (BMWM) status, a minor research with a two-step analysis methodology was performed in a few municipal wards of Patna City. The Participatory Urban Appraisal (PUA) methodology was applied to estimate the context and the organization of BMW management as well as to get a clear view of the work culture of the municipal authorities and problems of local residents, staff, and administration of the hospitals. The sampling of data was in the form of structural questionnaires in which 104 health workers, 38 doctors, and 62 nurses from different hospitals participated. The results revealed that the healthcare sectors are still struggling with proper planning & management of generated bio-medical wastes due to non-compliance with the existing guidelines of the Government of India. Based on the survey carried out, appropriate management plan for BMW was suggested.

Keywords: WHO; Patna City; Sampling: Bio-Medical Waste, Participatory Urban Appraisal.

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Waste Utilization and Recycling

Electrocatalytic Upgrading of Furfural, a Platform Chemical from Hemicellulose-rich Feedstocks

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The development of a multifunctional electrocatalyst for biomass-derived platform molecules can diversify the product outcome of biorefinery and strengthen its role in the current petroleum-dominated economy. This study demonstrated how the structural phase distribution of a transition metal dichalcogenides (TMDs) catalyst, MoS_2, can be exploited to control the reaction pathway between electrocatalytic hydrogenation (ECH) and electrocatalytic dimerization (ECD) of furfural. A series of carbon supported MoS_2 electrodes with different structural phase distributions, 1T and 2H, were prepared and fully characterized. The electrodes displayed good stability and successfully converted over 98% of furfural to target products. Under optimized conditions, the 1T-rich MoS2 electrodes were highly selective in producing an ECH product, furfuryl alcohol, with a selectivity of 94.4% over the ECD product, hydrofuroin, whereas the 2H-rich MoS_2 electrodes achieved up to 42.7% selectivity for an ECD product. Mechanistic investigation with underpotential hydrogen desorption (HUPD) studies and density functional theory (DFT) calculation revealed that 1T and 2H-MoS_2 played very different roles during the electrolysis of furfural. The HER-active 1T phase was less friendly to furfural's adsorption than the 2H phase, but its ability to generate adsorbed hydrogen (Hads) provided the necessary component to complete the ECH process. The 2H phase was a better platform for furfural and its radical intermediate adsorption, but its Hads deficient surface led to more ECD product. This study expands the opportunity to design multiphasic materials to control product selectivity during the electrocatalytic reduction of aldehyde compounds.

Keywords: MoS_2, Phase effect, Electrocatalytic hydrogenation, Furfural, Biomass upgrading.

Three Dimensional Activated Carbon Derived from Luffa Fiber Biomass for Capacitive Energy Storage Application

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Agricultural biomass waste derived three dimensional (3D) activated carbons have a great interest in capacitive electrical energy storage devices such as supercapacitors (SC) due to their low cost and abundance with interconnected, multi-channelled, and electrically conductive porous structure. In the present work, the 3D activated carbon was prepared by carbonization of Luffa fiber biomass waste, collected from a local agricultural farm, through hydrothermal technique with a chemical activation process at 800 ºC in Argon atmosphere. The prepared activated carbon honeycomb-like morphology with more voids and a surface area of 138 m^2/g. The degree of carbonization of the Luffa fiber was identified by Raman Spectroscopy and X-ray photoelectron spectroscopy techniques. Moreover, the electrochemical properties of the prepared activated carbon were evaluated in the typical three electrode system in 3 M KOH aqueous electrolyte using Cyclic voltammetry (CV), galvanostatic charge discharge (GCD), and electrochemical impedance spectroscopy (EIS) techniques. The current-voltage profile demonstrates the as-prepared electrode material shows a rectangular-like shape, which indicates the electric double layer capacitance (EDLC) characteristics in the potential window -1.0 to 0.0 V vs Ag/Cl. The value of specific capacitance 909 F/g at the current density of 1A/g was calculated from GCD curve. In the electrolyte solution, the electrical conductivity of the activated carbon was very less when compared with other activated carbons from different biomasses. Finally, we assembled asymmetric SC using the activated carbon (EDLC material) as a negative electrode material and Nickel-copper cobaltite ($NiCuCo_2O_4$ - pseudocapacitive material) as a positive electrode material PVA/KOH gel electrolyte and the performance of the device was tested CV, GCD, and EIS techniques. From CV curves at different scanning rates (0 to 1.4 V) and it was evident that both EDLC and pseudocapacitive behaviour was exhibited. The specific capacitance of the device was calculated as 220 F/g@ 1A/g with an energy density of 65 Wh/kg at a power density of 500 W/kg. This energy density was relatively higher than the similar type of the SC already reported. From the results, it has been concluded that the 3D activated carbon network from naturally abundant biomass can be an effective material for high energy density capacitive energy storage devices and also it would contribute to the sustainable circular economy.

Keywords: Activated Carbon, Luffa Fiber Waste, Supercapcitor.

Efficient Recovery of Phosphate from Aqueous Solution by Calcium Peroxide Decorated Iron-Rich Sludge Carbon: Adsorption Performance and Mechanism

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A large amount of waste containing phosphorus is produced in human production and life, which results extensive waste of phosphorus resources, and also leads to the formation of eutrophication of receiving water due to excessive phosphorus. In addition, a large amount of iron-rich sludge is produced in the process of coking wastewater treatment, which is currently treated as hazardous waste, and the targeted recycling technology is very lacking. Based on the environmental protection concept of waste treatment waste, this study calcined iron-rich sludge from coking wastewater treatment process into iron-rich sludge carbon, and loaded with calcium peroxide in appropriate proportion to prepare the function material (FeSC-Ca) for phosphorus recovery in wastewater. The results showed that FeSC-Ca had high phosphorus adsorption performance in a wide pH range (4.5~9.5) and under different water quality conditions, conforming to pseudo-second-order kinetics, and the maximum adsorption capacity reached 48.39 mg/L (calculated by P). The characterization analysis results showed that $Ca_5(PO4)_3(OH)$ and CaHPO4 precipitate were mainly formed in the phosphate adsorption process. In addition, CaO_2 hydrolyzed to produce H_2O_2, which accelerated the reaction speed and promoted the formation of iron-containing secondary minerals, thus further improving the adsorption performance of phosphorus. The research results are expected to provide theoretical and technical support for sludge resource utilization and phosphorus recovery.

Keywords: Iron-rich sludge carbon, Calcium peroxide, Phosphorus recovery, Resource utilization, Secondary iron ore.

Efficient Catalytic Hydrogen Production from FA over Pd Nanoparticles Loaded on Chitosan Biochar at Room Temperature

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The combustion of non-renewable fossil fuels leads to an increase in CO2 emissions and poses a serious environmental problem such as glacial melting, extreme weather occurrence and ocean acidification. Replacing fossil fuels with sustainable, clean energy is urgent to achieve carbon neutrality. Hydrogen with a high energy density (120 MJ Kg^{-1}) is a promising clean energy carrier and has already widely used in fuel cells. However, the safe and efficient storage and release of hydrogen has been a pressing challenge. Formic acid (FA) with high hydrogen content (4.4 wt%) has been extensively studied as a promising carrier for hydrogen storage. Designing highly efficient, low-cost and recyclable catalysts for FA dehydrogenation is a major challenge. Herein, N-doped biochar was prepared as a carrier for metallic Pd using N-rich chitosan as a precursor, the heterogeneous catalysts with excellent dehydrogenation performance were synthesized. TEM characterization showed that the Pd size of catalysts were mainly distributed between 2.2 and 2.6 nm. The small particle size and uniform distribution of Pd enabled the catalyst to achieve 100% conversion of formic acid to hydrogen in a short time. XPS analysis showed that the carrier was rich in pyridine N, which is benefit on the electron transfer between the N element and Pd. Strong metal-carrier interaction greatly enhanced the catalytic performance of catalysts. The initial TOF of the catalyst reached 615 h^{-1} with an activation energy of 39 KJ mol^{-1}.

Keywords: Hydrogen production, FA dehydrogenation, Pd-based heterogeneous catalyst, Chitosan biochar support.

Evaluation of Carbon Emission and Economy of Carbon Dioxide Mineralization for Building Materials Technology

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China's greenhouse gas emissions, mainly carbon dioxide (CO_2) is huge. The rapid peak CO_2 emissions and neutralization require the timely transformation of energy-intensive industries and the rapid deployment of new low-carbon technologies. Among them, the building materials with Portland cement industries are under great pressure of emission reduction and difficult to carbon removal. CO_2 mineralization combined with industrial solid waste resource utilization technology has opened up a path of large-scale energy saving and carbon reduction for building materials industry with lower cost attribute. Because of long asset life and high degree of marketization of products, early deployment of CO_2 mineralization has obvious economic benefits. In recent years, many related pilot projects have been reported one after another, promoting the improvement of technical maturity. However, for commercialization, this kind of technology still faces the following problems: (1) mismatch between raw materials and carbon sources; (2) uncertainty in operating costs; and (3) uncertainty in carbon prices. The research of the existing demonstration projects clearly points out the opportunities and effects of the reduction of operating costs and carbon price on the landing of the industry. Therefore, in principle, carbon pricing and further incentive policies are necessary measures for the implementation of CO_2 mineralization for building materials technologies. In this paper, three typical CO_2 mineralization for building materials technologies, namely CO_2 mineralization for precast, CO_2 mineralization for enhancing recycled aggregate and CO_2 mineralization for ready-mixed concrete, are systematically evaluated for the Life-cycle CO_2 emission reduction potential and technical economy. Here, compared to conventional technology, precast blocks, recycled aggregate, and ready-mixed concrete can achieve life-cycle carbon emission reduction of -195.34 kg CO_2-eq/m^3 (-120%), -64.73 kg CO_2-Eq/m^3 (139%), and -73.35 kg CO_2-Eq/m^3 (25%). While, the operational cost has a slight advantage, which can effectively reduce the technical cost by reducing the content of cement and using the lightweight aggregate. CO_2 mineralization technology can not only enable the carbon removal of building materials, but also have a significant premium and technological competitive advantage in the future carbon trading market and carbon neutrality policy scenario. Compared with the traditional process, the CO_2 mineralization process can achieve additional benefits of ~100 yuan/m^3, ~38 yuan/m^3, and ~19 yuan/m^3 in precast blocks, recycled aggregate and ready-mixed concrete products, respectively. This work can provide reference for the third-party decision-making of technological transformation and new technology commercialization investment.

Keywords: CO_2 mineralization, Industrial solid waste, Building material, Life-cycle CO_2 emission, Technical economy.

Sustainable Production Of Jet-Fuel Range Hydrocarbons And Carbonaceous Materials From Biowaste Catalytic Co-Pyrolysis

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Biomass provides a renewable and sustainable source of energy with the advantages of being carbon neutral and available in abundance. Bio-oil derived from algae thermochemical conversion shows high quality and conversion efficiency. Carbonaceous material is of interest in carbon capture and sequestration, green chemistry and material science due to its highly recalcitrant properties and benefits in climate change. Thus, this study investigated the production of jet-fuel range hydrocarbons and carbonaceous materials from in-situ catalytic co-pyrolysis of algal biomass and animal manure in CO_2 atmosphere. This study highlighted a sustainable treatment of algal bloom and animal manure with enhanced energy recovery and high-quality products. The results showed an enhancement of CO and H_2 production using CO_2 as pyrolysis medium. The major presence of $Ca_xMg_yCO_3$ in animal manure resulted in a higher production of aliphatic hydrocarbons in the pyrolysis of algal bloom. The presence of Mg_xFe_yK in algal biomass contributed to a large surface area of carbonaceous materials in the pyrolysis of animal manure. Catalytic co-pyrolysis is of interest in achieving sustainable waste management. The technological approach can be applied to other types of bioresources. Thus, this work provides a feasible approach in the conversion and management of marine and biowaste resources.

Keywords: Algal biomass, Biowaste, Catalytic co-pyrolysis, Jet-fuel range hydrocarbons, Carbonaceous materials.

Blockchain-based Artificial Intelligence of Things Nutrient-Rich Food Waste Selection Framework for Food Waste-derived Medical Textiles

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Medical textiles usage has multiplied over the decade. In the last two years, the use has exponentially increased due to Covid-19 across the nations creating supply chain-related issues and excessive resource consumption. This triggered sustainability-related questions highlighting the need for a sustainable resource for producing medical textiles. Very recently, researchers in the field suggested the food waste to fiber concept showing an excellent alternative for producing medical textiles. Nevertheless, the key concern here is the food waste selection with specific nutrients that maximizes the overall yield. Considering this as a serious concern, we explored a digital solution, i.e., the blockchain-based artificial intelligence of things (BAIoT) nutrient-rich food waste selection framework for food waste-derived medical textiles. This study provides conceptual proof and opportunities for leveraging BAIoT protocols in the biorefinery. We also discussed the BAIoT-enabled sustainable and transparent sourcing of food waste and the potential for creating the life cycle inventory of the food procured.

Keywords: Blockchain for waste management, Artificial intelligence of things, Nutrient-rich food waste, Food waste selection framework, Food waste-derived medical textiles.

Optimization of Wet Waste Pre-treatment Process and the Removal of Inert Fine Particles

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The amount of wet waste in Shanghai was 9,000 tons each day after the implementation the policy of waste sorting in China. It can be treated by the method of anaerobic digestion. While the poor performance of pre-treatment process has limited the application of anaerobic digestion. This paper takes a wet waste anaerobic digestion plant in Shanghai as a case study. Several measures were proposed to improve the performance of pre-treatment process. Firstly, replacing the pre-treatment with double-screw feeding to reduce the burden on the large material sorter based on the balance analysis of organic carbon in each processing unit. Secondly, controlling the moisture content in the material sorter below 70% to prevent the loss of organic matter. Thirdly, combining fine separator and pulper to reduce the loss of organic matter with large particle size. Meanwhile, the software of COMSOL Multiphysics was used to simulate the flow of kitchen waste slurry in a Venturi-like design pipeline. The results show that there is obvious inert accumulation in the 5 to 6 meters of the inert particle pipe section. The deposition simulation is carried out for different working conditions and different inert particles, and the initial concentration and the particle size of the inert particles have a great influence on the settlement effect. The optimized conditions in velocity, the initial concentration of inert matter, density and the diameter of pipeline was 1m/s, 5%, 1500kg/cm^3 and 8 mm, respectively. The proposal of this research scheme can effectively optimize the performance of wet garbage anaerobic digestion process.

Keywords: Wet waste, Anaerobic digestion, Pre-treatment, Inert particulate matter, Numerical simulation.

Employing ASPEN Plus for Process Modellng of Syngas Production from Municipal Solid Waste

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Municipal solid waste (MSW) generation around the globe amounts to approximately 2.01 billion tons per year. In response to rising MSW generation and environmental concerns, there has been an increase in global interest for waste recycling as a renewable energy source. Recovery of energy from waste is becoming increasingly popular as a means of lowering the country's reliance on imported oil. Waste to Energy (WtE) technologies can be used to produce clean, renewable energy at a lower cost while still being environmentally benign. MSW can be converted to syngas via various thermo-chemical conversion technologies. A kinetic free equilibrium model has been developed for the simulation of the gasification process of MSW using ASPEN Plus. The effect of temperature and Steam/MSW (S/M) ratio on the syngas yield was studied and optimum conditions were calculated for the conversion of MSW to fuel via gasification. It was observed that the maximum amount of syngas was obtained at temperatures above 800°C and when the S/M ratio is in the range of 0.2-0.4. Furthermore, gasification of MSW at S/M ratio 0.3 and 850°C temperature resulted in higher syngas quantity in the product gas alongside reduced CO_2 emissions.

Keywords : Simulation ; Syngas; Gasification; Carbon emission.

Performance Evaluation of Interlocking Paving Bricks Incorporating Waste Plastic as Alternative Aggregates

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Recycling is now necessary due to the problems caused by plastic waste's ongoing growth. Globally, 76% of the total plastic produced has been discarded as waste and less than 10% of this waste is recycled. Plastic can be recycled mechanically, chemically, or thermally, while mechanical recycling is still the most popular method. Without the requirement for chemical alterations or breakdown, mechanical recycling entails grinding and/or shredding with the potential for reuse as replacement materials. However, plastic waste still contributes to landfill and water pollution. Therefore, the purpose of this study is to assess how well waste plastic performs when combined with various aggregates for paving bricks. The mechanical properties of paving bricks with fully conventional aggregate as the control, paving bricks with coarse aggregate made of plastic waste, and paving bricks with fine aggregate made of plastic waste will be investigated using compression strength, flexural strength, freeze-thaw, absorption resistance, and slip tests. Additionally, three types of plastic waste (low-density polyethylene, polystyrene, and polyethylene terephthalate) will be put to the test to determine which type performs the best in terms of compressive strength. The acquired results will be contrasted with the standard PB's structural performance. This research will clarify how waste plastic can be used in PB and address the management issue raised by waste plastic disposal.

Keywords*:* Plastic waste; paving bricks; waste management; recycling.

Monitoring of Beach Litter in Waters of Hong Kong Using Aerial Drone

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Litter in the environment is a problem that affects the shores throughout the world. It causes ecological concerns due to its potential impacts on biodiversity and marine wildlife. As indicated by the HKEPD, western and southern waters of Hong Kong receive large amount of marine debris from the Pearl River Delta, especially during wet season. In order to set up a better strategy for marine conservation, quantification of beach litter is vital. In this study, we employed commercial aerial drone to detect litters on twelve ecologically important beaches scattered from north-western New Territories to southern Hong Kong Island, either categorised as coastal protection area or marine park/reserve. Sites were then ranked against their cleanliness for better follow-up action for marine conservation. The developed method will be readily transferred to the public or organisation of interest.

Keywords: Aerial drone, Beach litter, Plastics.

Choline Chloride-Dicarboxylic Acid Based Deep Eutectic Solvents for the Valuable Metal Recovery of Waste Printed Circuit Boards

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Waste printed circuit boards (PCBs) generated are growing exponentially yearly, and their management has gradually become a waste management problem. Until now, most waste PCBs have been landfilled, incinerated, or stored in recycling stations, but these operations may result in severe pollution of the surrounding soils by toxic heavy metals in PCBs, which is potentially harmful to the environment and human health. In addition, it is estimated that PCBs contain 13-26 times higher Cu content than ores. Therefore, PCBs are an attractive resource in urban mining. The recovery of valuable metals from waste PCBs is beneficial not only to environmental protection and health safety but also to renewable metal resources. The mature recycling process of valuable metals from waste PCBs mainly involves hydrometallurgy. The processing routes are typically very energy intensive, need strong acid for leaching, and generate large volumes of solid residues and wastewater, which must be further treated and disposed of in the subsequent operation. Thus, there is a challenging issue in developing clean and environmentally sound processes to realize efficient resource recovery from waste PCBs. Deep eutectic solvents (DESs), as a new type of green solvent, are generally eutectic mixtures formed by a hydrogen bond donor (e.g., carboxylic acid) and a hydrogen bond acceptor (e.g., choline chloride). DESs are involved in a complex hydrogen bonding network, thus resulting in significant freezing point depression compared to the parent compounds. The functional groups contain lone pair electrons, such as Cl^- and carboxyl in the DESs, to preferentially form complexes with metal ions in their oxide compounds and achieve efficient leaching. In recent decades, the great potential of the inexpensive, available, and environmentally friendly DESs to replace inorganic acids, has been demonstrated in the work of metal leaching. This study aims to develop a highly effective and green technique for leaching and recovery of valuable metals from metal powders obtained from the crushing and separation of waste PCBs. Considering the cost and leaching performance in relatively low temperatures, the hydrogen bond receptor is choline chloride ($C_5H_{14}ClNO$), and the oxalic acid ($C_2H_2O_4$), malonic acid ($C_3H_4O_4$), succinic acid ($C_4H_6O_4$) and adipic acid ($C_6H_{10}O_4$) are selected to be the hydrogen bond donor. The leaching kinetics using these DESs on the metal oxides (CuO, Fe_2O_3, ZnO) and elemental metal (Ag) were demonstrated. CuO can be dissolved in DES in the form of $[CuCl_4]^{2-}$, while it is expected that Fe_2O_3, ZnO, and Ag would be insoluble to reach Cu separation. The difference in leaching induced by different dicarboxylic acids can be further explored by density functional theory (DFT) calculations and Fourier-transform infrared spectroscopy (FTIR). The separation procedure of Cu in DES is also investigated by solvent extraction, multi-step precipitation procedures, and the direct addition of pure water to form copper precipitates, such as copper oxalate. In addition, the recovery feasibility using DES on the mixed-phase materials obtained from PCBs is also discussed.

Keywords: Deep eutectic solvent, Dicarboxylic acid, Metal recovery, Printed Circuit Board, Green leaching.

Effect Of 7, 8 Dihydroxycoumarin Protects Environment Toxicity of Cadmium Induced in Zebrafish (Danio Rerio) Embryos

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Cadmium (Cd) is one of the precedence pollutants in the environment which menaces the aquatic organisms. Cd is also shown to have deleterious health impairments causing male and female infertility in humans. In this study, we investigated the role of 7, 8- DHC as a potent rescuer of Cd induced toxicity using zebrafish (Daniorerio) model. The anti-oxidant property of 7,8-DHC was analysed and confirmed using 2,2-diphenyl-1-picrylhydrazyl (DPPH), ferric ion reducing power (FRAP) and hydroxyl radical (OH) assays. Further, we induced Cd toxicity in zebrafish embryos at 100-µM concentration and the intoxicated embryos showed a significantly reduced survival, delayed hatching and phenotypic aberrations at 24, 48, 72 and 96 hours post fertilization (hpf). Similarly, Cd intoxicated embryos showed an expressively increased cardiac function (170 ±1 beats/min and 172± 1 beats/min) at 48 and 60 hpf. Furthermore, the rescuing effect of 7,8-DHC was analysed via treatment of Cd intoxicated embryos at dosage dependent manner. At 100 µg, 7,8-DHC showed significantly reduced heart beat compared to the Cd intoxicated embryos. Moreover, 50 and 100 µg of 7, 8-DHC treated groups showed 103± 1 beats/min and 104±1 beats/min respectively. Histopathological interpretations revealed the rescuing effects on notochordal segmentation at 50 and 100 µg 7, 8-DHC in Cd intoxicated embryos at 96 hpf. Overall, our results clinched that 7, 8-DHC could act as a potent redox scavenger against Cd toxicity.

Keywords: Pollutants, Cadmium, 7,8 –DHC, Treatment, Toxicity, Zebrafish Embryo.

Generation and Utilization of Garden Waste in Shanghai: Status Quo, Challenges and Countermeasures Analysis

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With the urbanization and increasing of green space, the generation of garden waste has continued to increase. The resource utilization of garden waste is an important boost for to build a "green", "low-carbon" and "waste-free" city under the strategy to achieve carbon peak and carbon neutrality. As a megacity in the world and the science and technology innovation center in China, Shanghai was taken as a case to study the status quo of garden waste generation and resource utilization, as well as the challenges for its utilization. The experiences of resource utilization of garden waste in some typical cities were summarized. The systematic problems of garden waste utilization were analysed, and suggestions to promote resource utilization of garden waste were proposed.

Keywords: Garden Waste; Generation; Resource Utilization; Countermeasures.

Potential Utilization of Sewage Sludge for Cost Effective Natural Farming in India: Characterization and Treatment

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In India, sludge from STPs is usually disposed on land as manure or dumped in open areas. However, heavy metals pathogens and hazardous organic contaminants in sewage sludge restrict its use as a soil amendment. Open dumping and/or direct utilization of dewatered sludge on land may create problems like odor nuisance, groundwater pollution, and other public health hazards. In India most common sludge treatment methods are anaerobic digestion, mechanical composting, solar sludge drying and incineration are used to for the disposal. Hence, to understand the fate of sludge on land application, the characterization of dewatered or treated sludge in terms of pathogens, vectors, and heavy metals is desired.

For the study purpose, treated sludges from twenty-two sewage treatment facilities were characterized to develop the quality control indices in India. The findings revealed that except for K, all the dewatered sludge samples have pH, electrical conductivity, total organic carbon, TN, TP, and C:N ratios within the threshold range of the Indian Standard (Fertilizer Control Order (FCO) 2009). The heavy metals concentrations meet USEPA Class B sludge quality criteria but failed to meet the limiting concentrations specified by USEPA Class A sludge and FCO-2009 standards. Approximately 54% of the sludge samples fulfilled the vector attraction reduction criteria of USEPA criteria. This study used Fertilizer Index (FI) and Clean Index (CI) as a tool for categorizing sludge utilization into different classes (A, B, C and limited use classes LU-1, LU-2, LU-3) by their fertilizing potential, toxicity level, pathogen presence, and vector attraction reduction criteria. The findings revealed that all sludges belong to class C and lower category due to toxic metals, pathogens. However, sludge samples have fertilizing potential and further sludge treatment using typical composting, aerobic or anaerobic digestion, and solar or thermal drying could bring the sludges into the class A and B category.

Overall, FI value is reported ranging from 4.1 to 4.9 and CI value ranging from 2.5 to 5.0 and which indicates compost is best in quality having high-value potential and low heavy-metal content which is suitable for high-value crops such as organic farming. In addition, cost effective natural farming by utilizing high nutrient and pathogen free good quality sludge can create new livelihood generation activities and help implement a circular economy approach.

Keywords: Sewage sludge, Quality control indices, Heavy metals, Pathogens.

Simultaneous Adsorption Abilities of Inorganic-organic Modified Montmorillonite as Affected by Different Adding Sequences

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This study investigated the modification of montmorillonite, one of the major components in construction waste materials, to simulate their application for the fabrication of adsorbents, followed by the simultaneous adsorption abilities of these adsorbents towards hexavalent chromium (Cr) and bisphenol A (BPA). The adsorbents, inorganic-organic montmorillonite (IOMMts), were synthesized with three different adding sequences of keggin Al_{13} complex (Al_{13}) and hexadecyltrimethyl ammonium (HDTMA), where montmorillonite (MMt) was modified by a) Al_{13} first then by HDTMA (O-Al-MMt); b) HDTMA first then by Al_{13} (Al-O-MMt); c) Al_{13} and HDTMA simultaneously (Co-MMt). For comparison, MMt was also modified by Al_{13} and HDTMA individually (Al-MMt and O-MMt). The amounts of Cr and BPA adsorbed by IOMMts in a single pollutant system and a binary pollutants system were determined using HPLC-DAD. Furthermore, the adsorption isotherms of IOMMts towards Cr and BPA in these two systems were studied. The adsorption mechanisms were investigated based on the physical-chemical characteristics of IOMMts, which were determined by X-ray diffraction (XRD), thermogravimetric analysis (TGA), Fourier transform infrared spectroscopy (FTIR), scanning electron microscope coupling with energy dispersive X-ray detector (SEM-EDX), and BET surface area analysis. The adsorption results in single system revealed that Al-O-MMt and Co-MMt had better adsorption ability towards Cr and BPA than MMt, Al-MMt, O-MMt and O-Al-MMt. The TGA and adsorption results indicated that the decomposition temperatures of HDTMA and the adsorption abilities were similar for Al-O-MMt and Co-MMt, but different for O-Al-MMt. It supposes that the status of HDTMA in the interlayer of montmorillonite was affected by Al_{13}, providing IOMMt with a better adsorption function. In the binary pollutants system, the amount of BPA adsorbed onto IOMMts was reduced. On the other hand, the amount of Cr adsorbed onto IOMMts in the binary pollutants system was better than in the single pollutant system in lower concentration of Cr. It might be because the synergistic effect from BPA on the adsorption process of Cr is significant in lower concentration. In addition, the amount of Cr adsorbed increased with increasing concentration of BPA up to 100 mg/L, but decreased when the concentration of BPA was more than 100 mg/L. This could be due to the occupation of adsorption sites by BPA, preventing from adsorbing Cr.

Keywords: Bisphenol A, Hexavalent chromium, Inorganic-organic modified montmorillonite, Simultaneous adsorption.

Preparation of Nano-$CaCO_3$ By-product of Biogas Decarbonization with Microfluidic Device

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Biogas is a renewable resource, which contains about 50%-65% methane (CH4), 35%-50% carbon dioxide (CO2), water vapor and a small amount of hydrogen sulfide (H2S) in biogas. The existence of carbon dioxide will not only reduce the combustion heat value of biogas, but also cause corrosion to production equipment. Therefore,purification of biogas is one of the key technical links in biogas production . Nowadays, several technologies such as high-pressure water washing, absorption, membrane separation, and pressure swing adsorption are used to remove CO2. However, these processes are expensive and may lead to high CH4 losses. In addition, these methods do not make effective use of CO2. Reducing carbon dioxide emissions is a huge challenge. Carbonation appears to be a successful method because it allows long-term storage of carbon dioxide from industrial gas streams. f there are industrial wastes such as slag and carbon dioxide, it is beneficial to the environment to use them to produce precipitated CaCO3. This approach saves natural resources such as limestone, reducing energy consumption and overall CO2 emissions. Therefore, a new technology is needed that can not only purify biogas to obtain high-purity methane and recover carbon dioxide, but also produce high value-added products. Micro reactor or microfluidic equipment can be used to generate ultra-fine particles by mixing reaction materials through micro channels. Controllable preparation of ultrafine particles requires accurate control of the mixing flow field, residence time and concentration field in the microreactor. In the micro reactor, the key factor is the control of flow field to realize the controllable preparation of uniform particles. Especially, in the process of multiphase mixing, which involves the formation of liquid masses, droplets or bubbles in the micro channels. The dynamic change characteristics of dispersed phase are related to the nucleation and growth process of particles closely. In this report, the flow characteristics in the microreactor will be studied from the perspective of hydrodynamics, and the computational fluid dynamics (CFD) simulation method will be used to reveal the process law under the flow regulation to provide theoretical guidance for the design and operation of the microreactor and improve the understanding of the internal flow and reaction process of the microreactor. In the research work, we designed brand new microfluidic device and designed different microfluidic chips. It was used to prepare calcium carbonate particles with different particle sizes, and efficiently obtained high value-added nano-scale calcium carbonate particles. The CO2-enriched water was prepared by high pressure water scrubbing. Then the CO2-enriched water was used in the microfluidic device to react with Ca(OH)2 to form nano-CaCO3. After the preparation, our work also analyzed the properties of nano-CaCO3 particles. At the end of the research work, we also used the Computational Fluid Dynamics (CFD) method to simulate the micro-mixing reaction process.

The results show that keeping the flow rate of carbon dioxide solution unchanged, increasing the flow rate of calcium hydroxide solution will reduce the conversion rate of calcium hydroxide, but will improve the conversion rate of carbon dioxide and promote the formation of calcium carbonate. While keeping the flow rate of calcium hydroxide solution unchanged, increasing the flow rate of carbon dioxide solution will reduce the conversion rate of carbon dioxide, but it can improve the conversion rate of calcium hydroxide and increase the production of calcium carbonate.Secondly, Increasing the feed concentration of carbon dioxide will increase the molar flow of carbon dioxide at the outlet, more unreacted carbon dioxide will flow out of the reactor, the conversion rate of carbon dioxide will be reduced, the conversion rate of calcium hydroxide will be improved, and the generation of calcium carbonate will be promoted. In addition, the simulation calculation shows that increasing the distance between the reaction feed pipe and the discharge pipe can increase the contact area between carbon dioxide and calcium hydroxide effectively. Therefore, increasing the distance between the feed pipe and the discharge pipe is conducive to improving the conversion of carbon dioxide and calcium hydroxide and increasing the output of calcium carbonate at the same time. Finally, compared with circular chips, when semi-circular chips are used, although the conversion rate of calcium hydroxide is slightly reduced, the utilization rate of carbon dioxide is greatly improved, and the output of calcium carbonate is also improved. The main reaction area of calcium hydroxide is near the semi-circular chip, which makes the concentration far away from the reactor outlet reach a very low level.

Interfacing Biosynthetic CdS with Engineered Rhodopseudomonas Palustris for Efficient Visible Light-Driven CO_2-CH_4 Conversion

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Inspired by natural photosynthesis, interfacing living cells and abiotic inorganic semiconductors has led to a pioneering conception of photo-assisted biosynthesis, termed as semi-artificial photosynthesis. For example, targeting CO2-CH4 conversion, great progress has been achieved in the construction of the biotic-abiotic hybrid system based on methanogenic archaea. In this work, we construct a light-driven methanogenic biohybrid system based on photosynthetic bacteria and nano-photocatalytic materials. R.palustris (R.p) with recombinant [MoFe]-nitrogenase allowing for novel one-step CO2-CH4 conversion, and it also retain its inherent metabolic diversity and rapid growth. The visible light-responsive CdS nanoparticles (NPs) were simply biosynthesized and precipitated in situ on the surface of R.palustris by incubating the precursor reagents to the cultivation. Receiving the photoexcited electrons resulting from CdS NPs, this biohybrid system significantly activated intracellular CO2 metabolism of recombinant nitrogenase. As for the experimental section, five sets of contrasting trials were set up: R.p with and without light, R.p-CdS with and without light, R.p(Dead)-CdS. Then, a series of electrochemical and spectroscopic experiments have verified its involved properties of photoelectron transfer. Finally, transcriptomic analysis and related experiments were used to deeply investigate the underlying molecular mechanisms of CH4 production.

Transmission electron microscope (TEM) revealed that the CdS NPs irregularly precipitated on the cell surface,and the intrinsic band gap estimated with Tauc plot was 2.73 eV. The CH4 production in the biohybrid under visible-light irradiation was far outperforming of other controls. To further improve the efficiency of CO2-CH4 conversion in the biohybrid, three critical concentration parameters, cadmium ion,sulfur source and sacrificial agent were optimized, and the CH4 production increased in a nearly linear fashion up to 3 days and finally achieved 155 nmol/mL after 5-day photocatalytic experiments, a 13.4-fold increase compared to the pure bacterial system after optimization. Electrochemical impedance spectroscopy (EIS) and transient photocurrent response experiments validated the biohybrid reached higher photocurrent than that of the biological system. higher cell dry weight of biohybrid was generated in the photocatalytic process (1.33-fold compared with the bare cells). By transcriptome sequencing, we analyzed and assumed that photoelectron from CdS NPs enhanced great photoautotrophic ability at three levels: membrane interface, intracellular and whole cell. With the help of the cytochromes in the ETC, partial photoelectrons participated in cycle photophosphorylation, significantly enhancing ATP synthesis. Other part of photoelectrons transferred directly into the cell as a supplementary source of bioelectrons. In order to divert excess intracellular energy and electrons, R. palustris selectively activated nitrogenase for redox balance. The metabolic shift from CO2 fixation of the Calvin cycle to CO2 biomethanation weakened competition from other intracellular electron acceptors in a self-regulated way. Further, whole-cellular conductivity and resilience were enhanced by high expression of related proteins to maintain a high level of reactivity of the biohybrid system.

Our discovery encourages a novel insight and promising strategy for the improvemnet of the current CO2-CH4 biomanufacturing system.

Keywords: Photoelectron transfer, Rhodopseudomonas palustris, Photocatalytic conversion, Carbon dioxide reduction, Membrane-bound proteins.

Application of Hybrid Solar-Powered Electrocoagulation and Electrooxidation System for Textile Wastewater Treatment

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The textile industry is one of the significant consumers of dyestuff, chemicals, and water. As a result, a large amount of wastewater is generated. During the dyeing process at the dyeing unit, 30% of the dyestuffs remain unbound with the cotton cellulose fibers. The wastewater discharged from the textile dyeing industry is challenging to treat using conventional treatment methods as these effluents are complex, toxic to microorganisms, and recalcitrant to biodegradation. Limited studies have demonstrated that the hybrid electrocoagulation-electrooxidation (EC-EO) process is an efficient technology for eliminating different pollutants. However, the potential of this technology to tackle the problem of the textile industry in developing countries like Ethiopia has not been optimized. In addition, a very concentrated dye solution, equivalent to textile effluent, was used to test the efficacy of the treatment method, which is also not commonly considered in other studies. Furthermore, the current global concern related to the energy crisis and climate change demands the use of renewable energy as a power source. Therefore, to address this problem, a hybrid solar-powered electrocoagulation (EC) and electrooxidation (EO) process has been evaluated for its capability to remove color, total organic carbon (TOC), and chemical oxygen demand (COD). Aluminum (Al) and iridium oxide coated on titanium (IrO_2/Ti) were selected as anode/cathode for EC and EC-EO experiments, respectively. The results were evaluated based on the interaction effects of operating parameters of the treatment methods on the percentage of COD, TOC, and color removal. The hybrid EC-EO process obtained 97% COD, TOC, and color removal efficiency. In addition, the results of the combined spectroscopy analysis confirm the complete degradation of organic contaminants to carbon dioxide and water. Moreover, the optimum operating conditions are tested for real industrial wastewater effluents and show excellent performance in removing pollutants. Besides, the optimal working conditions were also evaluated using direct solar modules and showed comparable removal performance with conventional electricity. Thus, this study demonstrated that the treatment method using mesh IrO_2/Ti electrodes is a promising technology to meet the discharge limit for textile industrial effluents. Furthermore, this study can provide an effective solution for areas where electrical energy is an issue.

Keywords: Cotton textile wastewater, Hybrid electrocoagulation and electrooxidation, Solar powered, FTIR and NMR, Dye degradation extent.

Biodegradability of Non-biodegradable and Biodegradable Plastic through Circular Economy

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Plastics are ubiquitous in worldwide. They are used almost in every fields of technology due to their longer durability, high tensile strength, elasticity and non-degradable nature. Today's world is known as "the plastic age". Besides improving our lives, they are more harmful for us and for environment. Accumulation of large amounts of plastics in soil, and water has shown harmful effects on agricultural plants by inhibiting plant growth, and ingestion of micro plastics and Nano plastics through food chain causes dreadful diseases to humans and animals. Prevalence of climate change problem is also due to the accumulation of persistent plastics in environment. One solution for alleviating non-biodegradable plastics is using biodegradable plastics made of biodegradable biopolymers by which extracellular enzymes of microorganisms can utilize them as metabolic products and sole source of carbon and oxygen for the growth of microorganisms. This can help reduce the problems of climate change, micro plastic accumulation and littering. However, biodegradable plastics still lacks complete degradation by microorganisms or arthropods. In depth study is required to unwind complete biodegradation process by some enzymes isolated from plants, bacteria, and fungi. Here we highlighted few putative genes involved in the biodegradation process for further studies. In addition some of the recent assays used to test the biodegradability of plastics and bio-based plastics, their mechanism and applications. Few updates regarding alternatives of plastic are development of bio plastic mulch films for better crop plant yield. Future prospects have highlighted knowledge gaps which are required to study for the development of more alternatives of plastics.

Keywords: Biodegradation, Plastics, Bio plastics, Micro plastics, Nano plastics.

Utilization of Baobab Fruit Shell Waste as a Filler-Fibre for Enhancing Polyethylene Biodegradation and Improving Soil Fertility

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Baobab (*Adansonia digitata*) is a majestic tree majorly found in the arid and semi-arid areas of sub-Saharan Africa, with most of its parts (fruit-pulp, seeds, leaves, and fibrous filaments) considered to have over 300 different applications ranging from medicine, food, building materials, and so on. However, baobab fruit shell (BFS), which occupies more than 80% of the baobab fruit, is considered waste and discarded indiscriminately, posing a danger to the environment, which could be looked into and evaluate its possible application. Interestingly, previous literature has found many beneficial compounds and essential nutrients in the BFS, thus making it a potential filler fibre that may enhance the degradation of synthetic plastic materials. Therefore, it will be paramount if organic waste can be further valorized into value-added products for environmental sustainability. Hence, this study will examine whether BFS, when used as a filler fibre (at varied ratios), has an effect on mulch covers made mostly of polyethylene (PE) and whether soil fertility is improved while it is in use.

The use of mulch cover cannot be overemphasized, as it gives farmers many advantages by enhancing crop ripening and speeding its growth. Mulch covers are made from either low-density polyethylene (LDPE) or high-density polyethylene (HDPE), which can be black or clear in colour depending on the intended use (the black types warm the soil more than the clear types). However, there is a great challenge, especially when the materials become old and need replacement or after cropping season, which mostly ends with pieces of plastic buried in the soil. Besides, the cost, management, and high-temperature generation under the mulch cover were additional disadvantages associated with plastic mulch, which will be looked into during our investigation.

Furthermore, this study will employ standard laboratory procedures such as scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDS), Fourier-transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), X-ray diffraction (XRD), and dynamic mechanical analysis (DMA). Also, according to the standard methods, viscosity, storage modulus, and loss modulus investigations will be carried out in addition to the soil burial test.

Keywords: Baobab fruit shell, Polyethylene, Biodegradation, Microplastics, Soil fertility.

Fe^{3+} Addition for Enhancing the Formation and Stabilization of Aerobic Granular Sludge

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Aerobic granular sludge (AGS) has grained great attention due to its good settling property and high pollutant removal efficiency. However, it was found that AGS requires longer time to form the granular and has poor stability when it is used to treat wastewater with low COD concentration such as municipal wastewater. In this study, Fe^{3+} was employed to enhance the AGS formation and stabilization to treat municipal wastewater. During the cultivation of AGS, 3~5 mg/L of Fe^{3+} was continuously added. The results showed that Fe^{3+} addition accelerated the formation of AGS cultivated with simulated domestic sewage (COD 250~300 mg/L), and the granulation was achieved in 7 days, and mature AGS was cultivated on 25 days. However, AGS was not formed until 25 days in the control group without Fe^{3+} addition. After the AGS was matured, it was used to treat the synthetic municipal wastewater. It was observed that the continuous addition of Fe^{3+} was beneficial to the stability of the AGS, while the mature AGS without further addition of Fe^{3+} gradually disintegrated. After continuous operation for 300 d under the optimized parameters, AGS has achieved stable removal on COD, NH_4^+-N, TN and TP which were 90%, 94%, 69% and 42%, respectively. The study reveals that Fe^{3+} addition has shortened the AGS formation period and improved the stability of AGS. It provides a solution for AGS application to treat municipal wastewater.

Keywords: Municipal wastewater, Granulation, Stabilization, Long-term operation.

Optimum Strategies Of Regional Kitchen Waste Treatment Against A Background Of Carbon Mitigation

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Kitchen waste treatment (KWT) accounts for 6% of the global carbon emissions. Reducing the carbon emissions of KWT is regarded as an effective way to achieving the goal of carbon mitigation. In order to realize the carbon emission targets of our country, it is necessary to study the carbon emission characteristics and carbon emission reduction path of kitchen waste management system. In this study, a hybrid method, combining life cycle analysis (LCA), Copula functions and an interval linear programming model, was proposed. The carbon emissions of four technologies (i.e., landfilling, incineration, anaerobic digestion, and composting) for KWT were evaluated based on the LCA framework. Strategies for the multiple technologies were obtained using the interval linear programming model. This method can effectively identify the potentials for carbon mitigation in the KWT technologies with consideration of their eco-economic performance. To confirm the effectiveness of the method, a case study was conducted in the urban agglomeration of the Zhaoqing City of Guangdong Province in China. According to the characteristics of different treatment technologies, reduction strategies (combined incineration and landfill with biochemical treatment technologies) and simple strategies (combined landfill with biochemical treatment technologies, and landfill with incineration) were considered in this study. The results showed that the contribution of energy recovery efficiency and carbon mitigation would be the most obvious in anaerobic digestion combined with other treatment technologies. The optimization results showed that the performance of economic and carbon mitigation in the reduction strategy would be better than that in the simple strategy. Under the background of carbon mitigation, the application ratio of incineration and landfill combination, anaerobic digestion, incineration and landfill combination, as well as aerobic composting, incineration and landfill combination in 2025 would be 82.04%, 3.03% and 14.92%, respectively.

Keywords: Kitchen waste, Carbon emissions, Life cycle analysis, Interval linear programming models, Zhaoqing City.

Influence of C_{14} Alkane Stress on Cd and Nutrient Elements Uptake By Four Potential Petroleum Hydrocarbon Remediation Plants

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With the rapid industrialization and urbanization, soil contaminated with cadmium (Cd) and petroleum hydrocarbon has become a severe environmental and human health concerns. Petroleum hydrocarbon is a complex mixture of hydrocarbons, among which short chain alkane is a kind of pollutant with high component content and high toxicity. Thus, the influence of C14 alkane on growth, mineral nutrient elements uptake, and Cd uptake characteristics of four potential petroleum hydrocarbon remediation plants (*Lolium perenne* L. (ryegrass), *Ricinus communis* L. (castor bean), *Amaranthus hypochondriacus* L. (amaranth) and *Mirabilis Jalapa* L. (marvel of peru)) were investigated. The results indicated that the dry biomass yield of shoot and root of four plants gradually decreased with the increasing of C14 alkane concentration. The growth inhibition ratios of shoot and root at 1% treatment exceeded 60% and 40%, respectively. The interesting result is that C14 alkane elevated the concentration of Cd in the shoot of plants. 0.1% and 0.2% C14 alkane treatment increased ryegrass and amaranth Cd concentration in shoots. When the C14 alkane concentration increased to 0.5%, the Cd concentration in shoot of castor bean significantly increased 1-fold. The Cd uptake amounts of ryegrass and marvel of peru significantly elevated at 0.1% C14 alkane treatment, then gradually decreased with the increase of C14 alkane concentration. The Cd uptake amounts of castor bean and amaranth significantly decreased in the presence of C14 alkane. The C14 alkane treatment also significantly affected the nutrient elements concentration in shoot and root. It is noteworthy that C14 alkane treatment significantly increased the manganese (Mn) concentration in shoot and root of the four plants. The increase of soil DTPA-Cd and Mn concentration may be an important reason for the increase in plants Cd and Mn concentration. However, the inhibition of plant growth by C14 alkane reduced the Cd uptake by plants. This study provides a theoretical basis for understanding phytoremediation of Cd- C14 alkane co-contaminated soil.

Keywords: Soil, Cadmium, C14 alkane, Phytoremediation, Nutrient elements.

Carbon-Driven Persulfate Activation for Nonradical Antibiotic Degradation in Aquatic Surroundings

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Carbon-driven nonradical persulfate activation exhibits compelling advantages due to its good reactivity in complex aquatic surroundings. However, the catalytic capability of pure carbonaceous materials is dissatisfied. To seek the eco-friendly and efficient carbon-based persulfate activator, the following work was conducted. Enhanced adsorption and persulfate-driven oxidation of pollutant were simultaneously achieved on single boron-doped carbon, originating from a facile pyrolysis of glucose and boric acid. Boron with vacant p orbital can act as Lewis acid site to increase the adsorption capacity. High catalytic activity toward persulfate was attributed to the generation of carbon-based structural defects, and BC_3/BC_2O functionalties induced by B doping. Of note, the adsorptive and catalytic behaviors were significantly affected by B doping amount. With 0.82% B (CB-0.9), the best performance of 96.1% removal efficiency and 79.7% mineralization rate were obtained within 90 min by degrading sulfamethoxazole (SMX). Correspondingly, the rate constant (k_{obs}) was up to 0.0340 min^{-1} and the adsorption capacity was 56.20 mg g^{-1}. Furthermore, our findings suggested that adsorption positively promoted the subsequent oxidation. The effects of inorganic anions, pH, humic acid, and real water matrix were investigated. Combined with LC-MS analysis and frontier molecular orbital theoretical calculation, six possible degradation pathways were proposed. The toxicity effects of intermediate and parent SMX were monitored by the growth inhibition of Chlorella. Radical and non-radical pathways jointly resulted in the catalytic degradation of SMX, in which $^1O_2$ dominated the oxidation, $SO_4^{\cdot-}$/$^{\cdot}OH$/direct electron transfer process played the secondary role, and $O_2^{\cdot-}$ served as the precursor for $^1O_2$ production.

Keywords: Persulfate, Advanced Oxidation Processes, Carbocatalyst.

Odor Emission Characteristics from Unorganized Source of Kitchen Waste Management Plant and Control Strategy

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Odor emission has become a great issue for kitchen waste management plants. The complain from public requires responsible response. Odor emission from unorganized sources are the key problem. It is necessary to understand the odor emission characteristics and proper control solution is highly demanded. In this study, a typical kitchen waste treatment plants located in Guangdong Province of China was selected. The unorganized odor emission source of the treatment plant was the pretreatment workshop. The samples were collected and the odor concentration was measured and analyzed by three-point comparative odor bag method. Quantitative analysis of all aspects of the odor concentration were analyzed by three-stage cold trap, high/low resolution gas chromatography mass spectrometry (GC-MS) and liquid chromatography. The results showed that sulfur compounds, oxygen-containing organic compounds and terpenes were the main odorous gases in the plant. Ethanol, acetaldehyde, dimethyl disulfide, methyl sulfide and limonene were the main odorous pollutants treated by threshold dilution ratio analysis. Based on grey correlation, principal component analysis (PCA) and step-up regression analysis, dichloromethane was found to be the most closely related to the odor concentration. The CFD stimulation was employed to optimize the pretreatment workshop entrance design and the air exchange system. In addition, the air curtain parameters were calculated. The study provides the clear cause of odor which assists researchers to target the treatment.

Electrolytic Treatment of Septic Tank Sludge

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Septic tank systems are the most used treatment systems for the treatment of domestic wastewaterfrom isolated residences. The septic tank system produces sludge and scum due to sedimentation. The BFS is generally untreated due to the lack of methods for its management and treatment.

This project aims to treat, stabilize, and condition the septic tank sludge by electrolytic means andthis, by in situ generation of a bactericidal oxidant. This electrolytic system should allow the elimination of organic and inorganic molecules that generate foul odors while improving the filterability of septic tank sludge. The dehydrated sludge can then be reused as compost or for soilamendment in agricultural areas.

For this purpose, an electrochemical reactor of parallelepipedal type (500 mL of useful volume) including respectively electrodes, graphite cathode (surface of 110 cm²). Two types of anodes weretested, one of boron-doped diamond (BDD, active surface of 65 cm²) and titanium coated with ruthenium oxide (Ti/IrO2, active surface of 65 cm²) were used. The initial pH was set at 4 while imposing current intensities between 0.2A and 1A for electrolysis times varying between 10 and 40 min.

Following the electrochemical treatment, the sludge was flocculated with an organic polymer Percol 789 (Cationic polymer) at concentrations between 1 and 5 kg/tbs. A vacuum filtration unit including a Bruckner and a 25µm fiber filter is used for sludge dewatering.

The septic tank sludge came from the Neuville eco-center located in the Quebec City area. The initial total solids concentration of the sludge varied between 15 and 17 mg/L (1.5 to 1.7 % solids).

The application of electrochemical treatment improved the filterability of the septic tank sludge. A dryness of 28% was recorded following the application of electrochemical treatment, comparedto a dryness of 8% obtained with untreated sludge, but flocculated only. This increase in dryness allows for an 80% reduction in the mass of sludge generated. Additional analyses will have to be carried out to evaluate the sludge stabilization from a microbiological point of view (capacity to eliminate total and fecal coliforms) and the deodorization of the sludge while maintaining the fertilizing properties of the septic tank sludge.

Effect of Partial Replacement of Feed with Biofloc on Water Quality and Growth for Indian Major Carp (IMC) Culture

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The basic principle of the biofloc technology (BFT) is the retention of waste and its conversion to biofloc as a natural food within the culture system. Biofloc technology has recently gained attention as a sustainable method to control water quality, with the added value of producing proteinaceous feed *in-situ*. The present study was conducted to design an optimum feed mix for growth of Indian Major Carps (IMC) in light limited indoor culture with biofloc as a component along with commercial fish feed. Five numbers of tanks of individual capacity 1000 L was utilised for producing biofloc using aquaculture effluent from a nearby carp culture pond. Fifteen different feed mixes were prepared using fish feed and biofloc in dry (4% moisture content) and wet (90% moisture content) form at different proportions and used in feeding trials (three replications) conducted in 45 nos. of 50 L capacity glass aquarium stocked with three nos. of IMC fingerlings with average individual weight of 20 g for a period of 90 days. Fish survival was 100% in all the treatments. Mixture design was used to obtain a solution of best combination of feed source to obtain the optimum growth parameters of IMC. Optimum growth parameters (net yield, specific growth rate, protein efficiency ratio and feed conversion ratio) of IMC were obtained at feed mix containing 50% commercial feed and 50% wet floc. The nutritional quality of biofloc was found to be quite suitable for IMC. The images of 3-week-old biofloc captured in scanning electron microscope (SEM) indicated the presence of different types of bacteria, algae, protozoa, rotifers, etc.

Keywords: Biofloc, IMC, Dry floc, Wet floc, Mixture design.

Development of An Electrolytic Process Dedicated to the *In-situ* Treatment of Septic Sludge as An Adaptation Measure to Climate Change

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This research is part of the technological development useful for the management of septic sludge. By way of establishing a circular economy combined with an adapting approach to climate change, this work is based on exploiting the potential of decentralized electrolytic treatment of these residual effluents. Conventionally, the emptying of septic tank sludge is an essential activity ensuring the sanitation of isolated residences but generates non-negligible impacts in terms of greenhouse gas emissions since the emptied sludge must be transported, by vacuum trucks, to centralized processing centers. Beyond the costs associated with the transport of these effluents and their treatment, several municipalities complain of the emptying lack on their territory, due to the limitations of the management capacity and the workforce, which generates serious contamination of the surrounding environment.

In the light of this work, by following a parametric study followed and statistical modelling, the decentralized electrolytic treatment of septic sludge makes it possible to limit the travel of vacuum trucks by around 40%, and consequently makes it possible to reduce greenhouse gas emission. The treatment channel studied consists of stabilizing the sludge by electrooxidation, conditioning it by adding cationic polymer and dewatering it by filtration under pressure. The dry matter content of the sludge is increased by an average factor of 5.3, which implies a final dryness around 37.5%. In addition to the conventional approach, this system also ensures the complete disinfection of sludge, the elimination of odors and the improvement of the filterability structure. The operating costs related to this treatment, including the mobility of the system, its consumption of electricity and polymer, are 4 times lower than the conventional approach. Downstream of the treatment, this process makes it possible to take advantage of the physico-chemical properties of the dewatered sludge instead of their conventional disposal either by incineration or by burial. The resulting cake, namely dehydrated sludge, can be reused as a soil amendment since it is rich in nutrients. With a view to CO_2 sequestration, the resulting cake can be hydrothermally carbonized to produce hydrochar. The latter is considered as carbon sink but can also be used, under certain conditions, as a fertilizer or a source of energy.

Keywords: Septic sludge dewatering, Decentralized electrolytic treatment, Sludge valorisation, Carbone sequestration.

Characterization and Valorization of Marine Sediment

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Large volumes of marine sediments are dredged annually in ports, but changes in regulations will tend to restrict their disposal at sea. The recovery of part of these sediments as raw materials s in the feld of construction help to limit their storage and give them added value. Our study is then oriented towards the caracterization and the valorization of marine sediment.
This work focuses on the feasibility of using dredged marine sediment from TENES port as partial replacement of sand in mortar. Physical, chemical, mineralogy, and rheology characterization were carried out. This study revealed that the substitution of sand by sediments can be considered as a suitable option of their valorization. This solution should have a great economic and environmental interest.

Keywords: Marine sediment, Characterization, Valorization, Mortar.

Insights on Comprehensive Qualitative and Quantitative Approaches for Diverse Microbial Community Analyses, Wastewater Characterization, and Biochemical Process Performance of Full-scale SBR Plant in Roorkee, India

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This study was dedicated to a detailed analysis of the 3-MLD capacity full-scale SBR treatment plant installed at IIT-Roorkee to investigate the activated sludge communities and the insights into the processes that govern their presence and growth. This is one of the original comprehensive long-term investigations of the microbial community in the full-scale wastewater treatment plant in India, where conventional identification, molecular identification by quantitative 16SrRNA Ilumina-based metagenomic sequencing of anoxic selector compartments and aeration tank, and extensive process information related to treatment plant design and process performance have been compiled. Additionally to many other well-established factors, local conditions are elementary conditions of sharp change studied in wastewater characteristics from place to place. Pre-anoxic selector-equipped sequencing batch reactors (SBR) perform efficiently in removing different water quality parameters and Fecal Coliforms. The supervision of 3-MLD Full-scale SBR established at IIT, Roorkee, drew interest to the processes concerning simultaneous nitrification and denitrification (SND) and biological phosphorous removal (BPR) undergoing with the deviations in influent wastewater, particularly the readily biodegradable COD (rbCOD), and their effects on the microbiota.

Customary examining of all the SBR units for a period of two years disclosed that on the whole average removal efficiencies were >94% COD, >95% BOD_5, >95% TSS, >96% NH_4^+-N (0.7 ± 0.5 mg/L in effluent), >86% TKN, >69% TN (9.7 ± 3.0 mg/L in effluent), >42% Ortho-PO_4-P (1.6 ± 0.5 mg/L in effluent) and >46% TP and achieved <50 MPN/ 100 mL fecal coliform in the final effluent after disinfection. Anoxic tri-sectional selector and an aeration tank constituted one SBR followed by the other availed 76 ± 9% SND at rbCOD/ TCOD ratio of 0.12 ± 0.04 (R^2= 0.8 and $p<0.001$), rbCOD/ sCOD of 0.33 ± 0.10, sCOD/ TCOD of 0.35 ± 0.10, and COD/TN of ~12.8. The sludge volume index (SVI) of the aeration sludge was <50 mL/g. The qualitative optical microscopic experiments showed intracellular polymers (polyhydroxy butyrates (PHB) and polyphosphates), protozoa, floc morphology, and few types of filamentous bacteria (*Microthrix parvicella*, *thiothrix*, and *Nostocoida limicola)* in the sludge of the plant. Advanced three months' study by lowering SRT to 10days reduced the $TP_{effluent}$ to 1.7 mg/L. The microbial community dynamics after 16SrRNA analysis of the biomass revealed the presence of ammonia oxidizers (22%), nitrite reducers (5%) and denitrifiers (10%), sulfate-reducing bacteria (2%), and potentially resembling polyphosphate accumulating organisms (16%). Organic compounds oxidizers, i.e., Alphaproteobacteria, include the species of nitrifiers (*Nitrosomonas, Nitrospira*, and *Nitrospirillum*), and the species of *Pseudomonas, Rhodococcus, Flavobacterium*, and Beta proteobacteria class were liable for the denitrification process. The major genera responsible for P-removal were observed as *Acinetobacter, bifidobacterium,* and *Paracoccus*. Both the anoxic-aerobic sequential phases have benefitted the plant for higher treatment quality and proper growth of functional microorganisms; moreover, the influence of wastewater characteristics played a significant role. The study clarifies the degree of variations in wastewater and the composition of microbes are the key factors for laying out an optimized treatment system for COD, Nitrogen, and Phosphorus removal for the decentralized systems in the Indian scenario.

Keywords: Bio-selectors, Polyhydroxybutyrates, Readily biodegradable chemical oxygen demand, Sequencing, Sequencing batch reactors.

Circular and Green Economy in Solid Waste Management

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Biochar is a key solution to handle and manage the solid wastes generated from industries. It is a charcoal-like substance that is made by treating solid wastes in a controlled process called Thermal Cracking. Biochar has various applications such as adsorbent, fuel, fertilizer etc. The advantages of char over sludge are that raw sewage sludge cannot be applied or stockpiled directly to the land but biochar can be directly applied. Because, char does not have any pathogens so will not contaminate the land and grazing animals. Also, the calorific value of char is higher than that of sludge so it can also be used as fuel. Managing the solid wastes with current methods such as Land filling, Incineration, Stockpiling has many environmental issues such as risk of nutrient leaching, greenhouse gas emissions etc. Results based on the reaction carried out in our Rotary Kiln reactor with 10 kg of feed shows a 62 to 68 % conversion of STP sludge into biochar. Also, application of biochar as a fertilizer in different ratios carried out in mustard plant showed good results in the plant growth. The best way to manage sludge is to convert it into biochar and utilizing it as a fuel or fertilizer. On processing the bio solids, one not only could produce valuable biochar but also could reduce the quantity of waste disposals. It also makes much profit for the industries by reducing the energy needs and the cost on waste disposal. The production of char from solid wastes comes under circular economy and follows 3R system (Reduce, Reuse and Recycle) and thus will be sustainable resources.

Keywords: Solid waste, Biochar, Thermal cracking, Circular economy, Sustainable.

A Study on Improving the Mechanical Properties of Asphalt Concrete by Using EAF Stainless Steel Slag

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Along with the rapid growth of Taiwan's economy, the volume of road traffic has been continuously rising which leads to the fact that the strength of the current asphalt concrete can no longer support the present and future traffic load. Under the context of the United Nations' active promotion of the Sustainable Development Goals (SDGs), people around the world have gradually begun to focus on issues of the sustainability of resources. This study uses a by-product of steelmaking which is EAF stainless steel slag to replace fine natural aggregate with 0%-40% substitution to improve the mechanical properties of asphalt concrete. This study uses Marshall design to find the optimum asphalt content, and evaluate the effect of EAF stainless steel slag on the mechanical properties of asphalt concrete by conducting tests such as stability value, indirect tension, residual strength by water immersion, modulus of rebound, and latent change. According to the results of the tests, the optimum oil content of asphalt concrete decreases with the increases of EAF stainless steel slag substitution, which is helpful to reduce the total cost of asphalt concrete. Asphalt concrete containing EAF stainless steel slag has better resistance to water damage than the one without, and the resistance to water damage increases with the amount of the substitution of EAF stainless steel slag. According to the test results of stability value, indirect tension, modulus of rebound, and latent change, the strength and the resistance to deformation of asphalt concrete increase with the increase of EAF stainless steel slag substitution, and therefore indicates that the EAF stainless steel slag will help to improve the mechanical properties of the asphalt concrete.

Keywords: EAF stainless steel slag, Asphalt concrete, Mechanical properties.

Preparation of Purified Gypsum from Phosphogypsum via Selective Adsorption Route

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The annual production of phosphate fertilizer in China was more than 16 million tonnes, with a by-produce of 80 million tonnes of phosphogypsum per year. At present time only less than 45% of phosphogypsum was used as the cheap and primary building materials as cement retarder and gypsum board, etc., and most of the phosphogypsum was still unused yet. Calcium sulphate dihydrate, which was the main component of phosphogypsum, can be used to prepare high quality gypsum-based building materials and chemical fillers, etc., owing to its perfect cementation and high stability, but the co-existence of impurities (silicon, fluorine, phosphorus, iron, carbon, magnesium, aluminium, etc.) in phosphogypsum limited the practical application. The conventional methods of removing impurities from phosphogypsum as sieving, cyclone, water washing, acid leaching or alkali treatment, etc. were simple and easy to be adapted commercially, but only some of the impurities can be removed, producing the gypsum with a purity usually less than 95%. The present work reported a novel selective adsorption way to fabricate purified gypsum (with a purity ≥98%) from phosphogypsum. The experiments were carried out at pH<2.3 and with a solid ratio of 25%, adding a little amount of organic acids (R<5) to resist the interference of silica-aluminium-iron impurities. The organic impurities adhered on surface of phosphogypsum was removed by the reverse adsorption of sulfonate surfactants.

Keywords: Phosphogypsum, Impurity removal, Selective adsorption.

A Study on Improving the Mechanical Properties of Asphalt Concrete by Using EAF Stainless Steel Slag

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Along with the rapid growth of Taiwan's economy, the volume of road traffic has been continuously rising which leads to the fact that the strength of the current asphalt concrete can no longer support the present and future traffic load. Under the context of the United Nations' active promotion of the Sustainable Development Goals (SDGs), people around the world have gradually begun to focus on issues of the sustainability of resources. This study uses a by-product of steelmaking which is EAF stainless steel slag to replace fine natural aggregate with 0%-40% substitution to improve the mechanical properties of asphalt concrete. This study uses Marshall design to find the optimum asphalt content, and evaluate the effect of EAF stainless steel slag on the mechanical properties of asphalt concrete by conducting tests such as stability value, indirect tension, residual strength by water immersion, modulus of rebound, and latent change. According to the results of the tests, the optimum oil content of asphalt concrete decreases with the increases of EAF stainless steel slag substitution, which is helpful to reduce the total cost of asphalt concrete. Asphalt concrete containing EAF stainless steel slag has better resistance to water damage than the one without, and the resistance to water damage increases with the amount of the substitution of EAF stainless steel slag. According to the test results of stability value, indirect tension, modulus of rebound, and latent change, the strength and the resistance to deformation of asphalt concrete increase with the increase of EAF stainless steel slag substitution, and therefore indicates that the EAF stainless steel slag will help to improve the mechanical properties of the asphalt concrete.

Keywords: EAF stainless steel slag, Asphalt concrete, Mechanical properties.

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Innovative Waste Management Practices

Toxic Metal Transformation Characteristics of Fly Ash from Different Cooling Zones after Municipal Solid Waste Incinerator

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Fly ash from the solid waste incineration plants should be disposed carefully because it contains toxic metals. However, fly ash trapped from different cooling zones, such as economizer, spray dryer absorber (SDA) and bag filter (BF) , are mixed collected and treated, which would result in unstable chelating effect of toxic metals and also make it difficult to trace and supervision. This study aims to investigate the characteristics and behaviour of toxic metals in the fly ash samples collected from the three cooling zones, and reveal the impacts of different cooling zone condition on the toxic metal transformation. The fly ash samples were firstly analysed to identify their particle size distribution (PSD) and chemical phase characteristics by SEM, XPS, XRF and XRD. And then the total concentration and leaching testes of 10 elements were determined by ICP-MS and ICP-OES on the basis of the PSD. The results showed that the feature of three PSD curves distinguished from each other, which could be established by nonlinear fitting(R^2>95), and the proportion of fine particles(<20μm) gradually decreases in the order of BF (78%) > economizer (56.5%) > SDA (55.9%). The results of multivariate stepwise regression analysis of coupled data indicated that the particle sizes, metal speciation and volatility, were the dominated factors which influenced the migration and transformation of toxic metals during the cooling procedure of flue gas. The contents of toxic metals were negatively correlated with the particle sizes which meant finer particles contain more toxic metals. Volatile metals with higher leaching toxicity, such as Pb and Cd, were more likely to migrate with the flue gas to the back-end, while heavy metals with lower volatileness and leaching toxicity, such as Cu and Cr, tended to be condensed and enriched at the front-end. It reveals that the separated collection and treatment of fly ash trapped in different process units would contribute to reducing the environment risks of fly ash management. This study finally renovates the modern views of heavy metal migration in fly ash with respect to future perspectives.

Keywords: Fly ash, Toxic metal, Transformation characteristic.

Remediation & Reuse of Mercury Contaminated Site By Unique Two Stage Process Of Waterwash And Retord - Hazardous, Industrial And Special Waste Management

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A unique remediation process for mercury contaminated site in a sensitive residential-cum-tourist location has been developed for ensuring environmental protection and reuse for plantation. The mercury released from thermometer manufacturing process caused soil pollution, occupational health issues and made the land unusable. This resulted in the closure of the entire manufacturing facility and directions from environmental protection authorities for remediation in a land area of more than 40000m^2. The procedures, protocols and standards have been developed for remediation of mercury polluted soil surrounded by trees and plantation in a slopped area. The contamination of Hg ranges from 100 to 400mg/kg of soil and made the fertile land into a polluted barren land. This land has to be remediated to remove the mercury contamination and make the land fit for plantation. The unique remediation process started with detailed environment impact assessment study on the levels of mercury contamination inside the factory and the entire surroundings of more than 5km radius and water stream leading to the reservoir for a distance of about 20km. Development of suitable remediation process of more than 15000 tons of contaminated soil and sludge around the thermometer factory without causing damage to the tall trees and plantations in slope terrain is a major challenge. After detailed investigation, study, research and developments with lab and pilot scale remediation, a two-stage process of water wash and retard systems were designed and implemented the remediation of the entire contaminated area in the hilly terrain. The contaminated soil was taken in batches for remediation process by making contour trenches and the area is controlled by providing silt traps and retaining walls. The remediated soil after two stage treatment process with less than 20mg/kg is amended with nutrients and refilled in the trenches. The recovered highly concentrated hazardous category mercury from the contaminated soil is to be further concealed by adopting solidification process. After solidification, the hazardous category sludge is taken to the exclusive cells developed with water tight Reinforced Cement Concrete structures and High Density Poly Ethylene liners. The remediation program with the involvement of many national and international scientists and experts from multidisciplinary field is under final stage of implementation with a huge investment of nearly 20 million US Dollars which is first of its kind in Asia.

Keywords: Hazardous waste, Remediation, Mercury pollution, Environmental health.

Performance of Food Waste Pre-treatment System with the Aid of Solar-Heated Water

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Food waste is the most significant municipal solid waste (MSW) disposed of in Hong Kong landfills, accounting for 30% of the total MSW. Biodegradable food waste is currently disposed of at landfills, and methane would leak to the atmosphere result in global warming. Still, this practice is not environmentally desirable. Nevertheless, the popularity of food waste recycling is predicted to rise with the passage of the waste-charging scheme. This research analyzes the common food waste segregation habit in Hong Kong, and the rate of digestion of food waste using solar-heated water. In addition, the satisfaction rate of the system was assessed in terms of cleanliness and security. The food waste recycling process was reimagined by creating a mechanism for pre-treating food waste. The first Food TranSmarter in the world is in operation. Food waste is locally turned into slurry using this unique process, which is subsequently transported to the Tai Po Sewage Treatment Works for biogas generation. To collect and pre-treat food waste more efficiently, an improved version of a patented technology was developed called Mobile Food TranSmarter. It could be appropriate for locations and events like concert, expo, festival, and exhibition that have year-round consistent food waste supply. Food waste sampling from different sources was conducted to analyze the characterization of the food waste including the total solid content, volatile solid, pH value and chemical oxygen demand. Solar water heating systems can help speed up the process of food waste digestion rate. Mobile Food TranSmarter liquidized food waste by bio-mechanical actions with increase temperature without drawing more energy. The inorganic items maintained within the system included enormous bones and tools. Throughout the process, hot water is added to speed up the digest of food waste. Following the system's test run, the operators and site owners took part in a review session to evaluate the operation of the system. Nevertheless, there were several limitations throughout the test. The COVID-19 outbreak caused less frequent dining out and as a result less food waste was collected. During the study period, there was an average daily collection and handling of 200 kg food waste. All food waste was processed into a slurry and sent to a decentralized food waste facility. Forks and knives were seen to be among the items that were screened out of the system in the system. This suggests a problem with the food waste sorting procedure and the need for more training in this area. Different amounts of water were used depending on the feeding rate of food waste. By looking at the occupied system's volume, the food waste digestion rate was calculated. The site owner's assessment session gave excellent feedback about the odour and cleanliness issues. Since the system was sealed entirely and under negative pressure, there were no complaints.

Keywords: Food waste, Pre-treatment, Solar-heated water, Food waste digestion, Food waste sorting.

Evaluation of Bioaerosol Risk During Insect-Protein-Production of Biowaste

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Food waste management is an undressed challenge for all economies. Bioconversion using insects gradually become a promising technology for biowaste management and protein production, however, knowledge about the microbiological risk of bioaerosols is sparse and conventional methods failed to provide evidence of high-risk species. In this study, a panorama analysis of microbiological risk including distribution of endotoxin, antibiotic resistance genes (ARGs), mobile gene elements (MGEs), and virulence factor genes (VFGs) in bioaerosols during biowaste biodegradation by housefly (species: *Musca domestica*) were conducted. Results revealed that there is no connection between concentrations of 16S rRNA gene and endotoxin, bioaerosols in Fly rearing room possess the highest ARGs abundances, including 13 highest risk ARGs, and plasmids diversity. Conventional methods, such as PCR amplicon sequences and network analysis, fall short of providing the information of environmental microbes and infeasible in small sample size studies. Herein, through a metagenome and binning approach developed in this work, higher resolved taxonomic assignments at species level together with compelling evidence of ARGs/VFGs' host assignment from genetic perspective were provided. Totally 7381 ARGs copy number were assigned to 122 MAGs, bacterium in Acidobacteria phylum trend to harbour MLS-, bacitracin-, tetracycline-, and vancomycin-resistance genes. In contrast, Proteobacteria was the major bacteria phylum host for multidrug-resistance genes. Totally 181 VFGs copy number were assigned to 51 MAGs, higher VFGs copy number were detected in pathogen related genera *Burkholderia* and *Pseudomonas_B* (31 and 23, respectively), more precisely, at species level, *Burkholderia gladioli*, *Pseudomonas_B psychrotolerans_B*, and *Ochrobactrum_A pseudogrignonense* MAGs were the highest VFGs harbours. Bioaerosols in Bioconversion and Maggot separation zone were identified to own high density of metagenome-assembled genomes (MAGs) that carrying both ARGs and VFGs. Proteobacteria, Actinobacteriota, and Firmicutes phyla were predominate hosts of both ARGs and VFGs. Multidrug-Motility, Multidrug-Adherence, Beta Lactam-Motility, and Beta lactam-Others pairs were the most common ARGs-VFGs co-occurrence pattern in this study. Results obtained shed new lights on potential risks of insect-based conversion technologies, which are of great significance for precisely microbiological risk management and highlight the great power of metagenome and binning approach in microbiological risk assessment. Furthermore, if the insect conversion technology will be applied in larger scale to treat more biowaste, the scale impact on microbiological risk level should be prudentially considered before large-scale insect conversion plants construction.

Keywords: Antibiotic resistance genes, Virulence factor genes, Endotoxin, Metagenomics.

Development of Cushioning Materials from Water Hyacinth Fibers and Bagasse

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Cushioning material for packaging is also one of the materials that are more likely to be used as more purchases are made online. But it is found that more research still needs to be done on biodegradable materials. This experimental study aimed to develop cushioning materials made from water hyacinth and bagasse fibers and to compare the effectiveness of the developed cushioning materials with other cushioning materials commonly used in the market, such as foam cushioning beads and plastic air bubbles. The experiment was conducted from August to October 2022. It started by forming natural cushioning materials by separating fibers through the chemical process. Next, spin to distribute the water hyacinth fibers, then dry in the sun. After that, cut the water hyacinth's fibers to 7x8 centimeters. The fiber sheets of bagasse are cut, then rolled to form a worm shape, and shredded as fibers. Drop resistance test was performed by dropping boxes containing each cushioning material and glass ceramic from heights, i.e., 1, 1.5, 2, 3, and 4 meters, respectively. Conduct moisture testing of cushioning materials according to TIS 867-2547 standards. The results showed that the water hyacinth fiber sheet passed the drop resistance test, with the glass-ceramic not cracking at all heights. In comparison, other shockproof materials cause glass ceramic to break and crack at elevations ranging from 3 and 4 meters. In addition, the results of the moisture content test found that the moisture content of cushioning materials from water hyacinth fibers and bagasse passed the TIS 867-2547 standard, with the moisture content being in the range of 3% to 14%. Therefore, water hyacinth fibers should be promoted for further commercial use in cushioning materials.

Keywords: Compostable material, Shockproof, Packaging.

Utilization of Corn Wastes as Biochar in Amending Acidic Soil Grown with Corn

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Acidic soil is one of the major problems that farmers are encountering, for it can cause various complications in growing high-value crops. To address problems related to soil acidity, one of the solutions is to amend the soil. Biochar is one of the materials popular nowadays that is used as soil amendment. Biochar may come from different raw materials that were subjected to pyrolysis. In this study, the waste materials used were corn husk and corn cob. Another solution is applying organic fertilizer available in the locality, and in this case, chicken manure was applied. To determine the effectiveness of biochar derived from corn husk and corn cob and application of chicken manure in neutralizing soil pH, a 3 x 4 factorial pot experiment following the randomized complete block design was conducted. The first factor was the application of biochar such as (B1) without biochar, (B2) corn husk biochar, and (B3) corn cob biochar. The second factor was fertilizer materials such as (F1) farmer's practice (60-30-30), (F2) recommended rate of inorganic fertilizers (120-60-60), (F3) chicken manure, and (F4) combination of inorganic fertilizers and chicken manure. The result of this study revealed that application of biochar derived from corn husk and corn cob at the rate of 30tons/hectare and chicken manure at the rate of 10tons per hectare could increase soil pH from 4.25 to 5.40 and 5.35, respectively. Growth and yield of corn were significantly better in treatment applied with biochar and chicken manure and the combination of chicken manure and inorganic fertilizer. This is attributed to the increment of the soil pH, which is close to the optimum pH in growing corn, which is 5.80 to 6.20. This study suggests that applying biochar derived from corn husk and corn cob, and chicken manure can help neutralize acidic soil to make it more productive, particularly in growing corn. However, further study is recommended to test their effectiveness in field conditions and using other waste materials as biochar.

Keywords: Acidic soil, Chicken manure, Corn, Corn cob biochar, Corn husk biochar.

Study on Calculation Method of Carbon Emission Reduction of Industrial Solid Wastes Based on Fossil Carbon Fraction

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Incineration is the most attractive solid waste treatment solution. By 2020, 54.0% of all collected solid waste was mass burned for energy recovery in China. It is essential to address the greenhouse gas(GHG) mitigation caused by solid waste incineration. In this study, fossil carbon fraction(FCF) of different kinds of solid waste was taken into account. FCF was determined by 14C method using accelerator mass spectrometry(AMS). A modified Clean Development Mechanism (CDM) calculation methodology was proposed based on fire coal coupled solid waste to calculate CO_2 emission reductions of waste incinerators. The results indicated that when industrial solid waste was used to replace most of the coal at a 12:1 ratio in two 110t/h circulating fluidized bed boilers in a co-generation plant in Zhejiang Province, 179200 tons of annual standard coal could be saved. The annual carbon dioxide emission could be reduced to 178700 tons and the CO_2 reduction factor converted into solid waste carbon could be increased to 1.38 tCO_2e/t through the methodology. It was also found that synthetic rubber, artificial leather, plastics and other kinds of solid wastes showed differences in FCF content. As a result, there were some deviations between the computed results calculated with factual values and default values offered by Intergovernmental Panel on Climate Change (IPCC). This study provided a more accurate and effective way for the calculation of carbon emission reduction in China.

Key words: Solid waste, CO_2 emission reduction, CDM methodology, Fossil carbon, 14C method, AMS technique.

Treatment of Black Water by Advanced Anaerobic Baffled Reactor

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Problems with sanitation, water, and hygiene account for over 98.8% of fatalities in developing countries. Septic Tank (ST) is extensively used as an on-site wastewater treatment system for black water, but it can only remove about 50-55% of the BOD & COD from the black water. Present study demonstrated a possible future application of the anaerobic baffled reactor (ABR) for blackwater treatment are presented. For this purpose, an advance ABR system inoculated with enriched microorganism and bio augmented with microbial consortium was optimized and treatment efficiency of advanced ABR was simultaneously compared with the common septic tank. advanced ABR and Septic Tank (ST) were operated for more than seven months to treat synthetic faecal and real human faecal at water temperatures ranging from 25°C to 30°C.

Performance of advanced ABR & ST was evaluated in terms of removal efficiencies of COD, BOD, TSS, NH_4+-N, TN, & TP in advanced ABR & ST on the basis of different OLR were calculated. The COD Removal for advanced ABR, and ST was 94±1.2%, and 75±4%, respectively, for OLR 0.5 Kg COD/ m^3.day, whereas it slightly changed to 90±3.2%, and 78±6.5%, for OLR 0.25 Kg COD/ m^3.day. The BOD Removal for advanced ABR and ST was 95±1.2%, and 74±3.9% for OLR 0.5 Kg COD/ m^3.day whereas it was 89±1.9% and 77±4.6%, for OLR 0.25 Kg COD/ m^3.day. The TSS Removal for advanced ABR and ST was 92±3.2% and 75±1.2%, respectively, for OLR 0.5 Kg COD/m^3.day whereas it was 80±4.5% and 81±3.5%, for OLR 0.25 Kg COD/ m^3. Day. The NH_4+-N Removal for advanced ABR and ST was 4.8±6% and 1.2±7.9%, respectively, for OLR 0.5 Kg COD/ m^3.day whereas it was -6.9±16% and -1.5±15%, for OLR 0.25 Kg COD/ m^3.day.The TN Removal for advanced ABR and ST was 1.2±6.2%, and -2.5±8.3%, respectively, for OLR 0.5 Kg COD/ m^3.day whereas it was -11.2±173% and -6±19%, for OLR 0.25 Kg COD/ m^3.day.The TP Removal for advanced ABR and ST was 4.9±17%, and 3.14±17%, respectively, for OLR 0.5 Kg COD/ m^3.day whereas it was 2.3±19% and 3.7±15%, for OLR 0.25 Kg COD/ m^3.day. After the stabilization phase, advanced ABR was performing well in terms of COD, BOD and TSS, with a removal efficiency of more than 90%. The efficiency was not affected by the variation of organic loading to half, i.e., 0.25 kg COD/m^3. d. The TN, TP and coliform removal efficiencies was insignificant in advanced ABR and ST both.

Metagenomic analysis revealed that the top 5 most abundant bacterial phyla in all the steady- state digester samples were Firmicutes, Bacteroidetes, Proteobacteria and Chloroflexi. The phylogenetic tree demonstrated that the bacterial population of advanced ABR is more or less homogenous than for ST. Hence, the COD, BOD & TSS removal efficiency of advanced ABR was observed to be higher than the ST in the stabilized period.

Keywords: Advanced anaerobic baffled reactor, Septic tank, Phase separation, Blackwater treatment.

Food waste-Energy-Water-Emissions (FEWE) Nexus in the Food Service Sector: Comparative Life Cycle Assessment of Locally Produced vs Imported Meal

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Food waste, energy, water, and emission (FEWE) nexus in food service sector (FSS) should be analysed in order to ensure proper procurement and management of materials and energy flows to minimize environmental impacts from food systems. Life cycle assessment (LCA) is the method applied to analyse amount of energy use, water consumption, and emission along food supply chain (FSC). The FSC stages include all activities from agricultural production to consumption. In this study, the inventory of imported food ingredients and energy flows from pasta meal cooking at commercial kitchen in Hong Kong were audited then processed by SimaPro software. Similar process was repeated for the pasta cooked in Australia then shipped to Hong Kong as ready-to-eat meal. The pasta ingredients were unsalted butter, cheese, wheat flour, eggs, fresh truffles, and salt. When a comparative LCA is performed, amount of carbon footprint, energy footprint, and water footprint per meal portion is determined. Furthermore, food waste produced along the FSC is analysed using the FAO developed methodology in which the food waste is the function of quantity of food available at each stage along the food supply chain, food wastage percentages, conversion factors, and allocation factors. The results discussed the FEWE nexus trade-offs among the impact results along the FSC for both cases. The results shows that the ART meal's indirect global warming potential (GWP) causes higher carbon emissions than the LMO meal. Also, the direct CED of the ART meal is higher than that of the LMO meal. The direct WC of the ART and LMO do not differ. Furthermore, the indirect ART food waste (FW) is less than the LMO one, while direct FW for both ART and LMO meals is negligible. The study concluded that cooking meal in Hong Kong using imported ingredients results in better environmental performance than importing ready-to-eat meal.

Keywords: Food systems, Food service sector, Commercial kitchen, Environmental impact, Ingredients.

Rapid Determination of Moisture Content of Multi-source Solid Waste Using ATR-FTIR and Multiple Machine Learning Methods

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Rapid determination of moisture content plays an important role in guiding the recycling, treatment and disposal of solid waste, as the moisture content of solid waste directly affects the leachate generation, microbial activities, pollutants leaching and energy consumption during thermal treatment. Traditional moisture content measurement methods are time-consuming, cumbersome and destructive to samples. Therefore, a rapid and nondestructive method for determining the moisture content of solid waste has become a key technology. In this work, an attenuated total reflectance-Fourier transform infrared spectroscopy (ATR-FTIR) and multiple machine learning (ML) methods was developed to predict the moisture content of multi-source solid waste. A large number (1,272) of different types of solid waste samples were selected, including the most common solid waste components that have a great impact on moisture content: textiles, paper, leather, and wood. The collected samples were directly analyzed by ATR-FTIR to ensure the unity of the experimental conditions, which differs from the complexity of data sources in other studies. A combined model was proposed for moisture content regression prediction, and the applicability of 20 combinations of five spectral preprocessing methods and four regression algorithms were discussed to further improve the modeling accuracy. The hyperparameters of different combinations of ML models were optimized, and the performance, application prospects and limitations of the hybrid models were evaluated. Furthermore, the prediction result based on the water-band spectra was compared with the prediction result based on the full-band spectra. The results showed that ATR-FTIR-based measurements combined with spectral preprocessing and ML regression algorithms can be very powerful for determining the moisture content of multi-source solid waste. Based on the full-band spectra, the combination of first derivative preprocessing and the SVR (Support vector regression) algorithm was preferable for predicting the moisture content of multi-source solid waste, while ATR correction preprocessing combined with the SPA (Successive projections alogorithm)-SVR algorithm performed better for the water-band spectra. After the hyperparameter optimization, the R^2 (R-squared) values of the validation and test datasets and the RMSE (Root mean square error) value for the prediction based on the water-band spectra were 0.9604, 0.9660, and 3.80, respectively. The excellent performance indicated that the proposed combined models can rapidly and accurately measure the moisture content of solid waste, which is significant for the existing waste characterization scheme, and for the further real-time monitoring and management of solid waste treatment and disposal process.

Keywords: Machine learning, Solid waste, Prediction, Moisture content, Spectra preprocessing, Regression algorithms.

Environmental Friendly Approach of Treatment of Commercial Laundry Wastewater Using Extracellular Polymeric Substances (EPS)

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The problem of management and treatment of wastewater from commercial laundries is a matter of concern. The present study provides an effective and eco-friendly solution to the treatment of wastewater from commercial laundries in Quebec (Canada) by using extracellular polymeric substance (EPS) as bio-flocculant. EPS was produced from valorization of crude glycerol and paper mill sludge by a bacterial strain (BS-04). Two different types of EPS: Slime EPS (S-EPS) and Broth EPS (B-EPS) were used for treatment of commercial laundry wastewater (CLWW). This is the first study for treatment of CLWW using bio-flocculant EPS. A comparison between the conventional treatment of laundry wastewater (LWW) by chemical coagulants ($FeSO_4$, $CaCl_2$, Alum) and enhanced treatment by bio-flocculant EPS has been drawn in the study. Moreover, LWW treatment by combination of EPS and chemical coagulants was also investigated. It was observed that S-EPS (0.6 g/L) gave better flocculation activity (FA) than B-EPS. S-EPS alone can remove 83.20% of turbidity, 77.69% suspended solids (SS) and 76.37% chemical oxygen demand (COD). The best results were obtained by combining S-EPS (0.6 g/L) together with alum (300 mg/L) at pH 7 for treatment time of 30 min. This combination was able to remove 98% of turbidity, 95.42 % of SS and 83.08% of COD from LWW. When treatment time has been increased to 4 h at pH 7, it resulted in more than 88% COD removal from CLWW.

Transfer Learning Based Visual Geometry Group Network (Tlvggnet) for Classification of Recyclable Waste in China: Estimation of Energy Saving Potentials, CO_2 Emission Reduction, and Economic Analysis

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Smart municipal solid waste (MSW) sorting and recycling could effectively reduce greenhouse gas emissions. Developing an intelligent and efficient method for recyclable waste sorting is necessary in terms of policy demand and environmental benefits. The benefits brought by the classification of recyclable waste using the deep learning has been rarely discussed. Therefore, four types of Visual Geometry Group Networks (VGGNet) based on transfer learning (TLVGGNet) were performed for recyclable waste classification. Additionally, cyclical learning rate was adopted to quickly find the best global learning rate. Potentials of energy saving, CO2 emission reduction and economic benefit analysis were also discussed. Results showed that the method of transfer learning could shorten the training time (344.39 s to 266.64 s) and improve the performance of the TLVGGNet-11 model in the training dataset (97.66% to 99.75%), validation dataset (99.34% to 99.64%), and test dataset (84.60% to 88.10%). TLVGGNet-11 was considered the best model for recyclable waste sorting in terms of training time (266.64 s), accuracy (88.10%), precision (88.80%), recall (88.10%), and F1 score (88.00%). Reducing energy consumption and CO2 emissions are about 7.18~7.28 Mt standard coal (tce) and 219.21~219.26 kt CO2, respectively, by using TLVGGNet models. In addition, the economic benefit can be improved from 427.05 k¥/d to 1567.30 ~ 1602.03 k¥/d with the function of TLVGGNet models.

Keywords: Recyclable waste classification; Deep learning; Economic analysis; Environmental analysis.

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Thermal Treatment Technologies

Co-pyrolysis of Food Waste and Agricultural Waste: Mechanism and Process Optimization Study

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Co-pyrolysis of food waste with agricultural waste to produce hydrogen is considered as an effective strategy for clean waste treatment and high value-added product synthesis. This study investigated the co-pyrolysis mechanism and hydrogen yield of food waste with coconut fiber, rice straw and chinar leaves, respectively, at different mixing ratios by thermogravimetric analysis. Friedman, Kissinger-Akahira-Sunose and Flynn-Wall-Ozawa conversion techniques were applied to investigate the kinetic properties of pyrolysis of feedstocks with different mass ratios to reveal the pyrolysis behavior and apparent activation energy in all conditions. Based on this, response surface methodology (RSM) was applied to optimize the microwave co-pyrolysis parameters, thus the predicted maximum hydrogen yield. This study reflects the feasibility of industrializing the co-pyrolysis of food waste and agricultural waste, which contributes to ameliorating the potential for solid waste microwave co-pyrolysis for value-added products production, therefore providing a reference for the further development of clean disposal technology and waste resource utilization.

Keywords: Food waste, Co-pyrolysis, Biomass, Thermogravimetric and kinetic analysis, Microwave pyrolysis.

Study on Pyrolysis of Ultra-High Grade Oil Shale and Characteristics of Three-Phase Products

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Experiments on the oil shale pyrolysis are carried out in an electrically heated fixed-bed reactor to investigate the characteristics of three-phase products. In the range of 450~650 ℃, the yield of semi-coke gradually decreased with increasing temperature, the yield of pyrolysis gas gradually increased, and the yield of liquid gradually increased and then decreased, reaching a maximum of 32.29% at 500 ℃. The maximum value of 32.29% was reached at 500 ℃. Comparing the FTIR spectra of the original oil shale sample and the semi-coke, the pyrolysis process mainly occurred through the cracking of aliphatic compounds, the organic matter in the semi-coke was mainly aromatic compounds, and the inorganic matter was mainly clay minerals containing Si-O-Si; the alicyclic ether C-O-C cracking occurred at 500~550 ℃, which was related to the release of CO_2 and CO. The percentage of H_2, CO, CH4, and CO_2 in the pyrolysis gas was measured by gas chromatography, and it was measured that the per-centage of CO in the pyrolysis gas was the highest, decreasing from 83.77% to 71.43% with the increase of pyrolysis temperature; the percentage of H_2 decreased and then increased with the increase of pyrolysis temperature, and the percentage of H_2 decreased from 16.23% to 9.58% at 450~600 ℃ and increased to 11.64% at the pyrolysis temperature of 650 ℃. The production of CH_4 needs to be higher than the pyrolysis temperature of 450 ℃, and a further increase in the pyrolysis temperature will decrease the percentage of CH_4. The results of GC/MS analysis of shale oil showed that aliphatic hydrocarbons were the main components of shale oil, and the percentage of aliphatic hydrocarbon carbon chain shortened and decreased when the pyrolysis temperature increased, and the percentage of aromatic hydrocarbon components increased. The simulation results show that at a pyrolysis temperature of 500 ℃ and an excess air coefficient of 3.17, the system can be self-balancing by using pyrolysis oil and gas and 0.4% of coke for combustion, and the resulting high-temperature flue gas to heat the pyrolysis process. At the same time, 60.86% of the coke product is output. The high temperature flue gas produced by the system can also be used for other waste heat utilization processes.

Keywords: Ultra-high-grade oil; Pyrolysis; Three-phase products; Distribution characteristic, Aspen Plus, Self-balanced.

Synthesis Gas Production from Co-pyrolysis of Straw Biomass and Polyethylene Agricultural Film

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The co-pyrolysis of straw biomass and polyethylene film at different mass ratios was carried out in a small, fixed bed with CaO as catalyst. The resulting synthesis gas production, liquid and solid products, and pyrolysis kinetics were studied by gas chromatography and thermogravimetric analysis. The results showed that with increasing proportion of plastic in the feedstock, the CH_4 yield, and co-pyrolysis had a synergistic effect, reaching as high as 75.1 mL CH_4/g feedstock, while H_2 and CO yields continuously decreased. Comparing the experimental and theoretical yields of synthesis gas, the trends for CO and CH_4 were consistent, but those of H_2 and CO_2 differed widely. Straw and agricultural film had greater contributions to carbon oxides and hydrocarbons, respectively. The activation energy and pre-exponential factor showed increasing and decreasing trends, respectively, when the feedstock proportions and heating rate changed. Fitted linear correlation coefficients for all pyrolysis stages exceeded 0.99.

Keywords: Co-pyrolysis, Biomass, Plastic, Kinetics, Syngas.

Ash Fusion Characteristics of Sewage Sludge and its Inhibitors to avoid Slagging during Incineration

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Sewage sludge (SS) is a by-product from urban waste-water treatment. At present, the yield amount of sewage sludge is much increasing year by year in China with urbanization development. The incineration is an effective disposal approach towards sewage sludge, not only reducing the waste volume but also utilizing the heating value as a sustainable fuel in the waste-to-energy facility. In this article, the purpose is to clarify the ash characteristics and ash fusion temperature of sewage sludge collected in Shanghai. Furthermore, some trials were conducted to enhance the ash fusion temperature of SS through blending a certain amount of clay additive in order to avoid slagging phenomena in incinerator. The influence of several additives, incl. kaolin, bauxite, limestone and magnesium carbonate, on ash fusion point was investigated respectively upon use of many tests, e.g. XRF, XRD, SEM morphology analysis, EDS energy spectrum and ash fusion point test. The main results include: (1) The SS samples, collected from various water-waste plants, has been tested. And the ash fusion temperatures of most sewage sludge samples are lower than 1150^oC, as mainly due to higher level of Fe content in ash. The slagging trend is related with eutectic mixture with rich Fe and alkali metal combined during the incineration process of sludge. (2) The Si-Al additive, e.g. kaolin and bauxite, is not effective to change ash fusion temperature of SS with little dosage. However, much more amount of Si-Al additive is useful to increase fusion point if the amount of bauxite blended beyond 50wt% or kaolin added over 100wt%. The analyses based on ternary equilibrium phase diagram, e.g. SiO_2-CaO-Al_2O_3 could help understand the influence of the additive and the required quantity. (3) Compared with Si-Al additive, limestone works well to increase the fusion temperature to 1238^oC through blending 5wt% limestone into sludge ash samples. (4) Some Mg-bond minerals could also increase the ash melting temperature to 1236^oC with adding 5wt% of additive. (5) The addition of CaO or MgO into SS ash, as formed from limestone and magnesium carbonate blended, could convert Fe metal in the low-temperature eutectic to crystal ferrate. The function of alkaline earth metals is significant to increase the fusion point of sewage sludge ash and to decrease slagging trend in an incinerator. The effects of mineral inhibitors are important to control the ash characteristics, as could help to direct the suitable design about the incineration process of sewage sludge.

Keywords: Sewage sludge, Incineration, Ash fusion temperature, Slagging.

Emission and Distribution of Dioxin in a Coal-fired Power Plant Coupled with Garbage and Biomass

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This paper reports dioxin emission from the coupling of anaerobic pyrolysis of garbage and the co-combustion of biomass in a coal-fired power plant. In this work, the concentration and composition characteristics of dioxins in flue gas from chimney outlet and fly ash in front of dust collector were tested before and after coupling with garbage and biomass in a 55MW unit, and the impact of coupling treatment on environmental quality was analyzed, which can provide basic data for domestic coal-fired power plant collaborative disposal of garbage and biomass engineering environmental emissions, and lay a foundation for the development of this technology. The results showed that the total content of dioxins in flue gas was 0.0061 ng TEQ/m^3 when there was no co-combustion of other fuels. The total content of dioxins in flue gas is 0.0053 ng TEQ/m^3 when the ratio of co-burned garbage carbon was 1%. The content of dioxins did not change significantly before and after the garbage pyrolysis coupling, which was lower than the local emission standard. However, the actual emission concentration and toxic equivalent concentration of dioxins increased when the ratio of co-burned garbage carbon increased to 3%, and there was a risk of dioxin emissions. Therefore, garbage pyrolysis coupling is more suitable for low proportion coupling conditions. Under the condition of 10% biomass co-firing, the total dioxin content in the flue gas was 0.0018 ng TEQ/m^3, which was significantly lower than that in the raw coal condition and far lower than the local emission standard, indicating that the high proportion co-combustion of biomass is feasible and can promote the reduction of dioxin emissions.

Keywords: Dioxin, Coal-fired power plant, Garbage, Biomass, Co-combustion.

Fabrication of Hydrophobic Composite Material using Residues Derived from Incineration of Textile Waste

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Textile waste is one of the contributors that cause serious environmental pollution around the world. Even though large amounts of textile wastes can be separated from other municipal solid wastes, the end-of-life cycle of those textile wastes is disposed of by incineration, and the residues from incineration are usually dumped into landfills. The aim of this study was to develop a new pathway to improve the recycling of textile waste, and to increase the quality of residues after incineration processes via relevant pre-treatments of textile wastes for their application in fabrication of hydrophobic composite material to achieve sustainability and promote circular economy. The pre-treatment of textile waste was carried out by using polyvinyl alcohol (PVA) and oxidizing agents, formaldehyde and concentrated hydrochloric acid (HCl). After the pre-treatment for modifying the textile waste, the pyrolysis of modified textile waste at 900℃ was carried out, producing a stable aggregate of residues. The microstructural changes of residues derived from incineration for non-modified and modified textile waste samples were determined using X-ray diffractometry (XRD), Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) coupling with energy disperse spectroscopy (EDS), Brunauer, Emmett and Teller (BET) surface area analysis, and particle size distribution (PSD) analysis. The results indicated that the hydrophobicity of residues derived from modified textile waste was enhanced significantly. These residues revealed a stable and dense structure, and enhanced water resistance, which can be applied as a hydrophobic composite material for construction projects.

Keywords: Circular economy; Hydrophobic composite material; Hydrophobicity; Textile waste; Water resistance.

Production of A Novel Catalyst from Oil Palm Waste and Chitosan for Application in Catalytic Microwave Pyrolysis of Algae

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Oil palm wastes (OPW), comprising palm kernel shell (PKS), mesocarp fiber, and empty fruit brunch, are abundant wastes discharged from palm oil plantations. Improper management of the OPW causes serious pollution to the environment. Alternatively, the lignocellulosic-rich OPW can be fabricated into chitosan-rich catalyst for microwave pyrolysis of algae. In this study, OPW were engineered and converted into chitosan coated biochar (CTS/biochar) followed by examination of its application as a novel catalyst in the microwave pyrolysis conversion (MCP) of algae in value-added oil product. The results obtained revealed the production of biochar with different characteristics significantly affected the coating of chitosan and properties of the resulting biochar composite. PKS with the desired surface morphology and highest surface area (210 m^2/g) provided more contact area for the loading of chitosan and thus produced a chitosan-rich catalyst. The application of CTS/biochar in MCP of algae enhanced the thermal decomposition and 2-fold higher yield of pyrolytic oil compared to that without catalyst. The presence of chitosan enhanced the depolymerization of cellulose and hemicellulose in algae, resulting in an increase in the yield of pyrolytic oil. GC/MS revealed that the pyrolytic oil contains a mixture of acids, aldehyde, ketones, esters and hydrocarbons. Our results demonstrated the combination of CTS/biochar catalyst and microwave pyrolysis as a promising approach for waste and biomass recovery.

Keywords: Microwave extraction, Cocoon, Chitosan, Biofuel.

Utilization of Mechanochemically Pretreated Municipal Solid Waste Incineration Fly Ash For Supplementary Cementitious Material

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In recent years, municipal solid waste incineration (MSWI) has gradually become the mainstream technology of waste disposal in China, and the output of MSWI fly ash has increased to 8.5 million tons per year. MSWI fly ash was recognized as a hazardous waste because of its potentially toxic elements, including dioxins and heavy metals. The effective disposal and recycling utilization of MSWI fly ash has been attracting increasing attention. Mechanochemical (MC) treatment as a green and non-thermal method shows good stabilization on heavy metals and degradation of dioxins in MSWI fly ash. In the present work, the inhibition effect on heavy metals leaching with $CaSO_4$, $Ca_3(PO_4)_2$, NaH_2PO_4, and composite additives (50%NaH_2PO_4+50%CaO) as additives were investigated. The environment impact was assessed by Risk assessment code. Moreover, milled fly ash used to prepare high-volume fly ash blended cement mortars was investigated. The composite additive(50%NaH_2PO_4+50%CaO) showed the best inhibitory effect on heavy metals, and the leaching concentration of Cd, Cr, Cu, Ni, Pb, and Zn decreased by 95.21%, 46.84%, 99.42%, 49.91%, 99.83%, and 99.55%, respectively. The main products of the reaction between fly ash and phosphate was hydroxyapatite, in which calcium ions can be replaced by various metal ions through ion exchange reaction to form M-apatite. The sequential extraction procedure (SEP) results demonstrated that insoluble phosphates residues were generated. The overall heavy metal risk index (RI) of samples for MCFA-$CaSO_4$ MCFA-$Ca_3(PO_4)_2$, MCFA-NaH_2PO_4, MCFA-Composite additives were 1545, 1302, 1054, 481.3, 53.79 respectively. The raw fly ash belongs to the level of high risk and the MC treatment with composite additives showed the best control effect on environmental risk. In addition, the MC treatment reduced the particle size of fly ash, which decreased from 35 to 2um, and improved the chemical reactivity for resource utilization. Therefore, when MC treated fly ash was used as supplementary cementitious material (SCM), which will produce a filling effect and a pozzolanic effect improving the performance of fly ash concrete blocks. The MC fly ash provided nucleation sites and has a higher water-holding capacity continuously releasing water to carry out a hydration reaction to generate C-S-H. Compared to the untreated fly ash, the compressive strength of the MC treated fly ash concrete blocks curing for 28 days increased by 35.5% and exceeded 40 MPa, which was close to the strength of OPC. For dioxins, the concentration of PCDD/Fs of concrete blocks is only 4.70 ng-TEQ/kg, much lower than the Europe Union End-of-Waste proposal (20 ng TEQ/kg). In conclusion, the MC treatment effectively inhibited the leaching of heavy metals in fly ash and the utilization of MC-treated fly ash as SCM delivered a promising method for a green fly ash disposal.

Keywords: MSWI; Fly ash; Mechanochemical treatment; Heavy metal; Supplementary cementitious material.

Improving Biochar Properties by Pyrolysis of Palm Biomass for Use as Cement Based Materials

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Cement has been widely used in the construction industry. Production of cement generates carbon dioxide, which is a greenhouse gas. To reduce the utilisation of cement in the construction industry, it is proposed to use biochar as a supplementary cementitious material. Biochar is produced from readily available biomass such as palm kernel shell and empty fruit bunch. From the palm oil extraction process, there is a large amount of palm biomass that are available as wastes. Palm biomass were collected from a palm oil processing mill. They were washed and dried in an oven. After that, they were milled and sieved to a fraction of 2 mm. A tubular reactor was used to conduct the pyrolysis process. Temperatures between 200 to 800 ℃ were chosen as the operating temperature. A heating rate 10 ℃/min and holding time of 70 min were set all pyrolysis runs. Biochar yield was determined after the cooling process. Biochar was also analyzed with Thermogravimetric Analyzer (TGA), Scanning electron microscopy (SEM) combined with energy-dispersive X-ray spectroscopy (EDX) to understand its properties to be used as cement-based materials. The results obtained from the study shows that there is a potential for palm biomass to be used as feedstock as biochar production which can be utilised as cement replacement.

Keywords: Palm biomass, Pyrolysis, Cement replacement.

A Study on the Effects of Waste Glass Sand on the Properties of Bricks Contained with Incinerator Bottom Ash

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The object of this study is to investigate the effect of the waste glass sand (WGS) on the property of the brick. Moreover, the improvement on the bricks contained with incinerator bottom ash (IBA) was studied. Results obtained from SEM analysis show that the crystallization of clay minerals was in the shape of hexagon. The appearance of the crystal structure for the IBA was complicated and the grain shape of WGS appeared like water chestnut in which the surface was smooth and less pores were observed. Results of TGA show that a weight change was noticed at 450-650℃ for clay. Because the main component of the IBA was CaCO3, which decomposed into CaO and CO2 at 700℃, a drop of the weight was observed. The weight losses on WGS were not changed apparently within the temperature tested. The surface of WGS was smooth with less pores and was suitable for the use to improve the water absorption of bricks containing with IBA replacement. Moreover, the water absorption of bricks containing with 0% IBA replacement was 15.46% fired at kiln temperature of 850℃. However, the water absorption was improved to 14.86% when the amount of WGS replacement was used reaching to 15%, which met the class III requirement set by the CNS specification. The use of both IBA and WGS replacements in bricks lead to reduction on the compressive strength of the bricks. Moreover, test results show that the application of IBA replacement alone in bricks cannot conform to the requirement set by the specification. When the kiln temperature was higher than 950℃, the use of WGS could improve the compressive strength of bricks in which met the requirement set for class III bricks. The suggested maximum amount of WGS replacement was 5%.

Keywords: Waste glass sand, Incinerator bottom ash, Bricks.

Migration and transformation characteristics of molten heavy metals from MSWI fly ash under different additives

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The fly ash produced by MSWI (municipal solid waste incineration) is a kind of hazardous waste. It contains pollutions such as dioxins, heavy metals, and other harmful substances. The main disposal methods include solidified landfill, melt landfill and industrial materialization. However, the disposal of fly ash from MSWI is hindered by the closure and control management of the infected areas around the novel coronavirus epidemic. This paper investigates the effects of additives on the melting characteristics and heavy metal migration of MSWI fly ash ，which is based on melt landfill treatment with waste recycling and energy saving as the starting point. It provides theoretical support for the high-temperature melt treatment of MSWI fly ash in terms of microscopic morphology and composition. Firstly， based on CFB (Circulating fluid bed) MSWI fly ash, three additives are designed for ash melting characteristics experiments, including CaO, SiO_2 and Al_2O_3. By varying the content of the three, we derive the pattern of their variation on the melting temperature: all of them have a minimum range of additive to make the flow temperature, when insufficient and excessive additives will rise the flow temperature. Secondly, with different additives, the characteristics of heavy metal migration of MSWI fly ash are investigated. We find that CaO can effectively inhibit the volatilization of various heavy metal chlorides with low melting points. SiO_2 and Al_2O_3 have a facilitating effect on the formation of stable silica-aluminate crystals. Silica-aluminate crystals are the key to improve the solidification rate of chemical heavy metals and inhibit leaching. In the actual process, it would be best if a low-cost, silica-aluminate rich clay ore could be used. Finally, based on the melting characteristics, heavy metal migration and stabilization characteristics of MSWI fly ash under different additives, we analyze the microstructure and composition of MSWI fly ash after melt treatment and find that：Some heavy metals are solidified in chemically stable crystal structures after exchange with calcium ions and other ions. Some exist in the form of solid solution between the crystal lattice structure. Others are encapsulated by the crystal structure and not easy to leach, which is the main reason to inhibit the leaching of heavy metals. For achieving the reduction, harmlessness and resourcefulness of domestic waste to the maximum extent, we are steadily moving towards the goal of "waste-free city", responding to the sustainable development goal of the United Nations.

Keywords: MSWI fly ash, Melting, Heavy metals, Sustainable development.

The Application of Laser Ionization-Time-of-flight Mass Spectrometry Online Detecting System for Dioxins in a Municipal Solid Waste Incineration Plant

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With the increasing strict emission standards and supervision of dioxins from municipal solid waste incineration in China, and in order to explore the optimal operating conditions for incinerators to control dioxins emission, laser ionization-time-of-flight mass spectrometry online detecting system for dioxins was used to continuously monitor dioxin emission in the flue gas of a circulating fluidized bed incinerator. In this study, operating conditions were adjusted by putting phase-change heat exchanger into operation at the tail of incineration system to reduce the flue gas temperature, adjusting the quality of activated carbon (AC) and optimizing the combustion, and change trend and emission level of dioxin under different operating conditions were monitored, so as to determine the optimal operating conditions for the incinerator to control dioxin emission. The results showed that the dioxin average concentration decreased by 35.11%, from 0.131 ng TEQ/Nm^3 to 0.085 ng TEQ/Nm^3 after the phase-change heat exchanger was put into operation. When AC with iodine adsorption value of 800 mg/g was adjusted to 1000 mg/g, and kept the amount at 10 kg/h, the concentration of dioxin remained unchanged at 0.08 ng TEQ/Nm^3. After reducing the amount of treated solid waste, selecting the waste with more uniform crushing degree and adopting auxiliary combustion measures, the dioxin emission became low and stable, with an average concentration of 0.068 ng TEQ/Nm^3. Therefore, it was an effective way to control dioxin emission by stabilizing the combustion condition, fully burning solid waste and reducing dioxin generation from the source.

Keywords: Circulating fluidized bed incinerator, Dioxins, Online detection, Operating condition adjustment.

Humic Acid from Hydrochar: Correlation Between Unsaturation and Hydrothermal Humification of Hydrochar

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Biomass-derived hydrochar characteristics will change with hydrothermal conditions varying, which may influence its humification degree under alkaline hydrothermal treatment. This study prepared the hydrochars in different hydrothermal temperatures and pH, and revealed their potential for HHA production under alkaline hydrothermal conditions (denoted as HHAalk). The hydrochars, prepared under high temperature (200 °C) and strong acidic (pH 0) conditions, achieved high HHAalk yields (67.9 wt% and 68.8 wt%). It ascribed that the high content of acid-insoluble components in hydrochar (lignin-derived hydrochar, HHA and humins), up to more than 90 wt%, was favorable for HHAalk production. Cellulose and hemicellulose content in hydrochar and hydrochar yield were negatively correlated with HHAalk yield while acid-insoluble component content had a positive correlation. The unsaturation degree of hydrochar was suggested as a representative indicator for evaluating the humification potential of hydrochar. This study provides scientific support for preparation of suitable hydrochar with efficient hydrothermal humification potential.

Keywords: Hydrochar, Humic acid, Hydrothermal temperature, pH, Linear correlation.

High-Quality Syngas Generation from Waste Plastics by Catalytic Pyrolysis Over Iron-Based Oxygen Carriers

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Waste plastic is one of the most concerned solid waste issues all over the world. Converting waste plastics into value-added syngas ($H_2/CO/CH_4$) has attracted considerable attention. Herein, we reported on the innovative strategy of high-quality syngas production catalyzed by iron-based oxygen carriers. Synthesized and natural iron-based oxygen carriers have been applied for syngas generation from waste plastics, and both exhibited high catalytic performance.

Iron oxide complexes ($FeO_x/CeO_2@C$) were synthesized by the sol-gel combustion method. Microwave irradiation was applied for reaction enhancement and catalyst regeneration. The catalyst showed high selectivity towards syngas, which was over 94 vol% for high-density polyethylene (HDPE). The power of microwave irradiation showed a slight influence on the syngas yield and selectivity. This may be attributed to the intrinsic selective heating nature of microwave. The selectivity of syngas was maintained at ~95 vol% after three cycles while the syngas yield was reduced. The robust catalytic capability resulted from the synergetic effect between FeO_x and CeO_2. FeO_x possesses high dehydrogenation activity and CeO_2 could provide highly active oxygen vacancies by Ce^{4+}/Ce^{3+} valence states shift. The coke formed by dehydrogenation could be transformed into CO to promote syngas generation. Therefore, synthesized iron-based oxygen carriers showed high potential in waste plastics utilization.

Bauxite residue (BR) is a promising natural iron-based oxygen carrier with a high annual yield. The main components of bauxite residue are Fe_2O_3, Fe_3O_4, and alkali metals, which are highly active for syngas generation and dechlorination, respectively. Therefore, it shows a high potential for polyvinyl chloride (PVC) recovery, which is a challenge for thermal treatment. However, the catalytic reaction mechanism of PVC over BR has rarely been reported. We applied BR for simultaneous dechlorination and syngas production from PVC and obtained the highest dichlorination efficiency of 92% and syngas yield of 0.34 Nm^3/kg. The alkali metal compounds contributed to HCl adsorption at lower temperatures and were transformed into NaCl cubic crystals under high treatment temperatures. Dechlorinated PVC was then pyrolyzed and oxidized over FeO_x active sites to form H_2, CO, and CH_4. The higher reaction temperature and appropriate BR dose are conducive to high syngas yield.

Iron-based oxygen carriers have exhibited great potential for syngas production from a variety of waste plastics. The application of natural waste iron-based oxygen carriers and waste plastics is of great significance for circular economy and sustainable development.

Keywords: Waste plastic, Syngas, Iron-based oxygen carriers.

Evaluation of the Efficiency of Wet Torrefaction of EFB Fibre and Palm Fronds for Solid Fuel Production

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The empty fruit bunch (EFB) is the most abundant biomass from the palm industry, it has a low market value in the pelletization industry due to its inorganic content, mainly potassium. The removal of this bound inorganic content by water or acid washing is not effective. Palm fronds also have low market value due to its heterogeneous nature and high bulk density. Wet torrefaction destroys the cellular matrix of the biomass through breakage of polymer chains. This will allow the biomass to be depolymerized into organic compounds with low molecular weight. Therefore, wet torrefaction of EFB and palm fronds will improve the fuel properties of these biomasses, resulting in higher market value for these products and a reduction in the dependency of fossil fuels and the associated impact on the environment. The wet torrefaction reactions were conducted in a high-pressure reactor autoclave. Samples were loaded with the required amount of distilled water and the reactor was sealed. The temperature used ranged from 180ºC to 220ºC. The residence time varied from 15 to 45 minutes. After the residence time was reached, the reactor was cooled to room temperature. Liquid product was collected for composition analysis in GC-MS and solid product was dried prior to analysis. Proximate and ultimate analysis was conducted on the solid product, along with heating content (HHV) analysis, functional group analysis, surface property analysis, and grindability, strength and pelletization tests.

Keywords: Empty fruit bunch, Fuel properties, Palm fronds, HHV, Wet torrefaction.

Co-pyrolysis of Food Waste and Rice Straw: Hydrogen Yield Optimization Study

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Physico-chemical characteristics of kitchen food waste (KFW) and rice straw (RS) were explored to determine the optimum feedstock ratio for biohydrogen production. An in-depth investigation on the thermogravimetric degradation was conducted at different heating rates. Friedman, Kissinger-Akahira-Sunose, and Flynn-Wall-Ozawa iso-conversional techniques were applied to investigate the kinetic properties of different mass ratios of the feedstocks. The average apparent activation energy (Ea) increased for all co-pyrolysis blends, reaching a maximum for 75KFW blend samples. A microwave reactor was used to investigate product yields for different blend proportions. Gas chromatography analysis showed that co-pyrolysis improved production of biohydrogen. This work considers an experimental study of KFW and RS waste produced in Nanjing, China, performed over a catalyst to maximize synthesis of biohydrogen. The data obtained will be useful when considering establishment of industrial scale pyrolysis plants for biohydrogen in regions plagued with similar waste problems. Overall, this study reflects the viability of scaled-up KFW and RS co-pyrolysis as a waste management alternative and an effective and sustainable source of biohydrogen.

Keywords: Food waste, Microwave pyrolysis, Co-pyrolysis, Rice straw, Thermo-kinetic studies.

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Biochar and its Applications

Enrichment of Biochars for Improved Soil Conditions and Crop Productivity

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Development on the potential of biochar application includes infusion of nutrients within the biochar matrix supplied by mineral and organic fertilizer. Aside from the separate contributions of the fertilizers and biochar to soil health and productivity, enrichment is done for the complimentary positive effects of fertilizer within the biochar matrix. However, only a few studies have been found about the amount and combination mixture ratios of biochar (BC) and organic fertilizer (OF). This paper attempts to investigate the influence of biochar-enriched fertilizer (BEF) on the physicochemical properties of an acidic sandy soil (*Cumulic Hapludolls*) after application, and on the performance of purple yam. Coconut husk and swine manure were collected and prepared for thermal treatment using slow pyrolytic biochar producing stove at temperatures ranging from 300 to 650°C. The organic fertilizer was produced following the Philippine National Standards for Organic Soil Amendments. The resulting biochar was air-dried, pulverized, and enriched with OF at 1:4 (20% BC) and 2.3:4 (30% BC) biochar: organic fertilizer ratio. A series of comprehensive studies was conducted with all treatments applied at 5 t/ha as follows: (T1) OF only, (T2) enriched swine manure-OF pellets (20% biochar), (T3) enriched coco husk biochar-OF pellets (20% biochar), (T4) enriched coco husk biochar-OF pellets (30% biochar). Results showed that T1 yielded more aboveground parts of purple yam while higher tubers from enriched BC treatments, that can be attributed to the availability of nutrients for use by the crops for longer periods compared to the loose powder form. The combination ratio of 1:4 outperformed the other treatments on the above-and below ground fresh weight. The soil organic carbon (SOC) increased after harvest at treatments with enriched BC-OF mixes. The results imply that a lower requirement for organic fertilizer can sustain or improve the crop yield when combined with enriched BC, and economic benefits for crop production can be achieved with BC and OF combination. Very significant positive correlations were observed between the OC and Mg in the soil and aboveground dry weight with (r= 0.869) and (r=0.830), respectively. The amount of K remaining in soil after harvest were observed to be negatively correlated with aboveground dry weight strongly(r=-0.704) and tubers dry weight (r=-0.843). The positive influence of enriched BC on plant growth and soil properties suggests that enrichment is an effective way to overcome biochar's inherent low plant nutrients, making it a suitable technique helping to refine farm-scale nutrient cycles.

Keywords: Organic carbon, Organic fertilizer, Enriched biochar, Swine manure, Coconut husk.

Applicability of Commingled Food Waste Biochar as a Potential Fertilizer

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Food waste is one of the major components of domestic solid waste, comprising around 1.3 billion tonnes per year worldwide. Generally, the food waste is disposed of in polyethylene covers along with plastic bottles, spoons, etc., which makes it difficult for proper segregation and waste management. The present paper discusses the applicability of biochar obtained from microwave pyrolysis of commingled food waste (FW along with low-density polyethylene) as a soil improver where the release of nitrogen (N) and phosphorous (P) was studied. The pH_{zpc} and average pore diameter of the commingled food waste biochar (CFWB) were found to be 6.85 and 44 nm respectively. Leaching studies were performed to investigate the N and P release kinetics from the biochar. Four kinetic models namely the pseudo-first-order model, pseudo-second-order model, Elovich model, and Higuchi model were compared, and the study revealed that both N and P release followed Pseudo-second order kinetics. The average release of phosphate from the CFWB is calculated to be 273.30 mg/kg of biochar, which is comparable with the phosphate release rate of a chemical fertilizer named uncoated diammonium phosphate (DAP) i.e., 280 mg/kg. Similarly, the average release of nitrate from the CFW biochar is calculated to be 134.98 mg/kg of biochar, compared to the required range of 175–225 mg/kg by chemical fertilizers. Further, the toxicity analysis performed on the CFWB has proven it to be negligibly toxic to the microorganisms. Hence the aforementioned nutrient-laden biochar can be used as potential fertilizer in the farmlands.

Keywords: Commingled food waste biochar, Nutrient removal, Kinetics, Fertilizer.

Investigation on the Synthesis Strategy of MgO-biochar Catalysts for Glucose Isomerization to Fructose

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The biorefinery is an important approach for the current needs of energy and chemical building blocks for a diverse range of applications, which may gradually replace current dependence on fossil-fuel resources. Glucose isomerization to fructose is one of the most important reactions in the field of biomass valorization, which has been widely used in industrialized high-fructose corn syrup (HFCS) production. While HFCS application demands strict operating conditions, bears on high cost and long reaction time. Consequently, an alternative efficient solid catalyst is required which will exhibit high activity and stability. Lewis acid and Brønsted base catalysts have both been reported with effective catalytic performance for glucose isomerization. However, Sn-beta zeolites as one of the Lewis acid catalysts has been reported to have complex synthesis process and easy deactivation. The side reactions between most amines and reducing sugars (i.e. Maillard reaction) may occur with organic amines as Brønsted base catalysts, which could be a concern to the reaction efficiency. Various heterogeneous metal oxide basic catalysts such as MgO, CaO and TiO2 were also actively investigated for the catalytic performance of glucose-to-fructose isomerization. Among them, MgO has gained increasing interest due to its intrinsic basicity and wide availability from the natural environment. However, the MgO would be subjected to Mg leaching during the reaction and nanosized MgO may be prone to agglomeration. Therefore, effective dispersion of active MgO moiety on a porous support can be a solution to the above issue. To this end, the MgO-biochar catalysts for glucose conversion to fructose were prepared through three different synthesis methods followed by the subsequent characterization analysis and glucose conversion experiments. We also intend to scrutinize the difference in interactions between MgO precursor and carbonaceous support under varying synthesis conditions. In this study, effective isomerization was realized with ~26% fructose yield at only 80 °C for 2 h in water. Catalyst 3 prepared from one-step synthesis, although having the lowest loading amount of MgO, showed the highest activity and stability compared to those produced by two-step synthesis. Overall, this work provided a basis for advancing the design of metal−biochar composites.

Keywords: Biomass valorization, Heterogeneous catalysts synthesis, MgO, Biochar.

Synthesizing Yard Waste-Derived Biochar for Microwave-Assisted Degradation of PPCPs: Performance of Various Oxidants

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Yard waste is one of the most ubiquitous urban wastes in Hong Kong. As a lignocellulosic biomass material, it can be pyrolyzed to biochar, which shows superiorities over other carbon materials due to its low cost and carbon neutrality. The produced biochar can catalyze advanced oxidation processes owing to its tuneable characteristics depending on various pyrolysis conditions and modification approaches by contributing to the oxidant activation especially in the microwave-irradiated system because of its microwave absorbability. Compared to conventional heating, microwave irradiation can achieve rapid and volumetric heating and activate oxidants to generate highly reactive species (e.g., free radicals), which can significantly improve degradation efficiency. Pharmaceutical and personal care products (PPCPs) have been emerging contaminants in wastewater. It has been reported that the concentration of oxytetracycline (OTC) is extremely high in the effluent from the antibiotics production facilities, which is prone to be transformed yet difficult to mineralize. This study compared the OTC mineralization efficiency of various catalytic systems with different heating approaches and oxidants. It was found that microwave irradiation was significantly more efficient than conventional heating. With microwave irradiation, up to 100% of OTC was mineralized at 80°C within 1 min, while conventional heating can remove < 40% of the total organic carbon (TOC) with 5 times longer time for ramping to 80°C. In particular, H_2O_2 addition might not be efficient for the improvement of mineralization compared to the oxidant-free systems, while the most efficient is the $Na_2S_2O_8$ oxidant activated by CuO_x-loaded biochar, where only 1% Cu loading can achieve 95.6% TOC removal, indicating the critical roles of Cu species. Besides, it was interesting to find that NaClO can achieve 60.5% TOC removal without catalyst, which can be further increased to 85.9% after dosing CuO_x-loaded biochar. These results can further imply the importance of microwave irradiation and Cu species for NaClO activation. Based on the characterization results of Electron Spin Resonance, X-ray Photoelectron Spectroscopy, Raman Spectroscopy, X-ray Diffraction, etc., the high efficiency of the microwave-irradiated catalytic systems was ascribed to the generation of reactive species such as free radicals, as the amount of which was significantly higher than those in conventional heated systems. The plausible relationships between biochar properties and the interactions with microwave were also revealed. Besides, the generation of reactive species also increased with CuO_x loading, suggesting the Cu species could contribute to the oxidant activation. It was also found that the Cu species were stably loaded onto biochar by forming the Cu-N bond. Therefore, the synthesized biochar catalyst shows great potential for larger-scale application.

Keywords: Wood waste biochar, Catalytic degradation, Microwave irradiation, Wastewater treatment, PPCPs degradation.

Straw and Straw Biochar Differently Affect Microorganisms and Soil Organic Carbon Pools in Farmland Soil Under Different Water Regimes

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Incorporating amendments of straw and straw biochar can change soil organic carbon (SOC) components and biological properties. There are many studies on straw or straw biochar application influence of biochar on active SOC fractions associated with soil microbial activity, but the addition of straw and straw biochar comprehensive utilization remains poorly understood in the tobacco-late rice rotation system. We studied the change in the total SOC concentration, active SOC fractions and soil microbial communities with condition of alternation of wetting and drying, and long-term flooded in a 90-day incubation experiment. The results showed that upon straw addition, there was an increase in microbial biomass carbon (MBC), dissolved organic carbon (DOC), and easily oxidizable carbon (EOC). Upon biochar addition, there was an increase in SOC and water-soluble organic carbon (WOC). Revealed that the biomass of fungi and bacteria increase after straw and straw biochar addition. We further found that the fungal richness decreased, whereas biochar did not influence soil bacterial diversity in all treatments. A redundancy analysis showed that straw and straw biochar addition changed the community structure of bacteria and fungi by increasing soil carbon pools, and their community structures were regulated by SOC components. Our findings suggested that straw and straw biochar can improve soil labile organic carbon pools and soil microorganism's communities better than biochar, instead of straw biochar in the tobacco-late rice rotation system.

Keywords: Rice straw, Tobacco stems biochar, Soil carbon pool, Soil microbial community composition.

Synthesis of Ternary CeO_2/Fe_2O_3/R-GO Nanocomposite Loaded Biochar for Photocatalytic Degradation of Organic Pollutants

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In this work, a novel ternary CeO_2/Fe_2O_3/r-GO hybrid nanocomposite was synthesized through a one-step hydrothermal process followed by a thermal annealing with biochar derived from pea nutshell. The structural, morphological, electrical, and optical properties and their photocatalytic activities were studied in detail of prepared ternary nanocomposite. The CeO_2/Fe_2O_3/r-GO hybrid nanocomposite-biochar material displayed excellent adsorption characteristics, photocatalytic activities and boosted stability performance. The catalytic degradation efficiency of synthetized nanocomposite-biochar was performed with methylene blue and methylene orange degradation under constant UV irradiation light. The degradation efficiency showed that the methylene blue and methylene orange were 90% and 86% for the CeO_2/Fe_2O_3/r-GO hybrid composite which was much higher than pure CeO_2, pure Fe_2O_3, binary composite, and biochar. The CeO_2/Fe_2O_3/r-GO-biochar composites is considered as the effective catalyst for photocatalytic application. Furthermore, the scavenger investigation showed that hydroxyl radicals actively participated in the degradation process for the synthesized CeO_2/Fe_2O_3/r-GO-biochar hybrid composite. Additionally, CeO_2/Fe_2O_3/r-GO composite showed effective reusability in photocatalytic system over five cycles without any significant changes to its activity.

Keywords: CeO_2/Fe_2O_3/R-GO Hybrid nanocomposite, Biochar, Photocatalytic Degradation.

Melaleuca Bark-Based Biochar for Triclosan Adsorption and Energy Storage Applications

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Biomass-based carbon materials have generated tremendous interest in energy storage and pollutant removal. Herein, hierarchically porous biochar with high surface areas was synthesized based upon a simple two-step carbonization process using agricultural and forestry waste melaleuca bark as raw materials with less KOH activation. The results indicated that the as-prepared biochar had a high specific surface area of 1768.0 m^2 g^{-1}. Besides, the biochar showed excellent adsorption performance to triclosan, and the effects of initial dye concentration, adsorption time, initial pH, adsorption temperature and recycling performance were studied. As a triclosan absorbent, melaleuca bark-based biochar displayed a high removal rate up to 95.5% at 10 min. Moreover, the biochar exhibited a high specific capacitance (358 F g^{-1} at 0.5 A g^{-1}) as a supercapacitor electrode in aqueous alkaline electrolyte with a stable cycling performance after10, 000 charge/discharge cycles. The excellent adsorption capacities and electrochemical performance suggested that the obtained melaleuca bark-based biochar could be a promising candidate as an adsorbent and electrode material for supercapacitors.

Keywords: Melaleuca bark, Carbonization, Biochar, Triclosan, Adsorption, Supercapacitor.

Co-Application of Sewage Sludge-Chinese Medicinal Herbal Residues-Biochar to Antibiotics and Antibiotic Resistance Genes in Soil-Plant System

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Sewage sludge (SL), Chinese medicinal herbal residues (CMHRs) and biochar (BC) are normally treated as wastes that are potential soil amendments to tackle environmental risks. Antibiotics are a ubiquitous medication to promote health safety and productivity. However, the excessive use has contaminated the terrestrial environments and lead to the intractable booming of antibiotic resistance genes (ARGs). In this study, the fate and distribution of eleven pervasive ARGs (*tet* A, *tet* B, *tet* C, *tet* E, *tet* M, *tet* O, *tet* S, *tet* X, *sul* I, *sul* II and *sul* III) in environments were examined with different soil amendment treatments (SL-BC and SL-CMHRs-BC) with different proportions (5%, 10% and 20%, dry weight basis). Lettuce (*Lactuca sativa* L.) was grown in the soils and irrigated with low (3 µg/L) or high (30 µg/L) antibiotic-contaminated water to evaluate the capacity of ARGs spreading into the food web. The results of the real-time quantitative PCR (qPCR) indicated the abundance of ARGs in soils and lettuce leaves/shoots were significantly reduced by the types of soil amendments (SL-CMHRs-BC > SL-BC > control) and the antibiotics concentration in the irrigation water (3 µg/L > 30 µg/L). 20% SL-CMHRs-BC was considered as the most optimal proportion for the reduction of antibiotic concentration and corresponding ARGs in this study ($p < 0.05$). The accumulations of six ARGs (*tet* A, *tet* C, *tet* O, *sul* I, *sul* II and *sul* III) were relatively higher among the soil and crops samples, while the remnant five (*tet* B, *tet* E, *tet* M, *tet* S, *tet* X) were lower. The co-application of SL-CMHRs-BC was proven in our previous study for the alleviation of antibiotics contamination in soils. We continued the study and conferred another insight of evaluating the impact of SL-CMHRs-BC on antibiotic concentration and their relative ARGs. The antibiotic concentrations in all soil samples were greatly corresponded to their ARGs ($R^2 > 0.9$). Moreover, the ARGs of lettuce leaves/shoots were more positively affected by the antibiotic concentrations than of soils. The results implied the co-application of SL-CMHRs-BC could reduce the antibiotic concentration and the abundance of ARGs in soils and crops, which could promote a safer food system in the environment.

Keywords: Antibiotics, Antibiotic Resistance Genes, Sewage Sludge, Chinese Medicinal Herbal Residues, Biochar.

Molecular Simulation Combined with DFT Calculation to Guide the Directional Design of Heteroatom-Doped Biochar for Efficient CO_2 Capture

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Heteroatom doping technology has been widely used in adsorption and separation because it can significantly change the physical and chemical properties of materials. For stable gases such as CO_2, conventional carbon materials cannot show good adsorption performance, while carbon materials doped with heteroatoms have significantly improved their adsorption performance for CO_2 due to changes in their electronic structure, polarity and other characteristics. In this study, firstly, DFT was used to calculate the CO_2 adsorption energy of several elements doped biochar. Then corresponding models of disordered biochar with heteroatom doping were constructed, and the adsorption performance of different biochar for CO_2 was simulated by GCMC. Calculation results showed that heteroatom doping could improve the CO_2 adsorption capacity under low pressure, and the CO_2 adsorption capacity under high pressure was determined by the pore structure. Finally, the heteroatom doped biochars were prepared according to the theoretical calculation results. Based on theoretical results, a series of N-doped biochars were successfully prepared by a facile solvent-free method. Among them, the biochar prepared with corncob powder, K_2CO_3 and urea at 800 °C showed the highest adsorption capacity (138 mg/g at 25 °C and 1bar) and selectivity (38.24 at CO_2/N_2 = 10/90), which were relatively high in the current study under the same conditions. This biochar could rapidly desorb CO_2 at 100 °C, and 80% CO_2 could be desorbed in 10 minutes, indicating that it had a strong cyclic performance. The biochar also exhibited excellent thermal stability with a carbon skeleton loss rate of only 3.1% at 450 °C, which allowed the biochar to be used in a variety of scenarios. Notable, correlation analysis showed that ultra-micropores were the decisive factor for CO_2 adsorption at low temperatures; nevertheless, the effect of N-doping would gradually appear with the increase of adsorption temperature. In addition, we also prepared B, P, S doped biochar and tested the CO_2 adsorption properties of these materials. Except for S doping, other doping could improve the CO_2 adsorption capacity, and the adsorption capacity increased more obviously with the increase of adsorption temperature. This work guides the experiment with theoretical calculation, greatly reduces the trial and error cost of the experiment, and provides a simple and practical idea for the subsequent material design.

Keywords: Heteroatom doping, Biochar, CO_2 capture, DFT, Molecular simulation.

Study on Water Retention of Biochar Prepared from Coffee by-Products

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The by-products produced during coffee processing are equivalent to the production of the same amount of coffee beans. At present, most of coffee by-products are discarded randomly, resulting in resource waste and environmental pollution in Yunnan province of China. Biochar can improve soil water capacity and thus reduce irrigation frequency. In this study, 27 biochar samples were made from coffee peel, shell and grounds at different carbonization temperature (400 ℃, 500 ℃, 600 ℃) and time (2 h, 3 h, 4 h). The highest water absorption rates of biochar made from coffee peel, shell and grounds are 134.61%, 77.89% and 101.00% ($p<0.05$), respectively; the highest water retention capacities of biochar made from coffee peel, shell and grounds are 18.33%, 7.13% and 12.26% ($p<0.05$), respectively. The biochar made from coffee peel maintained at 600℃ for 2h have the highest water absorption rate of 134.61%, and the biochar made from coffee peel maintained at 600℃ for 3h have the strongest water retention capacity of 18.33%. Among 27 samples, the biochar made from coffee peel kept at 500℃ for 4h have the highest water absorption ratio (amount of water absorbed per unit weight) of 2.4469, during the period of the first water saturation. From the second water saturation to sixth water saturation, biochar made from coffee grounds at 600℃ for 4h have the highest water absorption ratios, which are 2.6557, 2.7569, 2.7908, 2.7342, and 2.6942, respectively. Based on the water absorption, water retention and repeated water absorption indexes, as well as the energy consumption (temperature and time) of biochar preparation, biochar made from coffee shell maintained at 600℃ for 2h can be applied to agricultural production for seasonal drought. To investigate the effect of the biochar in coffee drought resistance, pot incubation experiment will be performed from September 2022 to January 2023, indicators relate to coffee growth, photosynthesis and soil water retention will be studied.

Keywords: Biochar, Soil water retention, Coffee by-product.

Biochar Derived from Miscanthus sinensis and its Applications: Removal of Antibiotics from Aqueous Media

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Antibiotic pollution is a significant concern in aquatic habitats like surface water, groundwater, wastewater treatment plant effluents, aquaculture water, and hospital wastewater. A wide range of antibiotics with high concentrations has been detected in aquatic environments, particularly in the surface water next to livestock farms. The pollution by antibiotics raises antibiotic resistance in the environment and generates more environmental risks. Therefore, effective remedial strategies to remove antibiotics from the water environment are the need of the hour. Plant biomass-derived biochar is a potential adsorbent to remove antibiotics from the water environment. Plant materials are still a valuable resource for solving many global issues. This study assessed the functionalized biochar derived from *Miscanthus sinensis* to remove antibiotics from wastewater. Various antibiotics such as ampicillin, ciprofloxacin, oxytetracycline, penicillin, and streptomycin were investigated for their removal. Standardization of analyses of the antibiotics namely ampicillin, ciprofloxacin, oxytetracycline, penicillin, and streptomycin was also investigated. SEM-EDAX (Scanning electron microscopy with energy dispersive X-ray analyser), XRD (X-ray diffraction), and Thermogravimetric Analysis (TGA) were used to characterize the biochar after the removal of antibiotics. The results showed that the adsorbent could remove antibiotics such as (oxytetracycline) from aqueous solutions so that it can remove more than 92% (ampicillin) in less than 2 h from aqueous solution. A further study of the mixed antibiotics removal process will be developed to apply in wastewater treatment plants.

Keywords: Biochar, *Miscanthus sinensis*, Antibiotics, Functionalized biochar.

Effective Degradation of Chloramphenicol in Wastewater by Activated Peroxymonosulfate with Fe-rich Porous Biochar Derived from Petrochemical Sludge

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Excess sludge produced from biological wastewater treatment plant in petroleum industry is a kind of hazardous solid waste. Incineration and landfill are two types of conventional methods to treat and dispose the hazardous sludge, but high capital input is required for sludge transformation, oven configurations or membrane materials purchase. Conversion of hazardous sludge into biochar by pyrolysis method under oxygen limited condition has been considered as a good option to overcome the above challenges. This is not only an approach to reduce its environmental risk, but the sludge biochar has been also recovering resources and increase economic efficiency in removing organic pollutants from water body. In this study, metal-rich petrochemical sludge was used to produce activated sludge biochar (ASC) via a two-step method of pyrolytic carbonization (400 °C-800 °C) and subsequent KOH activation (abbreviated as ASC 400-800). The physio-chemical properties of ASC 400-800 were characterized by Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), Scanning electron microscopy (SEM), and Brunauer-Emmett-Teller (BET) and Raman. Further, the effect of the pyrolysis temperature of petrochemical sludge to obtain biochar catalyst with good adsorption capacity and catalytic performance for CAP removal in the sludge biochar/PMS system. The CAP removal was treated with different initial PMS concentration, initial pH value, and initial catalyst dosage and collected the treated wastewater and analyzed for the removal efficiencies of CAP, TOC, and High-performance liquid chromatography coupled with mass spectrometry (LC-MS). Hence arrived the optimum treatment conditions in catalytic CAP degradation f with the petrochemical sludge biochar.

Results showed that porous sludge biochar was prepared by the two-step method in which petrochemical sludge was sequentially treated by pyrolysis and KOH activation. XRD analysis revealed that Fe_3O_4, Fe^0, and graphitized carbon formed in ASC at 600-800 °C. At 800 °C, the specific surface area of ASC reached the highest value of 202.92 m^2 g^{-1}. The results showed that the increase in sludge pyrolysis temperature from 400 °C to 800 °C resulted in the enhancement of ASC adsorption capacity on CAP removal efficiency increased from 8.4% to 39.0%. ASC 800 showed higher CAP adsorption capacity with CAP removal efficiency of 39.0%. The CAP removal efficiencies of ASC 400/PMS, ASC 500/PMS, ASC 600/PMS, ASC 700/PMS, and ASC 800/PMS systems were 14.1%, 20.8%, 27.1%, 33.0%, and 49.4%, respectively. Among ASC 400-800, good characteristics made ASC 800 exhibited the best CAP removal performance in ASC 800/PMS system by the adsorption combining with catalytic degradation. The optimal conditions identified for 0.31 mM CAP removal were ASC 800 2.0 g L^{-1}, PMS 6.2 mM, and pH 2.0. The CAP removal efficiency of the ASC 800 was recorded as 95.7%, as well as TOC removal efficiencies of 55.7% within 120 min. $SO_4^{\bullet-}$, •OH, and $^1O_2$ may contribute to CAP degradation. Additionally, the possible catalytic mechanisms and CAP degradation pathways in ASC800/PMS system were proposed, intermediates from CAP degradation were identified by using LC-MS. Finally, intermediate products may be further degraded to small molecule products or mineralized to H_2O, CO_2, NO_3^-, NH_4^+ and Cl^- by reactive radicals in ASC 800/PMS system. Overall, this study confirmed that porous biochar derived from petrochemical sludge was an effective adsorbent or PMS catalyst to remove organic pollutants from wastewater.

Keywords: Petrochemical sludge, Fe-rich sludge biochar, Peroxymonosulfate activation, Adsorption, Chloramphenicol removal.

Synthesis of Waste Face Masks Assisted Magnetic-Biochar for The Removal of Malachite Green from Aqueous Solution

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The main cause of all illnesses on living organism is contaminated water. Dye is one of the water pollutants that, even in trace amounts, render water unfit for human consumption. The presence of low amounts of hazardous dyes in water has a significant environmental impact. Malachite green oxalate (MG) is a cationic toxic dye and used for product coloration in the textile, paper, rubber, leather and food sectors. Due to the discharge of untreated industrial waste water, surface and groundwater are contaminated with dyes. Malachite green exposure can have harmful effects for the body, including mutagenesis, teratogenicity, chromosomal mutations, pulmonary toxicity, fractures, and cancer. The removal of MG dye from water is very essential to providing safe drinking water. MG dye can be removed from water using a number of techniques, including photocatalytic, electrochemical, membrane, and adsorption. Adsorption stands out among them as the finest alternative approach for treating water because of its special qualities, including being easy, non-toxic, affordable, and sustainable. In COVID pandemic, the use of face mask is the primary tool to prevent the spread of virus and lessen exposure to virus. It was estimated that globally 1.6 million tonnes of disposable face mask were daily evolved as waste in pandemic situation. In developing nations, there is a dearth of information about appropriate management and disposal techniques, which has an impact on the environment. Creating valuable material from used facemasks for practical purposes could offer a variety of benefits.

The purpose of this study is to develop functional carbonised materials by the controlled pyrolysis of disposable face masks. The facemask waste mass was transformed into a useful carbonised material at the appropriate pyrolysis temperature, which ranged from 500 to 600 ^{o}C. The synthesised carbonised material has a high adsorption capacity, but it creates a bottleneck during filtration. To address this shortcoming, magnetically assisted waste facemask biochar (Fe_3O_4@FMBC) was created for the removal of MG dye from water. To achieve the highest adsorption capacity, several adsorption factors, including the impact of the initial concentration, contact time, various pH levels, co-ions, and dose, were tested. In order to understand the equilibrium data of the synthesised Fe_3O_4@FMBC, Freundlich and Langmuir adsorption isotherms were investigated. The findings of this study demonstrated that the Fe_3O_4@BC made from the waste face mask biomass is an efficient adsorbent.

Keywords: Waste Face Mask; Carbonization; Fe_3O_4; Environmental Applications.

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Catalytic Conversion Technologies

Nitrogen-doped Carbon as Efficient Catalysts for Metal-free Conversion of 5-Hydroxymethylfurfural to 2,5-Furandicarboxylic Acid

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Biomass conversion to value-added products through sustainable catalytic conversion is a pressing priority. The ever-rising global temperatures due to unsustainable industrial practices such as the use of rapidly depleting fossil fuels for the production of chemicals and their derivatives and fuels have led to a shift in the research focus toward the development of clean and green technologies. Biomass can be converted into platform chemicals such as 5-hydroxymethylfurfural (HMF) through acid dehydration of sugars which upon further oxidation can be transformed into the monomer of bioplastic, 2,5-furandicarboxylic acid (FDCA). FDCA has gained attention as it can be used for the production of green polymers thereby alleviating our dependency on fossil fuels. The oxidation of FDCA can be achieved through heterogeneous catalysis by the use of noble/transition-metal-based catalysts. The use of these catalysts not only increases the cost of operation but also poses technical barriers such as leaching/ deactivation of the catalysts during the reaction. To circumvent these issues, the current study demonstrates the use of metal-free N-doped carbon catalyst derived from biomass for the conversion of HMF to FDCA. A series of metal-free catalysts were synthesized by pyrolyzing chitosan and melamine as precursors and the thermal oxidation was conducted in methanol at 160ºC for 6 h. The as-synthesized catalysts displayed >90% HMF conversion with a promising yield of 5-formyl-2-furancarboxylic acid (FFCA) in 6 h. The metal-free catalyst prepared with chitosan and potassium carbonate as the activator displayed 43.3% FDCA yield, which can be attributed to heteroatom substitutions (graphitic N), high BET surface area (1487.7 m^2/g), and abundance of defects as observed through Raman analysis. It was noteworthy that the extent of different heteroatom substitutions (N and O) greatly impacted the catalytic performance of the catalyst. For the first time, the adsorption of the reaction intermediates, FFCA and FDCA is reported in the study. Through careful analysis, it was found that the catalysts with high C-O functionalities aided the adsorption of FFCA and high C-N content was responsible for the adsorption of FDCA. This study not only presents a cost-effective and efficient catalyst for HMF conversion but also demonstrates the mechanistic insights and roles of different heteroatom substitutions during HMF oxidation to FDCA.

Keywords: Biomass, 5-Hydroxymethylfurfural, 2,5-Furandicarboxylic acid, Metal-free catalyst.

Synthesis of Pd-CNT Based Hybrid and Its Application in Hydrogen Production from Formic Acid at Ambient Temperature

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The efficiency and sustainability of biomass energy have long made it a desirable energy source for hydrogen production. Dehydrogenation of formic acid has been extensively investigated for safe and easy hydrogen production. Thereby, various catalysts have been developed for aqueous formic dehydrogenation (FAD) reaction to efficiently produced hydrogen. However, there is still a lack of understanding of the reaction mechanism. Herein, to fundamentally comprehend the aqueous FAD reaction mechanism, we prepared carbon nanotubes (CNTs) as the preferred choice of support and treated at three different function groups (CNT, CNT-$_{COOH}$, CNT-$_{NH2}$) for the deposition of Pd nanoparticles. CNTs were used as the preferred support material for decomposing Pd nanoparticles were thoroughly characterized using XRD, XPS, SEM, TEM-EDX, BET, and FTIR. Significant difference in catalytic performance between PdCNT, PdCNT- $_{COOH}$, and PdCNT- $_{NH2}$ particles. The PdCNT- $_{COOH}$ catalyst provided higher catalytic performance than impregnation catalysts because it has a smaller particle size and a higher exposure to Pd than impregnation catalysts. A Pd catalyst supported on CNTs was then used to dehydrate formic acid over a sodium formate catalyst to generate H_2. The turnover frequency was measured at 395.24 mol H_2 Pd/h^{-1} after 5 minutes. H_2 production process is expected to be a much more efficient, sustainable, and economical process for H_2 production from biomass. Moreover, we have been performed to gain insights into the reactivity and decomposition of CO_2 feeding along two-reaction pathways on Pd (111), Pd (011) and Pd (001) surfaces. This work could provide promising strategies for the fabrication of cost effective and high-active Pd-based catalysts for formic acid dehydrogenation.

Keywords: Hydrogen, formic dehydrogenation, palladium, carbon nanotubes, turnover frequency.

Insight Into PCDD/Fs Catalytic Decomposition Mechanism Using Two Model Objects: Experiment and DFT Calculation

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Since the active temperature of conventional selective catalytic reduction (SCR) catalyst (e.g., V_2O_5-WO_3/TiO_2) for PCDD/Fs destruction (200-300 ℃) is higher than the actually temperature supplied by the catalytic reactor (generally below 200 ℃). Flue gas reheat always required to achieve high conversions, that consumes extra energy and needs additional device. In order to avoid flue gas reheat, developing catalysts that achieving PCDD/Fs decomposition effectively at low temperature is strongly needed. Accurate understanding the catalytic decomposition mechanism of PCDD/Fs is crucial. Most studies on PCDD/Fs catalytic decomposition mechanism selected chlorobenzenes as a model instead of using PCDD/Fs directly, due to the high toxicity, expensive detection and hard to obtain stable generating device of PCDD/Fs. Using chlorobenzenes as the model merely considered the chlorobenzenes ring structure but ignored the oxygen heterocyclic ring of PCDD/Fs, resulting in the incomprehensive understanding of the PCDD/Fs catalytic oxidation mechanism. In this study, o-dichlorobenzene and furan were used together as model substitutes, referring to chlorobenzene ring and oxygen-containing heterocycles structures in PCDD/Fs respectively. MnO_2-CeO_x/TiO_2 (MnCe/Ti) catalysts were selected and prepared by impregnation method. We planned to reveal the priority reactive groups in PCDD/Fs through investigating the interaction between o-dichlorobenzene and furan during the adsorption and oxidation decomposition processes over MnCe/Ti catalyst. Results indicated that competition adsorption effect existed between the o-dichlorobenzene and furan, while furan adsorption capacity increased gradually with temperature increasing and was larger than that of o- dichlorobenzene. For oxidation decomposition, the catalytic oxidation efficiency of furan achieved almost 100% in 150-300 ℃ and was not affected by the preadsorption of o-dichlorobenzene. However, o-dichlorobenzene catalytic oxidation was relatively weaker but enhanced instead when the catalyst was preadsorbed with furan, especially at low temperatures (≤200℃). In addition, higher CO/CO_2 selectivity (>85%) was obtained during furan catalytic oxidation. In light of these results, it was found furan was preferred to be adsorbed and oxidized by catalyst rather than o-dichlorobenzene. Therefore, we speculated that oxygen heterocyclic ring was more likely to be the priority reactive group in PCDD/Fs adsorption and oxidation. Based on several characterizations (such as EPR, Raman, XPS, H_2-TPR, NH_3/O_2-TPD, and in situ DRIFTS, etc.), furan preferred to adsorb on top site of Mn metal atom (Lewis acid) via its O atom, whereas o-dichlorobenzene tended to adsorb on surface oxygen vacancies via Cl atom. The redox ability of catalyst was enhanced after furan adsorption and oxidation for the amount of surface reactive oxygen species on the catalyst surface increased. However, the redox ability of catalyst was weakened after o-dichlorobenzene adsorption and oxidation. It can be ascribed to the anchor of Cl atom on surface oxygen vacancy that inhibited the formation of surface reactive oxygen species. This study provides theoretical and experimental guidance for the design of novel catalyst, that can achieve the decomposition of PCDD/Fs effectively at low temperature.

Keywords: PCDD/Fs, O-dichlorobenzene, Furan, Decomposition mechanism.

Solar-Driven Reforming of Waste Polyester Plastics for Hydrogen Evolution Over CdS/NiS

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To date, more than 8 billion tons of plastics have been produced, but 79% of them haven't been disposed of properly, contributing to the increasingly serious ecological problem. While the existing technologies are inadequate for the efficient and continuous disposal of plastic waste, photocatalytic technology has attracted wide attention in recent years. Photo-reforming technology provides an uncomplicated route to simultaneously recycle plastics and facilitate hydrogen (H_2) production, meeting the requirements of sustainable development. Herein, pure H_2 was produced from waste plastics through visible-light-driven reforming over the CdS/NiS (NiS modified CdS nanorods) photocatalyst. The CdS/NiS composite could be easily synthesized through a hydrothermal method and show efficient photocatalytic activity under normal temperature and pressure without expensive precious metals. The loading of NiS on CdS was proven could effectively reduce the recombination of photoexcited electrons and holes, which greatly improved the photocatalytic performance. Therefore, a variety of widely-produced polyester plastics, including polylactic acid (PLA), polyethylene terephthalate (PET), polybutylene adipate (PBA), polybutylene terephthalate (PBT), and poly-(butyleneadipate-co-terephthalate) (PBAT), were used as the feedstocks to successfully produce H_2 and organic chemicals through this photocatalytic path. Among them, the PLA exhibited the highest H_2 production rate, which was over 60 $mmol \cdot g^{-1} \cdot h^{-1}$ under optimized conditions. Furthermore, CdS/NiS could also reform real-world waste plastics (the commercial PLA drink straws) with photostability for at least 12 h, suggesting the stability and applicability of this system. Moreover, the mechanism of waste plastic photo-reforming via CdS/NiS catalyst was also proposed. The catalyst would generate photoexcited electron-hole pairs under illumination, then the photoexcited electrons reduced water to produce H_2. Meanwhile, the holes oxidized the plastics into value-added organics, including ketone, aldehyde, and acid products. As such, this photo-reforming system offered a sustainable approach to eliminate plastic pollution and simultaneously convert solar energy into carbon-free H_2, assisting the global sustainability goals and contributing to a carbon-neutral future.

Keywords: Photocatalytic, Plastic upcycling, Hydrogen production.

Renewable Fuels Production from Catalytic Fast Pyrolysis of Biomass with Montmorillonite Clay Loading Single-Atomic-Site Iron Catalyst

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Biomass waste could be converted to renewable fuels or chemicals through the catalytic fast pyrolysis process, in which the performance of the catalyst is the key factor for the yields and qualities of products. In this research, single-atom iron was loaded on the substrate of montmorillonite clay by the pyrolyzing coordinated polymer method for fuel production by catalytic pyrolysis of biomass waste, i.e. bamboo straw, corn straw, corn powder, sawdust, and wheat straw. The results showed that the liquid yields increased, and the gas products yield decreased in catalytic pyrolysis compared with direct pyrolysis. Due to the carbon deposition, the char yield slightly increased in the pyrolysis with the catalyst. The highest bio-oil, char, and gas yield were 56.9 wt. %, 41.3 wt. %, and 32.4 wt. % in corn powder (with catalyst), wheat straw (with catalyst), and sawdust (without catalyst), respectively. In direct pyrolysis, the corn powder generated the highest yield of oil, which was 49.1 wt. %. Results showed that the montmorillonite clay loading single-atomic-site iron catalyst could effectively increase the oil yield in the recycling the biomass waste. Corn powder is more suitable for liquid bio-oil production. This research could significantly improve the utilization efficiency of the supported metal to reduce the cost of the catalyst and improve the yield of liquid products, providing an effective method for the volume reduction and reutilization of biomass waste.

Keywords: Renewable fuels, Catalytic fast pyrolysis, Biomass, Montmorillonite, Single-Atomic-Site catalyst.

Fabrication of Cobalt Manganese Spinel for Highly Selective Oxidation of 5-Hydroxymethylfurfural to 2,5-Furandicarboxylic Acid

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With the rapid development of modern society, the plastic pollution as well as microplastic contamination have raised public concern. Bioplastic has attracted great attention due to the green raw materials and biodegradable property. 2,5-furandicarboxylic acid (FDCA), could be used as the precursor to produce green bioplastics such as polyethylene furanoate (PEF). Accordingly, the synthesis of FDCA could also be realized through the oxidation of 5-Hydroxymethylfurfural (HMF). However, the selective oxidation of HMF into FDCA remains challenging due to the lack of high-efficient catalysts.

Herein, cobalt manganese spinel catalysts with tailored structural symmetry and composition were synthesized through facile solution-based oxidation–precipitation and insertion–crystallization process as well as low-temperature calcination. Surface morphology of catalysts were characterized by Transmission Electron Microscopy (TEM) and Scanning Electron Microscope (SEM). The specific surface area was calculated following the multipoint N2-Brunauer–Emmett–Teller (BET) adsorption method. Element composition of catalysts were characterized by X-ray photoelectron spectroscopy (XPS).

Catalysts with different ratios of cobalt and manganese and different calcination temperatures showed different catalytic performances and experimental results suggested that Co2MnO4 behaved the highest catalytic efficiency. By adjusting the molar ratio of cobalt and manganese, Co1.2Mn1.8O4-400, Co1.5Mn1.5O4-400, Co2MnO4-400, Co2.2Mn0.8O4-400, and Co2.5Mn0.5O4-400 were synthesized. When the ratio of Mn and Co of the catalyst was changed from 2 to 0.5, the FDCA yield increased from 31.53% to 76.38; when the ratio of Mn and Co of the catalyst was changed from 0.5 to 0.2, the FDCA yield decreased from 76.38% to 5.57%. Besides, Co2MnO4-X (X represents the calcination temperature of 200, 300, 400, 500, 600 °C) were also prepared. Similarly, Co2MnO4-400 still presented the best catalytic performance.

Keywords: 5-Hydroxymethylfurfural; 2,5-furandicarboxylic acid; Cobalt manganese spinel; Lattice oxygen.

Sodium Alginate Based Carbon Aerogel Supported ZIF-8 Derived Porous Carbon as an Effective Adsorbent for Methane Gas

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Adsorption natural gas (ANG) is a technology in which natural gas is stored on the surface of porous material at relatively low pressures, which are promising candidates for adsorption of natural gas. Adsorbent with large surface area and porous structure plays a significant role for ANG technology, which is promised to increase the storage density of natural gas while decreasing the operating pressure. Here, we demonstrate a facile synthetic method for rational construction of sodium alginate (SA)/ZIF-8 composite carbon aerogel (AZSCA) by incorporating ZIF-8 particles into SA aerogel through a directional freeze-drying method followed by carbonation process. The structure characterization shows that the AZSCA has a hierarchical porous structure, in which the micropores originated from MOF while the mesopores are derived from the three-dimensional network of aerogel. The experiment results show that AZSCA achieved high methane adsorption of 181 cm^3/g at 65 bar and 298 K, along with higher Q_{st} throughout the adsorption range. Thus, the combination of MOF powders with aerogel can find potential applications in other gas adsorption.

Keywords: Carbon aerogel, ZIF-8, Sodium alginate, CH_4 adsorption, Hierarchical porosity.

The Impact of Water on Photocatalytic 5-Hydroxymethylfurfural Conversion over Cd-based Catalyst

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HMF (5-Hydroxymethylfurfural) is an important biomass derived platform chemical. It can be further oxidized to a series of derivatives, including Diformylfuran (DFF), 5-hydroxymethyl-2-furancarboxylic acid (HMFCA), 5-formyl-2-furancarboxylic acid (FFCA), and 2,5-furandicarboxylic acid (FDCA). Among them, DFF is a useful building block, including as a monomer in the synthesis of polymers, as an intermediate for pharmaceuticals or antifungal agents, precursor for conducting polymers and cross-linking agent for poly (vinyl alcohol). Therefore, there has been a great deal of concern about the synthesis of DFF from HMF in high yield and selectivity by improving catalytic strategies.
Photocatalysis is an alternative choice for DFF production, which can avoid high temperature and pressure during traditional thermal catalysis but only need light irradiation in mild condition. Although researchers have reported some successful examples on DFF production over photocatalysts, such as TiO_2, g-C_3N_4, CdS, BiW_2O_6 and $ZnIn_2S_4$, the production rates of DFF are generally very slow as a consequence of low concentration of initial HMF substrate or long reaction time, in order to obtain high yield of DFF and superior selectivity. Particularly, the complicated catalyst design is also highly needed because the conversion of HMF is sensitive to the condition. The existed studies indicate that DFF can be obtained when ACN was used as reaction solvent, almost without over-oxidize. However, the detailed mechanism is still not clear in molecular level. We recently found that the reaction of DFF production in ACN ceased even the conversion of HMF less than 45% accompanying with only 22% yield of DFF (10 mM HMF). Nevertheless, the reaction process can be conducted persistently after adding trace amount of water into ACN, and the yield of DFF can reach about 66% with more than 90% HMF conversion in 6 hours' reaction, much higher than that in pure ACN or water. What's more, yield of DFF can still achieve more than 60% even the initial HMF concentration was increased to 20 mM in the presence of trace water. For comparison, almost no DFF was detected in pure water under same condition even 100% conversion of HMF. Our control experiment suggests both oxygen and water are indispensable for efficient DFF production and HMF conversion in current condition. This work provides a feasible way for achieving efficient photocatalytic DFF production only by reaction solvent regulation without catalyst design, and it is very promising for us to further reveal the solvent-dependent product selectivity during photocatalytic HMF conversion.

Keywords: Photocatalyst, HMF, Selective oxidation, DFF, Solvent.

Construction of Direct Dual Z-System Ceo_2@N-GO/G-C_3N_4 Photocatalyst for Enhanced Waste Water Degradation

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Photocatalytic removing of contaminants in waster is an ultimate and utmost strategy to resolve the environmental problems. Our study aimed to develop a specific type of direct dual Z-system photocatalysts was construct. The results of the characterization showed that the CeO2 load g-C3N4 and N-doped grapheme oxide (N-GO) Z-system (CeO2@N-GO/g-C3N4) was successfully prepared by hydrothermal method. The best degradation rate closed to 100% for removing 2-Mercaptobenzothiazole (MBT), which is more than two times of pure g-C3N4 and CeO2. The enhanced photocatalytic performance may be related to the introduction of GO accelerates the electron transfer and enlarges the specific surface area of the composites photocatalyst, which can increase the contact with MBT. Also, the direct dual Z-system systems significantly improve the delocalized ability of the photoinduced charge carriers, which efficiently prolongs the lifetime of the charge carriers and reduces the electron-hole recombination rate. Meanwhile, the active species capture experiment and ESR analysis demonstrate that •OH, •O2−, and h+ are generated in the direct dual Z-scheme CeO2@N-GO/g-C3N4 photocatalytic system.

Keywords: Direct dual Z-system, MBT, Carbon Nitride, Wastewater, Degradation.

A Novel Nickel Catalyst Supported on Coal Gangue for Producing High-Value Carbon Nanotubes and Hydrogen

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Pyrolysis catalysis is a promising way to transform waste plastics into high-value products from an economic and environmental perspective. Low-cost catalyst is very important for batch treatment of waste plastics. In this study, a nickel-supported coal gangue catalyst was developed using low-cost coal gangue as catalyst support. In a two-stage fixed-bed reactor, polyethylene was pyrolyzed to produce carbon nanotubes and hydrogen. The catalyst and generated carbon are analyzed using a variety of characterization methods, including temperature-programmed oxidation, X-ray diffraction, scanning electron microscopy and Raman spectroscopy. The results showed when the catalytic temperature is 800 ℃, the Raman IG/ID of the product is 1.01, and the maximum hydrogen production is about 35.2 mmol/gPE. The high catalytic effect may be attributed to the rich metal iron in coal gangue. The nickel bimetal has a synergistic effect on the catalytic process. Therefore, nickel catalyst supported coal gangue is an efficient catalyst for the production of valuable carbon nanotubes and hydrogen for waste plastics.

Keywords: Coal gangue; Pyrolysis; Catalysis; Carbon nanotubes; Hydrogen.

Biochar-Fabricated Magnesium Ferrite (BC@MgFe2O4) Nano-Bio Composite for the Removal of Emerging Pharmaceutical Pollutants from Water

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Pharmaceutical contaminants are frequently discovered in water sources and wastewater treatment facilities as a result of their extensive consumption, poor metabolic efficiency, and careless disposal. Ampicillin is one of the antibiotics and used to treat some bacterial infections that affect the membranes surrounding the brain and spinal cord. Over the past year, the use of ampicillin has increased because it kills many infectious microbes. Many water researchers have noted that the surface water is highly contaminated by antibiotic-resistant pathogens. Eventually, it causes many impacts on the environment, human and animals due to the consumption of antibiotic-contaminated water. Neomycin is one of the aminoglycoside antibiotics, and it is used to prevent or treat bacterial skin infections. The neomycin in water affects both humans and aquatic animals. The removal of these antibiotics from water is very essential to providing safe drinking water. Several methods, like photocatalytic, electrochemical, membrane, and adsorption, have been reported for the removal of antibiotics from water. Among them, adsorption is the best alternative method to water treatments due to their unique features, such as being easily handled, non-toxic, economic, simple, and sustainable. In the last few decades, many adsorbents, like silica gel, graphene, metal oxides, etc., have been examined for the removal of antibiotics from waste water. Carbon-based biochar from plant wastes is the superior adsorbent material due to its unique properties, like its huge surface area and biodegradability. Hence, in this research, an attempt was made to synthesise and characterise the carbon-rich biochar from the waste *Annona reticulata* seeds (ARS biochar) for the removal of ampicillin and neomycin from aqueous medium. In addition, magnetic-based adsorbents possess many advantages, like a high adsorption capacity, a fast adsorption rate, and easy separation. Biochar-fabricated magnesium ferrite (BC@$MgFe_2O_4$) nano-bio composite was synthesised for the removal of ampicillin and neomycin from water. The different adsorption parameters, like the effect of the initial concentration, contact time, different pH, co-ions, and dosage, were carried out for the maximum adsorption capacity. Freundlich and Langmuir adsorption isotherms were examined to explain the equilibrium data of the synthesised ARS biochar and BC@$MgFe_2O_4$ bio-composite. Thermodynamic studies revealed whether the adsorption process was endothermic or exothermic. Kinetics models such as the pseudo-first order and pseudo-second-order models were investigated. The reusability of the synthesised BC@$MgFe_2O_4$ bio-composite was studied using a suitable eluent. The results of this study proved that the plant biomass-derived biochar-assisted BC@$MgFe_2O_4$ bio-composite is a potential adsorbent for the removal of emerging pollutants.

Keywords: Adsorption, Biochar, Magnetic, Antibiotic removal, Annona reticulata.

Functionalized rGO Nanoconfined Membrane-Induced Ultrafast Molecular Oxygen Activation for Enhanced the Gas-Solid-Liquid Interfacial Mass Transfer

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Molecular oxygen (O2), as an environmentally friendly oxidant, has unparalleled advantages over other oxidants because of its high selectivity, sustainability and efficiency. However, the limitation of dissolved oxygen (DO) amounts in aqueous solution and limited mass transfer efficiency and ultrashort reactive oxygen species (ROS) lifetimes will inevitably repress pollutants' degradation efficiency. To improve the reactions between pollutants/O2 and catalysts, we designed the gas-solid-liquid reaction interface-dominated tri-phase O2 system using a functional hydrophobic rGO membrane with an enrichment/activation layer of DO and pollutants. In the tri-phase system, the oxygen vacancy-rich rGO/CoFeOx hydrophobic membrane simultaneously improved the interface adsorption performance of emerging pollutants and DO, leading to a marked enhancement of interfacial pollutant concentration and DO levels. This led to a 100% removal of bisphenol A in 20 min at the reaction rate constant of 0.047 ms-1, which was 6-8 orders of magnitude higher than those of the conventional di-phase and suspension systems. Importantly, the nanoconfined membrane influenced the selective production/utilization of ROS, and the 1O2 yield reached a high value of 2.914 mmol/L, which was higher than that of the suspension system. Our findings first highlighted the importance of solid-liquid tri-phase reaction interface, design and providing low energy consumption and environmentally friendly wastewater treatment strategy.

Keywords: Molecular oxygen, Tri-phase reaction interface, Mass transfer, Functionalized rGO hydrophobic membrane, Reactive oxygen species.

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Hazardous and Industrial Waste Management

Remediation of Toxic Effects of Parthenium Hysterophorus Through Circular Economy by Using it for the Removal of As, Sb, Cd, Cr, U, F and other Heavy Metals from Waste Water

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Rapid proliferation and dispersion of invasive Parthenium hysterophorus (PH) has many negative impacts on biodiversity. Direct or indirect contact with this weed can induce life-threatening diseases to both human and animal population. Its invasive trait, seed dormancy, and remarkable phenotype plasticity over broad range of environmental conditions have induced economic losses to the nation due to less or no crop productivity. Manual management strategies like uprooting, burning, ploughing, & chemical herbicide utilization cause allergic reactions to workers and native crops or plants. Even burn ashes of this weed influence drastic environmental pollution. Very few Parthenium affected regions have been reported by researchers. Another major problem is toxic heavy metal(s) (HMs) accumulate on in water bodies which is also a major cause of environmental contamination. Common sources of HMs disposal are tannery, nuclear, and textile industries. Still there are many areas that are left to study about the negative impacts of this weed and HMs on that particular region. Analysing these major problems, this research proposal has highlighted an innovative idea of bioremediation method through circular economy that means remediation of toxic effects of Parthenium by utilizing its complete wastes for the synthesis of eco-friendly nanoparticles (NPs) to remove ubiquitous hazardous heavy metals (HMs) from water systems through nanobiosorption (NB) efficiently. This approach will definitely solve two serious environmental problems in a large scale. First is invasive Parthenium accumulation and management strategy. Second is toxic heavy metal accumulation in different water systems. Parthenium and heavy metal removal will eventually then improve crop quality and production, water quality, as well as human and animal health. Another objective of this research study is to apply for patents and collaboration with industry to utilize the technology by scaling up the process for mankind.

Keywords: Parthenium hysterophorus, Adverse effects, Nanoparticle synthesis, Heavy metals, Wastewater management strategy, Bioremediation, Circular economy.

Emission Characteristics and QSAR model interpretation of PCDD/Fs in a Large-scale Hazardous Waste Incinerator under Different Operation Conditions

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Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) emissions from hazardous waste incinerators (HWIs) have emerged as a great threat to environmental safety and human health, resulting in urgent effective control of the high emissions. In this study, the emission characteristics of PCDD/Fs from a large-scale HWI in China were studied under different conditions (inhibitor injection; feeding waste component). The operating conditions of the incinerator system will continue to change with the change of the feeding waste (the proportion of Cl% and S% content), the injection of inhibitors, and the parameters of air pollution control devices (APCDs). The emission characteristics of dioxins and the distribution of isomers have been analyzed in large-scale waste incinerators and laboratory conditions, but there is a lack of theoretical calculations that combine the molecular structure characteristics of dioxin isomers. The study not only reveals the effects of hazardous waste composition and APCDs parameters on PCDD/Fs emission characteristics, but also provided theoretical explanation through Quantitative Structure-Activity Relationship (QSAR) model. Results showed that the total concentrations of CBzs and PCDD/Fs in stack gas from the HWI ranged from 2.18 to 22.94 $\mu g/Nm^3$ and 0.98 to 18.53 ng/Nm^3, respectively. Increased chlorine content of feeding waste led to increased PCDD/Fs concentrations, especially PCDDs. The inhibition efficiency of $NH_4H_2PO_4$ with thiourea and $Ca(OH)_2$ is 42.2% and 9.4% respectively. 2,3,4,7,8-PeCDF (30.7%-44.2%) was the dominating congener of I-TEQ values under all conditions. Furthermore, the relationship among PCDD/Fs, CBzs, traditional pollutants (carbon dioxide, sulfur dioxide, nitric oxide, hydrogen chloride, and particulate matter), and operational parameters were analyzed under six conditions. Results indicated that PeCBz (r=0.764), HCBz (r=0.814), and quench tower water spray rate (r=-0.796) present strong correlations with I-TEQ values. After QSAR model analysis, the effect of C-H average bond length was weakened and the effect of C-Cl average bond length enhanced with the increase of chlorine content of feeding waste. The bond length increases, the bond energy decreases. The results indicated that reaction proceeds in the direction of the enhanced chlorine substitution reaction. Also, the effect of the highest occupied molecular orbital energy was enhanced, the molecule was more likely to lose electrons, and the molecular stability was reduced. Under the inhibition conditions, the enhancement effect of C-Cl average bond length with the addition of $NH_4H_2PO_4$ with thiourea was better than that of $NH_4H_2PO_4$ with $Ca(OH)_2$, which indicated that $NH_4H_2PO_4$ with thiourea had better inhibition efficiency on 17 toxic PCDD/Fs.

Keywords: Hazardous waste incinerator; Quantitative structure-activity relationship; Polychlorinated dibenzo-p-dioxins and dibenzofurans.

Electrooxidation Treatment and Dewatering of Septic Tank Sludge

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Septic tank systems are the most used form for treating domestic wastewater from isolated residences. Present bacteria in septic tanks partially degrade the domestic effluent and with sedimentation the effluent is separated to three layers, from the top we have scum, clarified effluent and at the bottom we sludge. Septic tank sludge is generally untreated due to the lack of management and treatment methods. This project aims to decontaminate and stabilize septic sludge using electrooxidation for the first part, the second part is dewatering the treated sludge by adding a cationic polymer for flocculation then separating the solid and filtrate using a vacuum pomp. This process of combining electrooxidation and dewatering should allow the elimination of organic and inorganic molecules that generate foul odors while improving the filterability of septic tank sludge. The dehydrated sludge can then be reused as compost or for soil amendment in agricultural areas. The process starts by a physicochemical characterisation of septic sludge sampled at an eco centre in Quebec, CA. Control tests of dewatering the raw sludge by only adding quantities from 1kg/tds (ton dry sludge) to 6kg/tds of cationic polymer (Percol 789). Before electrooxidation the sludge is acidified to pH 4 using sulfuric acid 2N. A parallelepipedal electrochemical reactor (500 mL of useful volume), a graphite cathode (surface of 110 cm²) and two types of anodes were tested, one of boron-doped diamond (BDD, active surface of 65 cm²) and titanium coated with iridium oxide (Ti/IrO_2, active surface of 65 cm²) were used for electrooxidation. Then dewatering, the sludge was flocculated with a cationic polymer Percol 789 (solution preparation 1g/L) at concentrations between 1 and 5 kg/tds then separated using a vacuum filtration unit including a Bruckner, vacuum pomp and a 25µm fiber filter. three parameters were studied, the current was varied between 0.2A and 1A, the time of the electrooxidation between 10min and 40min and polymer quantity between 1 kg/tds and 5kg/tds. The application of acidification and electrooxidation treatment improved the filterability of the septic tank sludge. A dryness of 28% was recorded following the application of electrochemical treatment, compared to a dryness of 8% obtained with untreated sludge, flocculated only (control test). This increase in dryness allows for an 80% reduction in the mass of sludge generated. Additional analyses will have to be carried out to evaluate the sludge stabilization from a microbiological point of view (capacity to eliminate total and fecal coliforms) while maintaining the fertilizing properties of the septic tank sludge. The quantity of foam generated during electrooxidation can't be neglected, hence the use surfactant like TWEEN 80 which was also degraded by electrooxidation and didn't help. Other methods will be tested like recirculation of the effluent during electrooxidation using a pomp.

Keywords: Septic sludge, Electrooxidation, Dewatering.

Toward the Adoption of Circular Economy in Africa: Prospects and Challenges

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Rapid urbanization and industrialization growth in African cities pose a daunting challenge to the management of municipal solid waste (MSW). The escalating population growth in African countries has resulted in massive MSW generation, which must be adequately managed. The African countries' linear economy (LE) method of MSW management increases greenhouse gases, depletes natural resources, and elevates climate change. If this menacing trend is not resolved, the situation may lead to severe environmental impact, pollution, a threat to existence, and a shortage of land space. Therefore, there is a need to adopt a circular economy (CE) approach in MSW management to meet the United Nations Sustainability Development Goals (UNSDG). This study seeks to identify the prospect and challenges of adopting CE MSW management in Africa. The CE is a contemporary approach for managing MSW by developed nations. But middle-income countries have not fully embraced and implemented the CE technique, while the majority of low-income countries are utterly unfamiliar with it according to recent studies. In this study, we fill this gap by reviewing MSW in eight purposefully selected African Countries. This paper applies a literature survey to investigate CE awareness and practices in selected African countries. The collated data was carefully analysed. The analysis indicates that partial recycling, reuse, and recovery of resources exist and relevant laws and enforcement institutions are already established in African countries to enhance the prospects of CE adoption in African countries. Nevertheless, lack of political willingness, corruption, financial instability, inadequate infrastructures, and the absence of advanced technology and institutional framework are some of the challenges needed to be addressed toward the adoption of CE. The result shows that South Africa and Mauritius have successfully adopted CE in a few urban regions for regenerating natural resources while the rural areas still use the LE method. However, other countries used in the study like Ghana, Nigeria, Kenya, Uganda, Libya, and Egypt are yet to establish waste management policies and roadmaps that could lead to CE adoption. Though there are sparse recovery and recycling of MSW practices taking place across the counties under the study. The current MSW generated in African urban cities is estimated as 378,904 tons/day and is expected to increase to 441,840 tons/day by 2025, this serves as a huge prospect for sustainable CE adoption in Africa as against the financial burden in LE practice. The CE adoption would promote the 3Rs (reduce, reuse, recycle) of waste before landfill disposal. This will directly reduce the green gas emission, promote job creation, and conservation of natural resources. Policies that are explicit, relevant, and appropriate in terms of trends, content, and context, as well as robust enforcement mechanisms, are recommended for MSW stakeholders.

Keywords: Africa, Circular economy, Municipal solid waste, urbanization, Waste management.

Extraction of Iron from industrial metal waste using bioleaching process

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Metallurgical industries usually generate enormous quantities of hazardous waste. In the process of extraction of iron zinc smelting industries produce a type of waste called as jarosite. Approx 142,000 tonnes or more quantities of jarosite is produced globally including India which is also one of the major jarosite producing country. Jarosite contains substantial amount of heavy and hazardous metals like As, Cd, Zn, Ga, Cu and so on which makes it one of the major environmental pollutants which was identified using XRF analysis. To identify the morphological properties of jarosite techniques such as XRD, FTIR, SEM, and EDS were performed. Due to direct disposal technique such as open tailing dumps it can cause acid mine drainage or can contaminate groundwater due to immobilization of heavy metals when stored for a long run. Conventional methods for treating jarosite can release pollutants like carbon dioxide etc and requires a good capital to operate. An eco-friendly and economical solution to problems is bioleaching of jarosite. With great respiratory flexibility to thrive in both aerobic as well as anaerobic conditions we took Shewanella putrefaciens our study to leach out iron from the jarosite. The extraction of iron was quantified by using ICP-OES which can create more commercial value of the waste and helps in reduction in environmental load.

Keywords: Shewanella putrefaciens, acid leaching, bioleaching, metal recovery.

Hazardous Industrial Waste Co-processing in Cement Plants

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India is the second largest producer of cement with annual capacity of 545 million tonnes. Cement manufacturing is an energy & resource intensive process. It consumes 9.10% of the total industrial energy, making it the third largest consumer of energy. Further each tonne of cement generates approximately 0.7 – 0.93 tonne of CO_2 depending on the kiln technology used. Thus, cement industry worldwide is adapting alternative methodologies for reduction of energy and resources during manufacturing process. Indian cement industries are no exception and are actively looking at innovative methodologies, such as co-processing of waste materials, to make the cement manufacturing a low carbon process. Substitution of the traditional fuels and raw materials (TFRs) with alternative fuel and raw materials (AFRs) i.e hazardous industrial waste, leads to sustainable cement production through resource circulation. The study thus analyzes two experimental trials with different hazardous industrial waste in different part of India and based on the data, the sustainability of the process was gauged. The clinker quality, cement property and leach behavior analysis was evaluated. The study also revealed environmental sustainability as no effect on emission was reported. The study thus showed the sustainability of process and resource circulation potential in Indian cement plants thus enhancing circular economy.

Keywords: Hazardous Industrial Waste, Cement plant, Co-processing, India.

Automation and Coding to Tackle SDG 11 & 12 – A Thai-EU Higher Education Institutions' Project

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The EU-funded project on Education & Training for Automation 4.0 in Thailand (ETAT) brings 6 Thai universities from the Eastern Economic Corridor together with 6 European universities. Jointly they have developed automation-controlled simulation systems and are working on the respective education and training materials.
The Thai Kasetsart University (KU) is one of the project partners. KU has put its focus on the environmental engineering sector and has developed an automation-controlled solid waste conveyor simulation system which is compliant with the needs of Thailand's commitment to meet the UN Sustainable Development Goals in the field of waste management as stated in "Policy Options and Actions for Expediting Progress in Sustainable Waste Management" at the Intergovernmental Preparatory Meeting for the 19th session of the Commission on Sustainable Development in 2011.
Precisely, KU has established together with the European partners a practice set to develop programming, control and display skills over the internet (IoT) with an automation-controlled conveyor simulation system. KU's project outcome comprises learning and teaching tools aligned with the most suitable methodology.
The automation-controlled conveyor simulation system refers to the SDG 11 (Sustainable Cities and Communities) as well as SDG 12 (Sustainable Consumption and Production). This simulation system ins built to raise learners' awareness about the waste indicators presented by United Nations Environmental Programme (UNEP) for SDG 11 and 12. Each segregation station is developed to add weighing facilities and other adds-on which can easily be adjusted by the learners for the training purpose.
Since the simulation mirrors a real automation-controlled municipal solid waste management conveyor system the challenge is to let learners be creative in improving this simulation system and to collect innovative ideas for subsequent try-outs and adjustments.
In order to provide a comprehensive overview about this ongoing project, the paper is structured in a brief presentation of the waste segregation simulation system with the automation programming and control parts. The 2nd part refers to Thailand's commitment to tackle SDG 11 and 12 in form of a literature review. The 3rd part will elaborate, how this simulation system will be made available for the formal education and training as well as for the life-long-learning process. The 4th part will work on a feasibility study of an automation-controlled conveyor system for a distinct central community in the Thai Eastern Economic Corridor. The final part will provide ideas, how to make this automation-controlled conveyor simulation system accessible to other education and trainings organisations in the ASEAN region and beyond.

Keywords: Waste segregation, SDG 11 & 12, Automation.

Global Energy Under the Impact Of The Coranavirus Pandemic

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The prevalence of the covid-19 pandemic has had a significant influence on different sectors. The global energy sector has been remarkably impacted by the coronavirus pandemic. The decrease in global energy demand because of the covid-induced lockdowns has taken a great expense on global energy investments. From an economic value, one of the sharp levels in the past 30 years is the current reduction in the energy system. The rapid cease in production has caused main disruptions in the energy supply chain. The shutdown of multiple main wind turbine manufacturing plants is a major instance of the impact the covid has had on the energy system. On the other hand, the pandemic led to a reduction in solar energy technologies end-users income, negative impacts of the economy on investments in solar industry projects with a 28% reduction, and many industries were forced to shut down. Meantime, it affected the development of energy availability in remote areas. Much research evaluated the connection between the covid, air quality, and electricity production from wind, solar, and nuclear energy. It was revealed that the covid pandemic slowed down the expansion of novel wind projects because of difficulties in the provision. A similar negative effect can be observed on air quality due to it had not improved as it could have. Global energy faced different challenges during the covid pandemic, including energy system reliability, resource management, consumption patterns, unreliability regarding novel energy projects, and reduction in investments. How long the impact of the covid pandemic will last, be subject to many agents and the reaction from policymakers and the operation they perform.

Keywords: Covid, Global energy, pandemic.

Impact of Pre-To-Post COVID-19 Lockdowns on Air Quality Index (AQI): A Tale of Three Cities With Different Lockdown Policies and Strategies

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In recent decades, there has been increased concern and apprehension with the disclosure of air pollution problems. Especially for susceptible people, their respiratory and cardiovascular systems are more likely to be affected by airborne pollutants. The coronavirus disease (COVID-19) quietly appeared at the end of 2019 and brought the world unprepared suffering and havoc. As of today, the gloom of COVID-19 still hangs over us, the sudden stagnation of human activities gives us an opportunity to explore the complicated and intimate relationship between air pollution, meteorological climate, and human activities. In this work, a multi-scale comparison of air quality concentrations of PM2.5, PM10, CO, SO_2, NO_2, and O_3 in Wuhan before and after the "lockdown" is presented. Due to the different attitudes of each country towards the outbreak, this work also compare the trends of air quality indexes (AQI) in Wuhan, Los Angeles, and Hong Kong under the influence of different lockdown durations, quarantine policies, and social regulations. The results analyzed from the open-source data show that levels of NO_2, PM10, PM2.5, CO, and SO_2 generally decreased from previous year during the same time period. Climate and air humidity also play a role in the concentration of pollutants in the environment. The implication of this work is that both the epidemic and the irreversible climate effects threaten human survival and health. The Covid-19 epidemic is a signal to the world that human activities have an impact on nature and that most of the global air pollution problem can be solved by changing human activities. It should be advocated that everyone should act to move toward a future of better air quality.

Keywords: COVID-19, Lockdown, AQI, Health Impact, Government policies.

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Landfill and Leachate Management

A Novel Sustainable Landfill Cover System Using Recycled Construction Waste Aggregates

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Due to the increasing population and urbanization, the production and management of municipal solid waste (MSW), including construction waste, have become a worldwide concern. The efficient use of recycled construction waste materials can reduce waste generation and preserve natural resources. However, no available study investigates the use of recycled concrete aggregates (RCA) as a landfill cover subjected to high rainfall intensity under humid climates. Based on advanced unsaturated soil mechanics, a new three-layer landfill cover system without a geomembrane is proposed to promote environmental protection and sustainability under all weather conditions. In this study, one-dimensional (1D) soil column, two-dimensional (2D) flume model and full-scale field tests were carried out to evaluate the hydrological performance of the novel landfill cover system using RCA under humid climates. This three-layer system consists of a top layer of fine-grained and a middle layer of coarse-grained recycled aggregates (i.e., FRC and CRC, respectively) overlying the bottom silty refuse soil. In addition, numerical simulations were conducted to back analyse the physical tests. Consistent results were obtained between the measured data and computed results. Even after the extreme rainfall with more than 100-year return period in Hong Kong, relatively high matric suction was well-retained in the new cover system. The 2D flume model test and numerical simulations revealed that the middle CRC layer could switch from a capillary barrier layer to a drainage layer to reduce infiltration into the bottom layer even under heavy rainfall. Most infiltrated rainfall water (i.e., more than 95% of total precipitation) can be diverted as surface runoff and lateral drainage through the two upper RCA layers. The rest of infiltrated water is stored in the cover system. During the field monitoring conducted in Shenzhen Xiaping landfill, the measured annual percolation through the cover system meets the recommended criterion by USEPA. The physical tests and numerical simulations consistently verified the effectiveness of the proposed sustainable three-layer landfill cover system using RCA without a geomembrane under humid climate.

Keywords: Unsaturated soil, Recycled construction waste, No geomembrane, Landfill cover, Field monitoring.

Assessing the Effectiveness of Iron Oxide Activated Carbon Nanocomposite and Iron Oxide Nanoparticles in landfill leachate treatment

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This study assessed the effectiveness of Iron Oxide Activated Carbon (IOAC) Nanocomposite and Iron Oxide Nanoparticles (IONPs) in landfill leachate treatment. Batch study experiments were carried out to investigate the effect of adsorbent dosage, contact time, and temperature on the removal efficiency of COD, DOC, colour, and UV_{254}. Results show that the optimum dosage was 17.5 g/L which resulted in a maximum removal of COD of 78.3% and 55.7% using IOAC and IONP, respectively. In addition, the effectiveness of IOAC and IONP to remove DOC was higher than COD with a maximum removal efficiency of 81% and 45%, respectively. However, the removal efficiency of colour was less using IONP (36.3%) but still high using IOAC (83.8%). Also, the removal efficiency of UV_{254} showed a relatively good performance using IOAC and IONP with a maximum removal efficiency of 87.5% and 46.8%, respectively. The contact time was found to be influential factor where the increase of contact time resulted in the increase of removal efficiency for all parameters. The optimum contact time was chosen to be 60 min where after this time, no significant removal was observed. For temperature effect on removal efficiency, no significant change in removal efficiency was observed with varying temperature. The regenerated IOAC showed excellent reusability and consistency as compared to the original IOAC with a decrease of 2.72–3.61% in the adsorption efficiency. Overall, this study confirmed that the IOAC and IONP could be used as powerful adsorbents for landfill leachate treatment.

Keywords: Iron oxide carbon nanocomposite, Iron oxide nanoparticle, Landfill leachate, COD, Colour removal.

Laboratory-Scale And Pilot-Scale Study On Chemical Co-Precipitation Treatment Of Old-Age Landfill Leachate

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Old-age landfill leachate typically contains high concentration of refractory organics (e.g., humic acid and fulvic acid), which contributes to high color intensity and chemical oxygen demand (COD). These refractory organics cannot be removed by biological treatment process in the existing landfill leachate treatment plant and the downstream sewage treatment work. The UV disinfection efficiency in sewage treatment work will be severely affected by the highly colored landfill leachate. In this study, a single-step co-precipitation reaction was developed in laboratory scale to remove those colored organics in pre-treated landfill leachate from existing landfill leachate treatment plant. More than 90% of color intensity and 70% of COD in pre-treated landfill leachate could be removed by the interaction between multivalent ions and refractory organics under neutral pH. A pilot-scale post-chemical treatment system with 100 m3/d treatment capacity was then set up in North-East New Territories Landfill in Hong Kong. On-site pilot trial was conducted in wet and dry season to evaluate the concentration variation of pre-treated leachate and its effect on the chemical co-precipitation process. Two solid/liquid separation techniques were also compared, namely sedimentation tank and dissolved-air floatation (DAF) unit. The color intensity, chemical oxygen demand (COD) and specific ultraviolet absorbance (SUVA) of the leachate were analysed using UV-vis spectrophotometer.

Comparing to sedimentation tank, DAF shows a more stable COD and color removal. The pilot results show that the DAF unit could give stable color removal at around 92%, while the color removal efficiency of sedimentation tank drastically fluctuated from 71% to 96%. Similarly, the DAF unit provided a more stable COD removal performance with average value of 73% removal, but the COD removal by sedimentation varied from 36% to 76%. The testing results demonstrated the seasonal change in leachate concentration and stable removal on color intensity and COD. The color intensity of the pre-treated landfill leachate was 2500 and 5500 PtCo in wet and dry season, respectively. The DAF unit gave a stable color removal at average 92% and 84% color removal during the wet and dry season, respectively. Although the COD value of pre-treated leachate was varied from 1100 to 1800 mg/L between wet and dry season, the DAF unit also provided a stable COD removal (73% removal in wet season; 62% removal in dry season). These results affirmed that the DAF unit is a reliable solid/liquid separation technique at different influent concentration.

After the chemical co-precipitation treatment with DAF unit, >90% of color intensity and >70% of COD in pre-treated landfill leachate was removed, which was consistent with the laboratory results. The SUVA of leachate was also significantly decreased from 18.5 to 5.2 cm-1. This study confirmed the mentioned chemical co-precipitation process could effectively remove the colored refractory organics in old-age landfill leachate. The chemical co-precipitation system could be introduced as a final polishing step to the existing landfill leachate treatment plant. It could greatly reduce the organic loading and improve the UV disinfection efficiency in the downstream sewage treatment work.

Keywords: Landfill leachate, Chemical co-precipitation, Humic acid.

Landfill Leachate Treatment Using A Combination of Biological and Electrochemical Methods

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Landfilling is the most familiar and easy way to dispose solid waste. Landfill is generally received via wastes from municipal near to a landfill. The waste collected is from commercial, industrial, and residential areas and many more. Landfill leachate (LFL) is formed when rainwater passes through the waste placed in landfills and consists of several dissolved organic materials, for instance aquatic humic substances (AHS), volatile fatty acids (VFAs), heavy metals, inorganic macro components, and xenobiotic organic matters, highly toxic to the environment. These components of LFL put a load on it, hence it necessitates the treatment of LFL prior to its discharge into the environment.

Various methods have been used to treat LFL over the years, such as physical, chemical, biological, physicochemical, electrical, and advanced oxidation methods. This study focuses on the combination of biological and electrochemical methods- extracellular polymeric substances and electrocoagulation(EC).

The coupling of electro-coagulation process with extracellular polymeric substances (EPS) (as flocculant) as pre and\or post treatment strategy provides efficient and economical process for the decontamination of landfill leachate contaminated with suspended matter, metals (e.g., Fe, Mn) and ammonical nitrogen. Electro-coagulation and EPS mediated coagulation approach could be an economically viable for the treatment of landfill leachate along with possessing several other advantages over several other methods. This study utilised waste substrates such as activated sludge, crude glycerol and waste cooking oil for the production of EPS using fermentation technology.

A comparison of different scenarios for the treatment of landfill leachate is presented- such as using EPS alone as bioflocculant, EPS and EC with EPS being the 1st stage and EPS and EC with EC being the 1st stage. The work establishes the use of crude EPS as a bioflocculant for the treatment of landfill leachate and wastewater from a site near a landfill along with EC being successful in removal of some major pollutants such as COD, turbidity, total suspended solids. A combination of these two methods is to be explored more for the complete removal of all pollutants from landfill leachate.

Keywords: Landfill leachate, extracellular polymeric substances, electrocoagulation, bioflocculant.

Tertiary Treatment of A Mixture of Composting and Landfill Leachates Using Electrochemical Processes

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The study investigated the treatment efficiency of coupled electrocoagulation (EC) and electrooxidation (EO) processes for composting and landfill leachate treatment in batch and continuous mode. These processes have been studied to evaluate the possibility of replacing the conventional physico-chemical processes of clarification and disinfection by the electrolytic approach. The EC process (using iron anode and graphite cathode) at a current density of 18.2 mA/cm2 for 2.5 min treatment time resulted in COD, turbidity, total phosphorus, total coliforms and fecal coliforms removal of 58.1, 72.9, 98.5, 97.9, and 97.2% respectively. Under the same operating conditions, the coupled EC/EO (using Ti-Pt anode, bipolar iron electrode, and graphite cathode) processes showed that the COD, turbidity, total phosphorus, total coliforms, and fecal coliforms removal of 56.5%, 78.3%, 96.3%, 97.2% and fecal coliforms 72.7%, respectively. The energy costs associated with the EC and EC/EO were 0.11 and 0.25 $\$/m^3$, respectively. Compared to the batch configuration, the continuous configuration of EC resulted in similar processing performance. However, the EC/EO process resulted in the production of chlorates, perchlorates, and trihalomethanes as by-products. Moreover, the continuous process slightly increases the pH and ammonia concentration of the leachate and also resulted in the metallic sludge production with an average dryness of 4.2%. The simultaneous clarification and disinfection by the electrochemical approach could be achieved in a single treatment step. The toxicity tests determined that the treated effluent was not toxic to *Rainbow trout* and *Daphnia* and meet the discharge criteria.

Keywords: Leachate treatment, Electrocoagulation treatment, Electrooxidation treatment.

Assessment of Total Content and Leaching Potential of Heavy Metals from Landfill-mined Fine Fractions Under Various Reuse Scenarios

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Fine fractions (FFs) constitute the largest component of the total excavated material reclaimed from landfill mining of legacy waste landfills or dumpsites. Feasibility for bulk reuse of FFs as earth-fill material and compost requires in-depth knowledge of their contaminant patterns and the leaching potential of heavy metals in different reuse scenarios. The present study aims to investigate the reuse potential of FFs (finer than 4.75 mm) retrieved from the landfill mining activity at Boragaon dumpsite located in the Assam state of India by assessing their total and leachable heavy metal content. The reuse feasibility of FFs as earth-fill material was assessed through three different laboratory batch leaching procedures, i.e. simple batch test (EN 12457-2), toxicity characteristic leaching procedure (TCLP) and synthetic precipitation leaching procedure (SPLP) to simulate different natural leaching scenarios. On the other hand, the reuse potential of FFs as compost was evaluated on the basis of total heavy metals concentration. All of the obtained results were compared with the regulatory threshold limits (RTLs) of national and international regulatory authorities to classify the FFs according to their environmental impacts. According to the EN12457-2 batch leaching test, all FFs were classified as non-hazardous but not inert due to elevated leaching of Cr than the RTLs imposed by the European Union council decision (2003/33/EC). The TCLP test also revealed that, as per the USEPA recommended limits, the FFs were non-hazardous in nature and thus did not need to be confined in hazardous waste landfills. Results from the SPLP test showed that the leaching of Cr, Cu, Zn, Mn, Fe and Al from FFs were above the stipulated RTLs of national and international drinking water standards. Therefore, unrestricted and bulk reuse of FFs as earth-fill material could contaminate the subsoil, groundwater, and nearby water bodies. Based on the total heavy metal analysis results, the reuse potential of FFs as compost was limited to non-agricultural purposes due to the high concentration of Cu and Cr, which exceeds the upper limits of the compost standards for India and Europe. An evaluation of metal leachability against their total metallic contents revealed that the released concentrations were mainly dependent on the nature of the leaching tests. The general sequence of heavy metals leachability from most leachable to least leachable was Cr > Mn> Zn > Cu > Al > Fe. The application of several leaching procedures in the present study demonstrated the need for various test methods for a comprehensive leaching assessment. To conclude, the implementation of specific design measures and treatment methods was necessary before the bulk reuse of FFs as earth-fill material in low-lying areas, embankments and deep trenches, as well as compost for horticulture.

Keywords: Fine fractions, Reuse, Earth-fill material, Compost, Leaching, Heavy metals.

Improvement of Upstream SWM Supporting the Start Up Operation of Four New Sanitary Landfills in Indonesia

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The Emisison Reduction in Cities (ERiC) SWM Indonesia Programme has been a collaboration between the Government of Indonesia and the Government of Germany implemented by German KfW Development Bank and supported by Swiss State Secretariat for Economic Affairs (SECO) in Malang City, Jombang Regency, Sidoarjo Regency and Jambi City. One of the objectives of ERiC has been the introduction of Sanitary Landfills (SLF) including sorting and composting stations, leachate treatment plants and landfill gas flaring in medium-sized cities to contribute to the implementation of the Indonesian Climate Change Strategy in urban areas. The SLF development has happened between 2018 and 2022. Increased efficiency in waste collection and promotion of sorting out recyclables and composting has also played an important role to ensure ERiC sustainability. An Accompanying Measures Consultant (AMC) has been assisting and facilitating the national Programme Management Unit of the Ministry of Public Works and Housing (MoPWH) and the local Environment Agencies in developing training, workshops, technical improvements, and local legal reform on upstream waste management.

As a basic measure for improving upstream conditions, the AMC has rendered assistance to pilots at TPS3R (MRF) in 2019/2020. Lessons were learned which are useful for capacity building and sound TPS3R operations in the future. The technical capacity of operators at TPS3R is quite good but still needs to be developed through technical guidance and assistance continuously. However, there is a large gap in staff capacity regarding management and entrepreneurship which is still relatively low. This has implications as inefficient waste service provided, inefficient management of labor, and inefficient financial management of both expenditure and income generation.

The process of assisting the TPS3R in Indonesia is still dominated by a technical approach, while the sustainability of TPS3R is strongly influenced by the readiness of governance at the Regency/City level as well as by the lowest level of government units in the villages and urban neighborhoods. During the process of AMC assistance, this has been evidenced in the TPS3R pilots where the performance of sorting and recycling activities decreased again after the process of assistance.

TPS 3R is seen as an important tool to achieve government prescribed service level targets and reduce the amount of waste to be landfilled which directly decreases mixed-residual waste delivery to new SLF. Hence, TPS3R must be an integral part of the waste management system under the responsibility of local governments which is manifested in the guidance and supervision of TPS 3R through the waste administration units of Local Governments, so that performance in collection and reduction of waste can be ascertained and SLF be operated to design standard.

The Sanitation Technology Center of the MoPWH has captured this issue and made plans for training and dissemination based on the AMC lesson learned in the four ERiC partner cities and regencies. There are ample opportunities for academics and practitioners to participate in supporting the operation of these four new SLF and their upstream TPS3R in terms of further technical and technological but foremost governance improvements.

Jawaharnagar Municipal Landill Leachate Treatment, Hyderabad, Telangana State

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The present study was undertaken at Jawaharnagar municipal landfill site of Greater Municipal Corporation of Hyderabad (GHMC), Telangana State, India in 2022 which generates 90,000 litres of leachate per day. The main objective of the leachate treatment was to remove organic compounds like color, suspended solids, ammonia and COD by coagulation-flocculation using polyaluminum chloride (PAC) as coagulant which has higher coagulant efficiency and relative low cost compared to the conventional coagulants. Jar test apparatus was used to conduct experiments for pH 7, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute for different dosage of PAC (0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0 g/L). The highest percentage of removal of suspended solids, color, COD and ammonical nitrogen were observed as 97%, 96%, 60% and 37% with PAC optimum dose of 2.0 g/l. The results indicate that the PAC was effective in leachate treatment which is very much suitable for high toxicity of waste and economically feasible for Indian conditions. The treated water can be utilized for other purpose apart from drinking.

Keywords: Coagulant, Leachate, Polyaluminium chloride, Treatment.

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Electronic Waste Management

Facile recovery of CuO nanostructures from discarded Printed Circuit Boards: Evaluation of photocatalytic activity

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Due to the rapid evolution in electronic industries and high demand, electronic equipments have a shorter life in developed and developing countries markets, causing the generation of tons of electronic waste. Discarded Printed Circuit Boards (PCBs) are one of the secondary resources of high-purity copper, and precious materials, which if disposed of inappropriately may present several environmental risks. Therefore, recycling waste PCBs using environmentally friendly and suitable sustainable resource utilization techniques is in high demand. This research study focuses on the production of copper oxide nanoparticles (CuO NPs) from reclaimed copper via a facile precipitation route to obtain a high added-value nano-product. The obtained CuO NPs were subjected to various characterization techniques such as X-ray diffraction (XRD), Fourier Transform Infrared Radiation (FTIR), Raman spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), UV-visible spectroscopy, and the BET method. XRD analysis confirmed the as-synthesized NPs were monoclinic CuO of size 22.33 nm without any impurity. FTIR confirmed that the synthesized product is pure CuO. Raman spectra exhibited the presence of three Raman active phonons of CuO with a red shift. FESEM revealed the surface morphology of synthesized CuO. HRTEM analysis confirmed that the NPs were nearly round spheres. The direct band gap is found to be 1.97 eV. The NPs have a specific surface area of 20 m2/g and a mesoporous structure. This mesoporous structure can find potential applications as a photocatalyst for pollutant degradation studies to combat water pollution. In this respect, the as-synthesized nanoparticles are investigated for their photocatalytic activity through the degradation of textile dyes. Hence e-waste can be utilized to produce nanomaterials with added values, thus reducing the problematic e-waste, preserving naturally occurring ores, and decreasing environmental problems.

Keywords: Electronic waste, Printed circuit boards, CuO nanoparticles, Photocatalyst.

A Review on Improved Collection Approach for Small IT and Telecommunication Equipment Waste in India Under Circular Economy

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Booming information technology (IT) around the globe, India in particular, has shown tremendous growth after the digital revolution and digitization of the economy and education system. The increasing market of electrical and electronic equipment (EEE) creates a significant E-waste generation problem. Due to lack of E-waste collection and the involvement of the informal sector create havoc in the systematic E-waste management approach. This article gives insights into the circular economy (CE) in E-waste to streamline formal E-waste collection and increase methodological treatment options. Small IT and telecommunication equipment waste is one of the untouched sectors in E-waste. However, it could have significant recovery potential for precious and rare earth elements under urban mining and can help to achieve CE. As the collection system is one of the essential factors in the integrated waste management hierarchy, the article will discuss existing E-waste collection practices and innovative methods for improved E-waste collection in India. The generation of small IT and telecommunication equipment waste majorly belongs to the secondary generators (local repair shops) of E-waste. The primary waste generator or EEE consumers practiced repairing and replacing damaged/exhausted components at local repair shops instead of buying new items. This practice led to irregularity and disturbed streamlining in E-waste management. Multiple case studies and best practices were reviewed in the small IT and telecommunication equipment sector to address such irregularity. This will help to compare and adopt the best collection approach considering the Indian scenario. However, there is limited research on CE in E-waste; this limitation will be addressed through this article by creating a value chain. Considering multiple scenarios, targeting secondary waste generators under extended producer's responsibility can be an effective approach for regular collection in comparison with the primary waste generator. Finally, varying collection approaches could be different based on the market and consumption or waste generation patterns. In conclusion, the E-waste management system should be focused on the best collection approach for improving collection efficiency.

Keyword: Circular economy; E-waste; Small IT and telecommunication equipment; Electrical and electronic equipment.

E-waste Hazards: Encourage the Need for Green Electronics

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With rapid advancement in technology, electronic waste (e-waste) or Waste Electronic and Electrical Equipment (WEEE) are an emerging danger. The e-waste poses crucial contamination problems the eco-system. The primary cause behind unrestrained electronic waste around the globe is the speedy advancement of innovation. Low production cost of electronic gadgets is also play an important role in increase of e-waste. Because to this, exceptionally large amounts of e-waste must be discarded each and every year whose disposal is a main issue. To handle this problem of e-waste, reducing and recycling of waste play a vital role. These techniques also help in configure the circular economy. This paper sums up the data of e-waste generated worldwide with special reference to India, along with focusing on the advantages of recycling. This paper also highlights the impact of e-waste on the eco-system and how green electronics could be one of the practical solutions to this.

Keywords: E-Waste, Electronic scrap, WEEE, Green electronics.

Evaluating WEEE Generation, Disposal Decision and Consumer Preferences in Support of Reverse Logistics for a Circular Economy in Hong Kong

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The growth in the waste electrical and electronic equipment (WEEE) is a growing issue in Hong Kong and mechanisms for the proper management of e-waste are urgently needed. Drawing on the circular economy (CE) as a solution for the city's WEEE challenge is a promising approach: the concept bears relevance for the city's waste management hierarchy, constitutes an established approach for managing post-consumer waste streams and helps conserving virgin resources. Given the value of discarded electronics due to function and inherent metals, CE approaches such as repair, refurbishment and remanufacturing combined with a reverse logistics mechanism can strengthen system soundness and stakeholders' responsibilities.

One comprehensive mechanism in this context is the Producer Responsibility Scheme for WEEE (WPRS), which has been gradually implemented in Hong Kong since 2016. Yet, detailed statistics on WEEE generation at the household level and how physical and psychological factors influence the consumer preference regarding the disposal decision and reverse logistics for CE are absent. The study aims at estimating WEEE generation in Hong Kong's households and evaluate consumer's preferences regarding the End-of-life management of electronics. Herein, particular focus is set on residents' attitude towards reverse logistics for WEEE and other mechanisms and patterns related to the CE's R-principles. The main hypothesis of this study is that product-specific, physical and psychological factors are positively related with consumer willingness to support CE approaches in WEEE management.

In terms of materials and methods, the study will use survey data from two waves in 2022 covering over 5,000 households. Additionally, models on the estimation of EEE marketisation and respective WEEE generation will be adopted to complete and extrapolate survey data. Particular focus will be put on the consumption of white and brown goods commonly used in Hong Kong, i.e. air-conditioners, refrigerators, washing machines, televisions, monitors, laptops, mobile phones and, tablets/iPads. To explore consumer preferences for existing disposal channels and contrast these with actual behaviour patterns, the theory of planned behaviour (TPB) will be employed. The TPB's core elements of attitude, subjective norms and awareness of consequences in regard to the WPRS and the circular economy concepts will be verified via the partial least square path modelling (PLSPM) approach.

The study is limited to certain types of EEE from households, but will develop framework for future research on other types of electronics from schools, universities, offices and other public institutions may also be carried out. In sum, the findings will provide a fundament for future research on material flow analysis, value chain analysis and life cycle analysis of WEEE management by e-waste traders in Hong Kong as well as offer CE policy recommendations for policy-makers.

Keywords: Circular Economy, WEEE generation, Disposition decision, Reverse logistics.

A Green Slurry Electrolysis to Recover Valuable Metals from Waste Printed Circuit Board (WPCB) in Recyclable pH-Neutral Ethylene Glycol

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The continuous growth of e-waste necessitates an efficient method to recover their metal contents to improve their recycling rate. The successful recovery of the metallic component from Waste Electrical and Electronic Equipment (WEEE) can generate great economic benefits to incentivize the industrial recycling effort. In this study, we report the use of slurry electrolysis (SE) in pH-neutral ethylene glycol (EG) electrolyte to extract and recover the metallic component from waste printed circuit broad (WPCB) powder. The system operates at room temperature and atmospheric pressure, and the electrolyte can be recycled multiple times with no signs of chemical degradation. The EG electrolyte system can oxidize the metallic component without triggering anodic gas evolution, which allowed us to incorporate a reticulated vitreous carbon (RVC) foam anode to maximize the capture and oxidation of the metal content. The system demonstrated up to 99.1% Faraday efficiency for the cathodic metal deposition and could recover Cu from the WPCB powder in a selective manner of 59.7% in the presence of 12 other metals. The SE reaction system was also scalable and displayed no compromises on the Cu recovery selectivity. With the ability to leach and recover metallic content from WPCB in a mild and chemically benign condition, the SE system displayed much promise to be adapted for industrial-scale metal recovery from WPCB.

Keywords: Slurry electrolysis, Ethylene glycol, Waste printed circuit broad (WPCB), Reticulated vitreous carbon.

Effect of Magnetised Nutmeg Seed Shell-Based Biochar on the Bioleaching of Printed Circuit Boards

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One of the numerous extraction techniques being utilized to recover metal resources from e-waste is the bioleaching approach, which is beginning to gain prominence due to the eco-friendly nature. Our investigations have looked into the enhanced effect of biochar on the bioleaching by bacteria found in old e-waste Printed circuit boards from waste clock momentum is selected for this study which have copper in high quantity. Nutmeg seed shells, which is an agricultural waste are utilized as a substrate for the synthesis of biochar. Biochar is then coated with magnetized Fe particles with the help of plant extract which is proved for the presence of reducing and capping agents required for the reduction of magnetic iron nanoparticles from ferric and ferrous salt. The plant extract which is taken in the study is from nutmeg seed shell itself by extraction method using water as solvent. This composite is used to improve the bioleaching process by enhancing electron transfer because of its rich functional groups, developed pore structure, and substantial specific surface area. Due to the enhanced properties of magnetic biochar, it is growing in popularity among researchers. Magnetized biochar analyzed using BET surface area analyzer, FTIR, XRD for the detailed study of surface characteristics and functional groups helping for the bioleaching processes and microbial growth. After adding biochar, the static bioleaching experiment that lasted 10 days to observe the effect of composite in the leaching rate of copper (Cu). The amount of copper is analyzed by ion chromatography using UV detector. The dynamic bioleaching experiment further confirmed that the 30-day cumulative Cu leaching under the stimulation of biochar composite is increased compare to the normal bioleaching condition. The beneficial impact of biochar on microorganisms was mostly seen in two areas. Biochar's distinctive porosity structure created an environment for microorganisms to live in while retaining a wealth of nutrients. Furthermore, biochar can serve as an excellent physical medium to promote electron transfer, increasing the ability of bacteria to oxidize. The inclusion of biochar may also be effective in preventing precipitation from developing during bioleaching, hence accelerating electronic waste breakdown and metal element release. This work demonstrates that biochar-composite-enhanced bioleaching may be an effective and advantageous method for recovering metal resources from electronic wastes.

Keywords: Nutmeg seed shell, Biochar, Magnetisation, Electronic waste, Bioleaching.

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Construction and Demolition Waste

Binder Testing of Mixed Plastics-Polymer Modified Bitumen for Asphaltic Wearing Course

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This paper reports an experimental study on the use of recycled mixed plastics, derived from municipal solid waste, in polymer-modified bitumen for infrastructural applications such as construction and maintenance of roads, carparks, runways and underground facilities. The objective of this study is to evaluate the binder properties and performance for asphaltic wearing course to produce optimized mixtures by the plant-mixed dry process. The laboratory works performed include binder testing on penetration, softening point, rotational viscosity, short-term aging, storage stability and dynamic shear. Based on the binder test results, a suitable range of mixed plastics contents by mass of binder is recommended to be used in the asphalt mixtures.

Keywords: Binder testing, Mixed plastics, Polymer-modified bitumen, Asphaltic wearing course.

Prediction of Illegal Dumping by Using Geographically Weighted Regression

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Construction waste, also called construction and demolition (C&D) waste, is the solid waste generated from various construction activities. When it is generated at source, C&D waste is often a mixture of multifarious compositions including inert materials (e.g., concrete, brick, tile, asphalt, stone, soil, glass, and gypsum) and non-inert materials (e.g., steel, timber, plastic, textile, paperboard, and vegetation). Understanding their specific compositions is critical for the subsequent waste management decision-making, e.g., reuse, recycling, or landfilling. However, in real-life practice, this is often an onerous task by segregating and weighting their proportions respectively. This research aims to contribute method that can predict the compositions of a C&D waste dump by combining computer vision, big data, and machine learning. The method requires three inputs, i.e., the surface image, weight, and volume of a C&D waste dump. Firstly, the surface image is leveraged for identifying waste composition types based on the computer vision technique. Then, the weight and volume are used for inferring the most possible quantity combination of identified composition types using a big data-enabled probability analysis. Lastly, the method is verified by using a large construction waste disposal data set collected from Hong Kong. Applying this method, the detailed waste composition type and respective amount can be accurately and swiftly derived. The method not only supports waste disposal facility operators to decide optimal treatment schemes, but also assist construction site managers to make appropriate waste management plans. Future research is recommended to transfer our method to other solid waste domains to enable its beneficial applications.

Keywords: Construction and demolition waste, Waste management, Composition prediction, Computer vision, Big data.

Construction & Demolition Waste Challenges – An Analysis using the Analytical Hierarchy Process

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In a developing country like India, Construction & Demolition (C&D) waste generation is very high, amounting to 150 million tonnes per annum. 35% - 40% of the global C&D waste comprises the waste generated by the Indian subcontinent. In spite of the Indian government having issues the C&D Waste Management Rules, 2016, only 1% of the total C&D waste is recycled. As the Indian construction industry is forecasted to grow at the compound annual growth rate (CAGR) of 10%, the utilization or reuse of recycled C&D waste is absolutely necessary to achieve the sustainable development goals (SDGs). Thus, there is a need for a greater reuse and recycling of C&D waste for substitution of raw materials in construction sector; further, improper disposal of C&D waste is adding to environmental pollution and loss of economy. Moreover, C&D waste often integrates with the municipal solid waste (MSW) stream to increase the burden on landfills. So, identification of criteria which are preventing proper management of C&D waste is an absolute essential to find a foolproof solution to the issue. The study has been done to assess the major parameters which pose as challenges to C&D waste management. Additionally, the analytical hierarchy process (AHP) has been used to compute the degree of threat being imposed by the parameters to identify the most critical parameter. This is done to curb the identified problem at the very root. Furthermore, it would help create more effective strategies to overcome the challenges of C&D waste management.

Keywords: C&D Waste, Sustainability, Waste management, India, AHP.

International Conference on
Solid Waste 2023:
Waste Management in Circular Economy
and Climate Resilience

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O · PARK2

Organic Resources Recovery Centre Phase 2

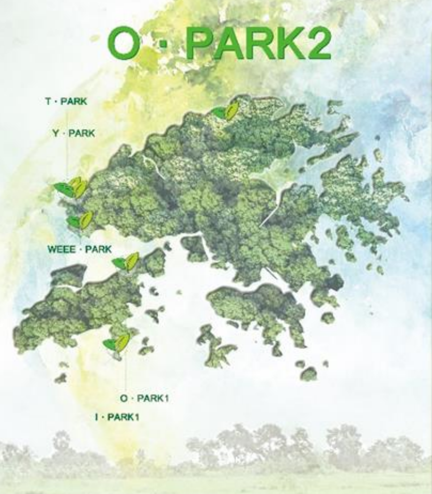
Overall Project Introduction

AJA JOINT VENTURE

01 Vision

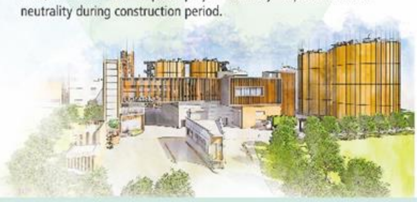
To combat global warming, China officially proposed the "30 · 60" decarbonization goal in 2020. In response to the national strategy, Hong Kong has also proposed to strive to achieve carbon neutrality by 2050. The Hong Kong Government announced in 2021 the Waste Blueprint for Hong Kong 2035, setting out the vision of **"Waste Reduction · Resources Circulation · Zero Landfill"**. To achieve the goal of **"Zero Landfill"**, the Government will continue to develop waste-to-energy facilities, with a view to progressively replacing the disposal of municipal solid waste in landfills. This includes the expansion of the organic resources recovery centres to raise food waste treatment capacity, alleviate pressure and odour problem of landfills, and lower greenhouse gas emissions.

The Organic Resources Recovery Centre Phase 2 (O·PARK2) will convert food waste into electricity and fertiliser with anaerobic digestion technology to recycle food waste into renewable energy. At the same time, O·PARK2 is the **most advanced low-carbon construction project in Hong Kong** currently. During construction, the contractor applied low-carbon construction techniques and offsetting the remaining carbon emissions by purchasing carbon credits, so as to achieve carbon neutrality during construction. In operation, O·PARK2 will generate electricity with biogas, providing renewable energy for Hong Kong and reducing electricity generation by fossil fuels. In addition, it will reduce organic waste to be disposed of at landfills, helping cut down on carbon emissions.

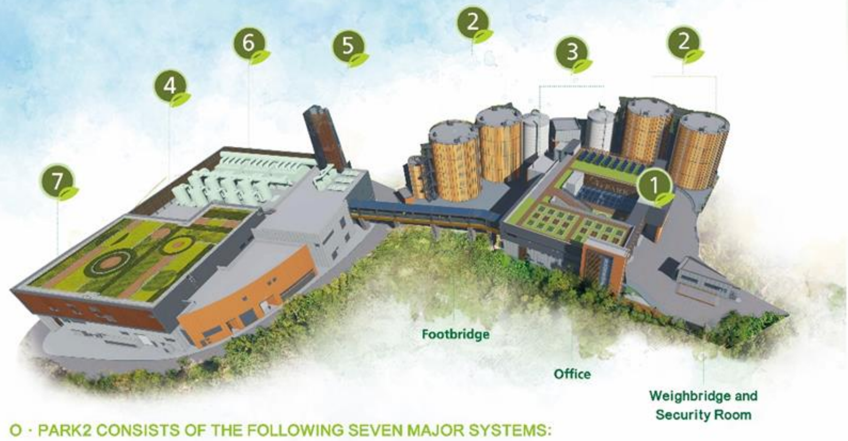


02 Project Introduction

O·PARK2 is a representative green project implemented under **Design, Build, and Operation (DBO) mode.** The project is constructed by Alchmex International Construction Limited (Alchmex) in conjunction with the Jardine Engineering Corporation Limited and Agrivert Limited (AJA Joint Venture). After careful consideration by Environmental Protection Department (EPD), the project was located in **Sha Ling, North District,** covering an area of 2.5 hectares. O·PARK2 is the **second organic resources recovery centre** in Hong Kong. At the same time, O·PARK2 as a pilot project actively explores carbon neutrality during construction period.



03 Major Systems of O · PARK2



O · PARK2 CONSISTS OF THE FOLLOWING SEVEN MAJOR SYSTEMS:

1. Food Waste Reception and Pre-treatment System Automated recording, efficient sorting, and retaining as many organic substances as possible
2. Anaerobic Digestion System
Biological digestion, biogas production, and digestate recycling
3. Biogas Purification and Storage System
Collection by piping, dehumidification and desulfurization, storage for power generation
4. Granulation System
Centrifugal dehydration, digestate granulation, high-quality fertilizer production
5. Combined Heat and Power System
Biogas-to-electricity, heat recycle, self-consumption and surplus electricity exported to power grid
6. Centralized Air Pollution Control System
Enclosed operation of key equipment and facilities, negative pressure, removal of odorous compounds
7. Wastewater Treatment System
Green innovative wastewater treatment, water-recycling and energy-saving

Waste-to-Energy

Client	Environmental Protection Department
Employer's Representative	AECOM
Contract Type	Design, Build, Operation
Contractor	AJA Joint Venture
Design and Build	Commenced in 2019
Operation	Scheduled for commissioning in 2024, 15-year operation period