香港浸會大學 HONG KONG BAPTIST UNIVERSITY

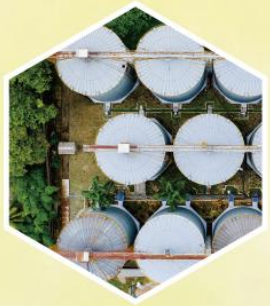
香港浸會大學理學院 HKBU Faculty of Science

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

APASWM Asia-Pacific Association for Sustainable Waste Management

INTERNATIONAL CONFERENCE ON

SUSTAINABLE BIOWASTE MANAGEMENT 2021



12-15 April 2021
Hong Kong Baptist University
Hong Kong SAR, China

Abstract Book

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International Conference on Sustainable Biowaste Management 2021

Abstract Book

12th – 15th April 2021

Hong Kong SAR, P.R. China

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International Conference on Sustainable Biowaste Management 2021

Organised by

Sino-Forest Applied Research Centre for Pearl River Delta Environment (ARCPE)
Institute of Bioresource and Agriculture (IBA)
Asia Pacific Association for Sustainable Waste Management (APASWM)
Hong Kong Baptist University

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WELCOME MESSAGE

First I would like to take this opportunity again to express my sincere thanks to all your support for this "International Conference on Sustainable Biowaste Management 2021 (SBM2021)" , and 'YOU' made this conference a great success. I am so privileged and very pleased to have your participation in this conference to deliberate on advancement in biowaste management and its role in biocircular economy.

SBM 2021 will definitely provide you a great opportunity and platform to exchange your views, visions, and experiences on bio-technology, bio-fertilizers and bio-products, and climate change abatements related to biowaste management. The outcome will have immense benefit to Hong Kong, Asia-Pacific partners and Western countries through knowledge exchange, fostering of collaborations and development of appropriate waste management technologies.

This year we have an overwhelming 438 participants coming from 39 countries all over the world to attend the conference. In addition to 7 keynote presentations, there will be three parallel platform sessions and 3 parallel poster sessions daily for 3 consecutive days with a total of 89 platform presentations and 45 poster presentations. There will be 3 poster presentation sessions each day for 3 days and poster presentations for each day covering 10 specialized themes.

Outstanding papers will be published in special issues of Bioresource Technology and Detritus after review. Best Poster Awards and Young Researcher Awards are also waiting to acknowledge and embrace your knowledge and potential. To encourage the participation from the developing countries, we have set aside some funding to invite prominent scientists to participate the conference.

Due to pandemic Covid-19, we have deferred the conference from 2020 to 2021 and finally we have decided to go have a virtual SBM2021 conference in April 12 to 15, 2021. I look forward to meeting you all at the virtual SBM 2021 and wish you enjoy the conference.

Heartily thanks to all your support for the conference.

Conference Chair
Prof. Jonathan W.C. Wong, PhD, MH, JP
Sino-Forest Applied Research Centre for Pearl River Delta Environment, Institute of Bioresource and Agriculture and Department of Biology
Hong Kong Baptist University
Hong Kong SAR, P.R. China

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International Conference on Sustainable Biowaste Management 2021

Conference Programme

Conference Theme

Increasing urban population and industrialization are the key factors causing serious global environmental problems including increased solid waste generation, decreased soil quality, inadequate nutrient recycling, and increased emission of greenhouse gases. Similar situation is faced in densely populated Hong Kong which generates over 10,000 tonnes of municipal solid waste per day, of which 35% is food waste. Landfilling remains the main treatment technology which has additional environmental consequences. All these issues are interlinked and therefore there is a pressing need to develop integrated biotechnological approaches which allow efficient (bio)organic waste conversions for production of chemicals, materials, energy and food to provide greater profitability and environmental sustainability. However, current situation of such technologies overall in Asia including Hong Kong is not very appealing and technologies are not well integrated to achieve the goal of sustainability. Therefore, SBM 2021 creates a timely platform to bring successful case studies and research innovations from developed and developing countries and devise strategies for waste management industry which is expected to face a huge transition with more business opportunities. In the past, our four international conferences, ICSWHK 2011, ICSWHK 2013, ICSWHK 2015 and BioWCHK 2016 have provided a vibrant interactive platform for exchanging expertise. Following the huge success of these conferences, SBM 2021 with its special focus on biological waste management through integrated approaches will further provide impetus to the available and future technologies through critical evaluation. The outcome will have immense benefit to Hong Kong, Asia-Pacific partners and Western countries through knowledge exchange, fostering of collaborations and development of appropriate waste management technologies.

Conference Venue

The Conference is hosted by the Institute of Bioresource and Agriculture and Sino-Forest Applied Research Centre for Pearl River Delta Environment, the Hong Kong Baptist University, Hong Kong SAR, P.R. China. It will be held online from 12-15 April 2021.

Conference Structure

The Conference includes:

- **Main Conference**: From 12 to 14 April via Zoom
  - Keynote sessions
  - Parallel oral sessions
  - Poster Q&A session
- **Training Workshop** 15 April 2021 at 10:00 am-1:00 pm (HKT) via Zoom
  - Workshop on Composting Process, Compost Quality and Use
- **Technical Field Trips** 15 April 2021 at 2:30 pm- 4:05 pm (HKT) via Zoom
  - Virtual field trip to Hong Kong O·PARK1

Keynote Sessions

The conference is structured into 3 keynote sessions: Keynote Session I, Keynote Session II, and Keynote Session III. Each presentation is scheduled for 30 minutes. All will be presented in a strict time schedule, in

order to allow participants to move between the sessions. The chair-persons have the responsibility to ensure that the presentation schedule is strictly followed.

Parallel Oral Sessions

The conference is structured into 3 parallel oral sessions: Session A, Session B, and Session C. Each presentation is scheduled for 12-17 minutes (12/17 minutes for oral/invited presentation). All will be presented in a strict time schedule, in order to allow participants to move between the sessions. The chair-persons have the responsibility to ensure that the presentation schedule is strictly followed. The Q&A session will be arranged at the end of each session.

Poster Presentation and Viewing Sessions

A continuous poster presentation will take place on the website (https://sbm2020.hkbu.edu.hk/poster-session). Three parallel Poster Q&A sessions are dedicated each day over the conference period (12 April: 5:10 pm-5:40 pm HKT; 13 April: 5:30 pm-6:00 pm HKT; and 14 April: 5:30 pm-6:00 pm HKT). Participants are invited to view posters and exchange views and ideas with the authors who are invted to appear in their respective Zoom poster Q&A session.

Training Workshop

A training workshop on "Composting Process, Compost Quality and Use" will held on 15 April 2021 from 10:00 am-1:00 pm (HKT) via Zoom. It will provide the insightful and useful information about basic composting concept, food waste composting, compost quality and its application. It is designed to enlighten the participants on the basic composting process operation requirements, available technologies, compost quality and standard, and its potential use in agriculture and landscaping.

Technical Field Trip

O · PARK1, Hong Kong's first of its kind food waste recycling project, which is capable of handling 200 tonnes of food waste per day. It adopts anaerobic digestion and composting technologies to recycle source separated food waste into biogas and compost. The biogas will be used to generate electricity and apart from the internal use within O · PARK1, about 14 million kWh of surplus electricity, which is equivalent to the power consumption by some 3,000 households, can be exported each year. The virtual technical field trip will be held on 15 April 2021 from 2:30 pm- 4:05 pm (HKT) via Zoom.

International Conference on Sustainable Biowaste Management 2021

Instructions for Presentations

Instructions for Oral Presentations Preparation

Plan your presentation

Each presentation is scheduled for 30 minutes for Keynote Speeches, 20 minutes for Invited Speeches and 15 minutes for oral presentation (12 minutes for presentation and 3 minutes for questions and discussion). If the audience has additional questions, they will be asked to discuss their questions with the presenter after the session. No extension of the time set for presentation can be accepted. In fact, as there will be 3 parallel sessions, participants may have the possibilities to go between parallel sessions.

Upload your Presentation Information (Deadline to upload: 20 March 2021)

1. Login the website
2. click "personal profile" or "Submission ID" (on the top left corner of the page) to upload the presentation information
3. click Submit to submit the presentation information
    a. Title of the abstract
    b. Presenter's Name, headshot, and biography to be displayed on the website

Pre-recording Your Presentation in Zoom

All presentations of SBM2021 will be virtual. To ensure the sessions do not overrun due to the unstable internet connection, we request you to prepare and upload a video of your presentation.

There are several video conferencing tools available to easily record a presentation. In this method, you can show your face via webcam and display your slides as you talk. You can use any meeting software as long as you get a good quality recording and your final file is in the MP4 format. Here are some links to instructions on recording a meeting on common platforms:

- WebEx: Video Conferencing - Record a Cisco Webex Meeting
- Skype: Skype for Business: Recording a Meeting | Information Technology Services | Bemidji State University
- Google Meet: Record a video meeting - Meet Help
- Zoom: Local Recording – Zoom Help Center
- GotomeeHow to Record a GoToMeeting Session | Techwalla and How to Convert and Open the GoToMeeting Recordingsting:
- Microsoft Teams: Record a meeting in Teams - Office Support
- Tencent Meeting (For Chinese user only)

Guidelines for Preparing Your Video

Duration:

- Invited speech: 17 minutes
- Oral speech: 12 minutes

File size: 100MB max

Video file format: mp4

Dimensions: Minimum height 480 pixels, aspect ratio: 16:9

Uploading Your Presentation to the Presentation Module

Follow the instructions below to upload your presentation. An individual presentation link will be sent to you by email by 1 April.

1. Be sure to record your presentation.
2. You will only need to upload the .mp4 file as that file incorporates Audio, Camera and Content Slides (PowerPoint) all in a single file.
3. You will receive an email by 1 April with instructions and link for uploading your presentation. Utilizing the same instructions, you will be able to upload the .mp4 Zoom recording file. Depending on the size of the resulting file, this may take some time, so be patient as the file uploads. If you have not received this email by 1 April, please contact sbmconf@hkbu.edu.hk.

Guidelines for Online Presentation

One day before the session

1. Make sure you have installed the Zoom software in your computer.
2. You will receive a Zoom meeting Invitation email with the information as follows:
    - Time (Hong Kong Time)
    - Date
    - Session information
    - Zoom link

20 mins before the session

1. Join the Zoom meeting.
2. The admin staff will invite you to join the waiting room for briefing and testing.
3. Once the briefing and testing has been completed, the waiting room will be closed.

Online LIVE presentation

1. The Session Chair will introduce you by reading your name and organization and inform you to start the presentation.
2. Share your screen, click to full screen mode and start your presentation.
3. The Chair will remind you at the last 5/1 minute(s) of your presentation.
    - Invited speech: 17-min
    - Oral speech: 12-min
4. NO Q&A session immediately after your presentation, but there will be a common Q&A session for all presenters at the end of the session. Hence DO NOT leave the Zoom after your presentation.
5. The Chair will read the questions on the chat box for you to answer.
6. **If you fail to appear in the session 20 mins before the session, the admin staff will run the pre-recording at your presentation time slot.**

Pre-recorded presentation

1. The Session Chair will introduce you by reading your name and organization and inform you to start the presentation.
2. The admin staff will run your pre-recording
3. NO Q&A session immediately after your presentation, but there will be a common Q&A session for all presenters at the end of the session. Hence DO NOT leave the Zoom after your presentation.
4. The Chair will read the questions on the chat box for you to answer.

Instructions for Poster Presentations

Posters Q&A Sessions

The Posters Q&A Sessions will be arranged during the main conference. Each poster presenter will have 3 minutes of live Q&A via Zoom meeting for the session.

Upload your Poster (Deadline to upload: 31 March 2021)

1. Login the website
2. click “personal profile” or “Submission ID” (on the top left corner of the page) to upload the presentation information
3. click Submit to submit your poster and other requested information
    a. Title of the abstract
    b. A one-page **Vertical Poster** in PDF format
    c. Presenter’s Name, headshot, and biography to be displayed on the website
    d. Abstract in PDF format

Each poster presenter will be able to participate live in Q&A during the poster session.

Poster PDF Requirements

Note: your Poster PDF should be one page only.

1. All poster presenters should provide a one-page Poster PDF.
2. The A0 poster size formatted vertically is the most popular based on the usual, physical dimensions for the SBM2021.
3. Please upload your poster file(s) to the website (https://sbm2020.hkbu.edu.hk/poster-submission) by 31 March 2021. If you have any trouble with the upload poster file(s), please contact sbmconf@hkbu.edu.hk .

Guidelines for Poster Presentation

One day before the session

1. Make sure you have installed the Zoom software in your computer.
2. You will receive a Zoom meeting Invitation email with the information as follows:
   - Time (Hong Kong Time)
   - Date
   - Session information
   - Zoom link

20 mins before the session

1. Join the Zoom meeting.
2. The admin staff will invite you to join the waiting room for briefing and testing.
3. Once the briefing and testing has been completed, the waiting room will be closed.

Online LIVE poster Q&A

1. The Session Chair will introduce you by reading your name and organization.
2. The admin staff will display your poster by sharing the screen to the audience.
3. Turn on the audio and video at your side to answer the questions.
4. There will be 5 minutes for your Q&A session.
5. The Chair will read the questions on the chat box for you to answer.
6. **If you fail to appear in the session 20 mins before the session, the admin staff will run the pre-recording at your presentation time slot.**

Main Conference Programme

Conference Venue: Online, Time Zone: Hong Kong Time

12April 2021 (Monday)
Opening Ceremony: MC: Dr. Reeti Kumar (1430-1500)
Welcoming Address: Prof. Jonathan Wong, MH, JP, Conference Chair, Hong Kong Baptist University, Hong Kong (1430-1435)
Opening Address: Prof. Rick Wong, Interim Provost, Hong Kong Baptist University, Hong Kong (1435-1440)
Opening Keynote: Mr. Wong Kam-sing, GBS, JP, Secretary for the Environment, Hong Kong SAR Government (1440-1455)
Zoom Photo Taking (1455-1500)
Keynote Session **Chair: Prof. Jonathan Wong (1500-1600)**
Resource Recovery from Bio-wastes: Bioeconomy Perspectives for Energy and Environmental Sustainability Prof. Ashok Pandey, Editor-in-Chief of Bioresource Technology India (1500-1530)
Sustainable Biowaste Management in Developing Countries Prof. Agamuthu Pariatamby, Editor-in-Chief of Waste Management and Research Malaysia (1530-1600)

		Session: A		**Session: B**		**Session: C**
1600-1700		**A1: Advance Anaerobic Digestion**		**B1: Bio-nano Technology for Biowaste Recycling**		**C1: Sustainable Bioconversion of Waste to Resource**
		Chair: Dr. Suyun Xu		**Chair: Prof. Gu Ji-Dong**		**Chair: Dr. S Venkata Mohan**
1600-1617 Invited Talk	A	#124/Prof. Michael Nelles/ Increasing the Efficiency of Mechanical-Biological Residual Waste Treatment Through the Fermentation Stage of the Liquid Pressed Organic Fractions (Germany)	A	#303/Dr. Deepak Pant/ Bioelectrochemical Systems for Wastewater Treatment and Resource Recovery: From Lab to Field Applications (Belgium)	A	#304/Prof. Samir Kumar Khanal/ Bioconversion of Wastes-to-Resources: Opportunities and Challenges (USA)
1617-1629	B	#174/Mr. Wachiranon Chuenchart/ Integration Approach of Anaerobic Co-digestion and Microaeration as an Alternative Solution for Municipal Organic Waste Management (USA)	B	#43/Dr. Ka Yu Cheng/ Microbial-Electrochemical Reactors for the Treatment of Alkaline and Saline Waste Streams (Australia)	B	#470/Prof. Mohammad Golabi/ Integrated Soil and Organic Waste Management as a Resource Recovery Strategy for Resilient Agriculture in Guam (USA)
1629-1641	C	#64/Mr. Kin Kuen Cheung/	C	#408/Dr. Shuai Gao/	C	#70/Dr. Asad Iqbal /

		The Beginning of Food Waste and Sewage Sludge Co-Digestion in Hong Kong (Hong Kong)		Structured Carbon Monolith for Gas Absorption: Using Nano-biochar as Precursor (Australia)		Integrated Food Waste with Wastewater Management in Hong Kong: Transformation, Energy Balance, Economic Analysis (Hong Kong)
1641-1653	D	#106/Dr. Nantenaina Rabetokotany/ Rapid Estimation of Higher Heating Value (HHV) and Biochemical Methane Potential (BMP) by using Organic Wastes Characteristics: Application in Tropical Environment (Madagascar)	D	#127/Mr. Rahul Jaideep/ Enhancement of Fuel Properties of Yard Waste through Torrefaction (Malaysia)	D	#60/Mr. Johannes Biala/ The Circular Economy for Organics as a New Paradigm for Advancing Organics Recycling Activities (Australia)
1653-1700	E	Q&A	E	Q&A	E	Q&A
1710-1740		**PA1: Poster Q&A Session Anaerobic Digestion**		**PB1: Poster Q&A Session Bioconversion and Bioproducts**		**PC1: Poster Q&A Session Advance Bioconversion**
		Chair: Prof. Ajay Kalamdhad		**Chair: Prof. Agamuthu Pariatamby**		**Chair: Dr. Guneet Kaur**
		Marking: Prof. Jing Liu		**Marking: Dr. Ka Yu Cheng**		**Marking: Dr. Mukesh Awasthi**
	A	#108/Mr. Shamsundar Subbarao/ Decentralised Waste Management and Green Economy: A Case Study of Pre-Processed Waste Input to 25kg/Day Kitchen Waste Biogas Plant Established at Pramati Hill View Academy School, Mysuru, India (India)	A	# 535/Ms. Poonam Sharma Extraction of pectin from Citrus limetta peel: An approach towards waste management (India)	A	#25/Ms. Zhen Li Exploration on the Best Preparation Scheme of Activated Carbon from Solid Waste in Sugar Refinery (China)
	B	#98/ Dr. Davidraj Johnravindar Effect and Optimization of The Use of Biochar Addition of Food Waste/Sludge Anaerobic Co-Digestion (Hong Kong)	B	#173/ Ms. Triya Mukherjee/ Influence on Iron Nanoparticles on Bacillus Subtilis Growth and Production of Value Added Products in Electrofermentation System (India)	B	#178/Dr. Reeti Kumar Selective Photocatalytic Oxidation of 5-Hydroxymethyl-2-Furfural to 5-Formylfurancarboxylic Acid Using Vanadium Doped Carbon Nitride (Hong Kong)
	C	# 160/ Dr. Jialin Liang/ Effects of Different Conductive Materials on the Anaerobic Co-Digestion of Food Waste and Waste Activated Sludge and Their Digestate Dewatering (Hong Kong)	C	#555/Dr. Bishwambhar Mishra Groundnut Oil Cake: Useful nutrient for pullulan production by Micrococcus Luteus (India)	C	#219/ Dr. Zhi Zhu Selective Oxidation of 5-Hydroxymethylfurfural over A Molybdenum Carbide Quantum Dot Catalyst (China)
	D	# 115/ Miss Mengyao Wang / Effect of Biochar Added on Anaerobic Digestion of Methane from Municipal Sludge and Kitchen Waste (China)	D	# 523/Ms. Varsha Bohra Untangling the Genome of Rare Uncultured Bacterial Species from Plant Biomass Hydrolyzing Microbiome (India)	D	# 512/Dr. Cai Wenfei Catalytic Fast Pyrolysis of Rice Husk for the High Quality Liquid Fuels Production

						(Hong Kong
	E	#175/ Miss Renisha Karki Anaerobic Co-Digestion of Coffee Pulp and Cattle Manure for Enhanced Biofuel and Organic Fertilizer Production (USA)	E	# 539/Mahek Patel Deoiled Cake as an Alternate Substrate for Green Energy Production (India)	E	#147/ Mr. J Shanthi Sravan Kumar Regulatory Influence of Conductive Materials on Interspecies Electron Transfer and Carbon Flux During Electromethanogenesis (India)
	F					
1750-1900		**A2: Advance Anaerobic Digestion**		**B2: Bio-nano Technology and Applications in Waste Recycling**		**C2: Sustainable Bioconversion of Waste to Resource**
		Chair: Prof. Michael Nelles		**Chair: Dr. Deepak Pant**		**Chair: Prof. Samir Kumar Khanal**
1750-1807 Invited Talk	A	#48/Dr. Suyun Xu/ Comparison of Goethite and Activated Carbon on Methanogenesis from Volatile Fatty Acids (China)	A	#118/Prof. Gu Ji-Dong/ CO_2 Capture and Microbial Catalytic Conversion to Bioenergy CH_4 in Oil Reservoir Systems (China)	A	#170/Mr. Johannes Biala/ Developing Sensor-Aided Collection of Source Separated Organic Food Waste (Australia)
1807-1819	B	#129/Dr. Kati Goersch/ Use of Biogenic Residues for the Production of Biomethane (Germany)	B	#120/Mr. Ranaprathap Katakojwala/ Resource Efficient Sustainable Production of Nanocrystalline Cellulose through Agri-waste Biomass Valorization (India)	B	#62/Dr. Vo Chau Ngan Nguyen/ Improving Waste Management Approaches for Small Livestock Farms in Vietnam (Vietnam)
1819-1831	C	#134/Ms. Shanta Dutta/ Efficient Catalytic Production of Levulinic Acid from Starch-rich Food Waste Using a Biphasic System (Hong Kong)	C	#591/Dr. Xiaolei Zhang/ The Impact of Heavy Metals in the Wastewater Sludge on Lipid Accumulation of Oleaginous Microorganism (China)	C	#121/Prof. Qi-Tang Wu/ Long-Term Safety Assessment of Indirect Agricultural Application of Municipal Sewage Sludge through Net Bags (China)
1831-1848 Invited Talk	D	#366/Prof. Ajay Kalamdhad/ Decentralized Treatment of Biodegradable Municipal Solid Wastes (India)	D	#79/Dr. Jun Zhao/ One-pot Approach Conversion of Fructose to 2,5-Diformylfuran by Carbon-based Metal-free Catalysts (Hong Kong)	D	#109/ Dr. Dhundi Raj Pathak Organic Waste Potential and Recycling Strategies in Municipalities of Nepal for Sustainable Solid Waste Management (Nepal)
1848-1900	E	Q&A	E	Q&A	E	Q&A
1900-2010		**A3: Advance Anaerobic Digestion**		**B3: Bio-nano Technology and Applications in Waste Recycling**		**C3: Sustainable Bioconversion of Waste to Resource**
		Chair: Prof. Jing Liu		**Chair: Dr. Ka Yu Cheng**		**Chair: Dr. Guneet Kaur**
1900-1917 Invited Talk	A	#362/Prof. Yan Zhou /	A	#392/Dr. S Venkata Mohan/	A	#472/Prof. Ji Li/

		What Else Do We Need Know about Pretreatment? (Singapore)		Waste Fed Biorefineries for Sustainable Chemicals and Fuels (India)		Recycling Use of Organic Waste: New Approach for a Developed City in China (China)
1917-1929	B	#267/ Mr. Marcel Pohl/ Biogas Monitoring Programme III: Energy Efficiency Assessment of 61 Biogas Plants in Germany--Outcomes and Methodological Challenges (Germany)	B	#59Mr. Ke Wang/ Design and Construction of Nanobiocatalysts Consisting of Immobilized Lipase on Nanostructured Clay Surfaces for Biodiesel Production (China)	B	#151/Dr. Alireza Bazargan / Opinion of Waste Management Experts on the Implementation of Smart Waste Management in Tehran (Iran)
1929-1941	C	#73/Miss Liwen Luo/ Feasibility of Pressure Mediated Two-phase Anaerobic Digestion to Improving Methane and its Underlying Mechanisms on Hydrolysis (Hong Kong)	C	#179/Mr. Kyle Rafael Marcelino/ Nanobubble Technology Application in Aquaponics (USA)	C	#344/ Dr. Sumeth Wongkiew Bioponics – a Biological Nutrient Recovery Technology in Bio-Circular-Green Economy
1941-1958 Invited Talk	D	#220/Prof. Jing Liu/ Manure Management for Methane Mitigation – In-vitro Determination of Methane Emission from Manure for Improved Inventory Modelling (Sweden)	D	#58/Prof. Roger Ruan/ Innovative Fast Catalytic Microwave-assisted Thermochemical Conversion of Bio-Wastes for Energy and Fuels Production (USA)	D	#168/Dr. Guneet Kaur/ Urban Waste-based Biorefinery Processes for Transition to a Circular (Bio)economy (Canada)
1958-2010	E	Q&A	E	Q&A	E	Q&A

13 April 2021 (Tuesday)						
		Session: A		**Session: B**		**Session: C**
1500-1605		**A4: Composting**		**B4: Biochar and its Application**		**C4: Bioconversion for Bioproducts**
		Chair: Dr. Mukesh Awasthi		**Chair: Dr. Nirakar Pradhan**		**Chair: Prof. Shan He**
1500-1517 Invited Talk	A	#223/Prof. Jonathan Wong/ Resource Recovery from Solid Anaerobic Digestate: A Critical Review on Circular Bio-Economy Perspective (Hong Kong)	A	#298/Dr. Daniel C. W. Tsang/ Food Waste Hydrochar for Catalytic Degradation of Organic Contaminant (Hong Kong)	A	#47/Prof. Binghua Yan/ Bio-Electrofermentation Coupled Ion Substitution Electrodialysis for Improved Carbon Conversion to Carboxylic Acids (China)
1517-1529	B	#158/Mr. Yubo Cao/ Nitrifier Denitrification Dominates Nitrous Oxide Production in Composting and Can be Inhibited by an Innovative Nitrification Inhibitor: Electric Field (China)	B	#29/Miss Mengyao Wang/ Production of Biochar using Biogas Residue and Adsorption of Ammonia-Nitrogen and COD in Biogas Slurry (China)	B	#145/Dr. Chong Li/ Characterization and Application of a Natural Derived Bacterial Consortium for Efficient Lignocellulosic Biomass Valorization (China)
1529-1541	C	#308/ Mr. Shiyi Qin Biochar as Smart Candidature to Improve the Microbial Communities and Mitigate the Greenhouse Gases Emission Poultry Manure Composting(China)	C	#30/Miss Gaihong Wang/ Synthesis of Ternary Micro-Electrolytic Fillers using Biochar from *Lycium Barbarum* L. Branches and Its Application in Wastewater Treatment (China)	C	#146/Dr. Avanthi Althuri/ Integrated Bioethanol and Bio-crude Production through Two-stage Yeast Co-fermentation and Hydrothermal Liquefaction (India)
1541-1553	D	#34/Mr. Narsi Ladumor/ Composting of Food Waste Anaerobic Digestate at ORRC1, Hong Kong (Hong Kong)	D	#72/Dr. Ravindran Balasubramani/ Influence of Modified Ricehusk Biochar on Gaseous Emission (South Korea)	D	#155/Mr. Harishankar Kopperi/ Concomitant Production of Extracellular Polymeric Substances (EPS) and Polyhydroxyalkanoate (PHA) from Isolated Providencia Sp: Characterization and Composite Preparation (India)
1553-1605	E	Q&A	E	Q&A	E	Q&A
1610-1720		**A5: Composting**		**B5: Biochar and its Application**		**C5: Bioconversion for Bioproducts**
		Chair: Dr. Vasanthy Muthunarayanan		**Chair: Dr. Daniel Tsang**		**Chair: Prof. Guanyu Zheng**

1610-1627 Invited Talk	A	#166/Dr. Xuan Wang/ The Progress of Composting Technologies from Static Heap to Intelligent Reactor: Benefits and Limitations (China)	A	#50/Dr. Suchithra T. Gopakumar/ Biomass to Aviation Fuels: Conversion Routes and Challenges (Malaysia)	A	#300/Prof. Mohammad Taherzadeh/ Anaerobic Digestion, Volatile Fatty Acids and Membrane Bioreactors (Sweden)
1627-1644 Invited Talk	B	#135/Dr. Mukesh Awasthi/ Biochar as Smart Candidate to Regulate the Fate of Heavy Metals (Cu and Zn) Resistant Bacteria Community during the Poultry Manure Composting (China)	B	#105/Dr. Ammaiyappan Selvam/ Biochar Influences the Impact of Antibiotic in Soil (India)	B	#95/Prof. Sandhya Babel/ Cultivation of Microalgae in a Microbia Fuel Cell for Enhanced Bioelectricity Generation Treating Wastewater: A Comparative Study of *Chlorella vulgaris* and *Scenedesmus quadricauda* (Thailand)
1644-1656	C	#171/Miss/ Dongyi Li/ Effect of Biochar Addition on Food Waste Digestate Composting at Low and High C/N Ratios (Hong Kong)	C	#348/ Dr. Bing Song/ Nano-biochar Production as a Supplementary Sector of Conventional Thermochemical Biorefineries (New Zealand)	C	#81/Dr. Debkumar Chakraborty/ Development and Process Optimization of Reactive Extraction for Carboxylic Acid Removal from High Solid Leach Bed Reactor (India)
1656-1708	D	#55/Mr. Selvakumar Muniraj / Characterization of the Distillery Sludge Based Compost and Vermicompost (India)	D	#157/Mr. Chuangxian Bian / Upgrade and Transformation for Biogas Plants Based on Efficient Utilization of Heat Energy (China)	D	#67/Mr. Edward Antwi/ Hydrothermal Carbonization of Mango Seeds (Germany)
1708-1720	E	Q&A	E	Q&A	E	Q&A
1730-1810		**PA2: Poster Q&A Session Composting**		**PB2: Poster Q&A Session Bioconversion for Biofuel**		**PC2: Poster Q&A Session Other Bioconversion for Technology**
		Chair: Dr. Manu M.K.		**Chair: Dr. Suchithra T. Gopakumar**		**Chair: Dr. Bing Song**
	A	#104/ Prof. Franz Gassner Potentials for Mitigating Greenhouse Gas Emissions through Dietary Changes and Food Waste Prevention: Case Study Macau (Macau)	A	#176/ Mr. Santhosh Jatangi Integrated Biohythane Production from Food Waste-Influence of Increasing Organic Loads (India)	A	#66/ Prof. Deepak Pant An Integrated Biotechnology for Gold Recycling from E Waste Using Thiourea with *Bacillus* and *Lysinibacillus* Sp. (Hybrid) Combination (India)
	B	#130/ Miss Xiaoxiao Guo Estimation of Greenhouse Gas- N_2O Emission Variation by Denitrification Bacteria During Oxygen Depletion in Bohai Sea of China (China)	B	# 515/Mr. Arun Sathyan Comparative Study on the Biomethane Potential of Terrestrial and Aquatic Weeds (India)	B	#63/ Mr. Pradeepkumar Sugumar Studies on Bioleaching and Recovery of Metals from Printed Circuit Boards Using Acidophile and Alkaliphile Bacteria (India)
	C	# 537/Ms. Shaili Vyas Biocoversion Of Municipal Solid Waste to Compost (India)	C	# 534/Ankita Adesra Valorizing Secondary Sludge of Dairy Industry for Biohythane Production (India)	C	#122/ Mr Rajesh Kona Biosynthesis, Isolation and Quantification of Phycobiliproteins by *Desertifilum Sp.*

						SVMIICT2: Effect of Differential Light Intensities (India)
	D	#391/ Miss. Tao Liu Conversion Food Waste and Sawdust into Biofertilizer Employing Black Soldier Fly Larvae (Diptera: Stratiomyidae) under the Optimized Condition (China)	D	#132/Mr. Teoman Alan Comparison of Different Adsorbents for Iodate Removal in Water Environment (Thailand)	D	#169/ Mrs Hemalatha Manupati Duckweed Biorefinery with Dairy Wastewater Treatment (India)
	E	# 371/Miss Xiuna Ren Elucidating the Optimum Added Dosage of Diatomite during Co-composting of Pig Manure and Sawdust: Carbon Dynamics and Microbial Community (China)	E	#75/Dr. Baskar Gurunathan Development of Sustainable Biodiesel Production from Madhuca Indica Using Green Chemistry Principles And Techno-Economic Analysis (India)	E	
1815-1915		**A6: Composting**		**B6: Bioconversion for Biofuel**		**C6: Bioconversion for Bioproducts**
		Chair: Dr. Xuan Wang		**Chair: Prof. Sandhya Babel**		**Chair: Prof. Binghua Yan**
1815-1832 Invited Talk	A	#309/Prof. Zengqiang Zhang/ Performance of Black Soldier Fly Larvae for Manure Composting (China)	A	#165/Dr. Nirakar Pradhan/ Biotransformation of Organic Substrates to Biofuel and Bioproducts by *Themotoga Neapolitana* (Hong Kong)	A	#76/Prof. Guanyu Zheng/ Importance of Sludge Conditioning in Attenuating Antibiotic Resistance: Removal of Antibiotic Resistance Genes by Bioleaching Conditioning and Subsequent Composting (China)
1832-1844	B	#689/ Ms. Shaili Vyas Biocoversion Of Municipal Solid Waste to Compost (India)	B	#102/Dr. Wei Zhang / Improvement of Sludge Dewaterability by Anaerobic Digestion and Mechanism Analysis Based on Moisture Distribution (China)	B	#78/ Mr. Rajat Kumar Bioprocess Robustness of Newer Polyhydroxyalkanoate Producers as Sustainable and Persistent Strains (Hong Kong)
1844-1856	C	#56/Dr. Vasanthy Muthunarayanan/ Toxicity and Histopathological Effect of Distillery Industrial Sludge on the Earthworm Eudrilus Eugeniae (India)	C	#61/ Dr. Balwinder Singh/ Production of Xylitol by Immobilized Candida Tropicalis Ebl-X39 Cells From Rice Straw Hydrolysate (India)	C	#626/ Ms. Bhoomika Yadav Production, Characterisation and Applications of Extracellular Polymeric Substances (EPS) using Activated Sludge Fortified with Crude Glycerol (USA)
1856-1905	D	Q&A	D	Q&A	D	Q&A
Keynote Session: (1910-2010) Chair: Prof. Jonathan Wong						
1910-1940	Separate Collection of Biowaste in Germany-Status Quo and Optimization Potentials, Prof Klaus Fricke (Germany)					
1940-2010	Bioconversion of Organic Waste to Useful Products, Prof. RD Tyagi (Canada)					

14 April 2021 (Wednesday)						
		Session: A		**Session: B**		**Session: C**
1500-1605		**A7: Emerging pollutants and fate during resource management**		**B7: Bioconversion for Biofuel**		**C7: Bioconversion for Bioproducts**
		Chair: Dr. Ammaiyappan Selvam		**Chair: Prof. Gina Villegas Pangga**		**Chair: Dr. Michael Sauer**
1500-1512	A	#53/Mr. Abhishek Khapre/ Confirmation of Landfill Gases Oxidation in Phytocapping Systems in India using Computational Biological Tools (India)	A	#116/Emmanuel Dugan/ Effects of Biochar and Maize Stover Mulch on the Physical Properties of a Sandy Loam Soil and Maize Yield (Ghana)	A	#156/Dr. Venkateswer Reddy Motakatla/ Polyhydroxyalkanoates (PHA) Production using Bacterial Strains (Germany)
1512-1524	B	#159/ Miss Zhang Xinyuan Strengthening Electron Transfer through Supplementary Electric Field Could Reduce the Potential Environmental Risk of Heavy Metal and Antibiotic Resistance Genes in Aerobic Composting	B	#164/Miss Feifei Liu/ Study on the Migration Behaviour of Heavy Metals and Characteristics of Phosphorus-enriched Biochar Prepared by Microwave Pyrolysis of Municipal Sewage Sludge (China)	B	#57/Mr. Kaarmukhilnilavan R S/ Bioflocculant Production by Newly Isolated Bacteria from Activated Sludge using Fish Market Waste as a Nutrient Source (India)
1524-1541 Invited Talk	C	#301/Dr. Obulisamy Parthiba Karthikeyan / Bio-Waste Recycling and Greenhouse Gas Emission Reduction (USA)	C	#153/Dr. Gina Pangga/ Assessing Biochars as Bio-products from Slow Pyrolysis of Different Organic Resources and Evaluate Properties as Soil Conditioners (Philippines)	C	#302/Dr. Michael Sauer/ Cell Factories for Bulk Chemical Production from Industrial Side Streams (Austria)
1541-1553	D	Q&A	D	Q&A	D	Q&A
1610-1730		**A8: Microplastics in the Environment**		**B8: Bioconversion for Biofuel**		**C8: Alternative Biowaste Utilization**
		Chair: Dr. Sunita Varjani		**Chair: Dr. Zhao Jun**		**Chair: Prof. Konstadinos Abeliotis**
1610-1622	A	#49/Dr. Quan Wang/ Effect of Microplastics on the Greenhouse Gaseous and Ammonia Emissions During Organic Waste Composting (China)	A	#128/Miss Jia Wen Chong/ Multi-Stage Computer Aided-Molecular Design (CAMD) Approach in Bio-Oil Solvent Design to Upgrade Bio-Oil Quality (Malaysia)	A	#45/ Dr. Ashoka Gamage / Improvement of Mechanical Thermal and Barrier Properties of Cassava Starch-Based Cast Films Using Natural Fibers (Sri Lanka)
1622-1634	B	#133/Ms. Piyathida Pupuang/ Occurrence of Microplastics in Commercially Harvested Blood Cockles	B	# 533/Anil V. Shah Refuse Derived Fuel as A Source of Energy Production: A Way Towards	B	#448/Mr. Yuyang Hou/ Application of Coffee Hull Fiber in Thermoplastic Composites (China)

		in Thailand (Thailand)		Sustainability (India)		
1634-1651 Invited Talk	C	#39/Prof. Gert Morscheck/ Biodegradable Plastics - Pros and Cons Bioplastics (Germany)	C	#141/Prof. Shan He/ Effect of a Supersized Vortex Fluidic Device on the Mechanical Properties and Microstructure of a Biodegradable Film (China)	C	#136/ Prof. Konstadinos Abeliotis / Environmental Assessment of the Transformation of Food Waste to Animal Feed via a Solar Drying Unit in Greece (Greece)
1651-1708 Invited Talk	D	#532/ Dr. Sunita Varjani/ Composting as a Sustainable Technology for Coversion of Municipal Solid Waste to Biofertilizers: Road Blocks and Perspectives (India)	D	#91/Miss Yan Yu / Improving the Ash Removal Efficiency of Agricultural Residues by Traditional Water Leaching and Microwave-Assist Leaching (Canada)	D	#299/Prof. Jishuang Chen/ Material Utilization of Biomass and the Development of Straw/Plastic Rattan Composites (SPRC) (China)
1708-1720	E	Q&A	E	Q&A	E	Q&A
1730-1800		**PA3: Poster Q&A Session Composting**		**PB3: Poster Q&A Session Biochar and Its Application**		**PC3: Poster Q&A Session Emerging pollutants and fate during resource management**
		Chair: Dr. Vasanthy Muthunarayanan		**Chair: Dr. Obulisamy Parthiba Karthikeyan**		**Chair: Prof. Gert Morscheck**
	A	# 536/Mr. Nidhi Kundariya Characterization of Food Waste for Value Creation (India)	A	#143/ Mr. Salvo Salvacion The Use of Coconut Husk and Cattle Manure Biochars in Remediating Mine-Contaminated Soil Grown with Upland Rice (Philippines)		#22/ Dr. Ashoka Gamage Development of Nutrient Management Technologies for Sustainable Rice Farming for Mitigating Water and Atmospheric Pollution (Sir Lanka)
	B	# 476/Mr. Pottipati Suryateja Thermophilic Degradation of Vegetable Waste using Rotary Drum Composter and Efficacy of Rotary Drum Followed by Vermicomposting (India)	B	#180/Ms. Divya D. R. Nutrient Recovery using Biochar Derived from Agricultural Waste and its Environmentally-Safe Reuse (India)		#33/ Mr. Arjun Kumar Gupta Intellectual Property Rights in E-Waste Management: Why and How? (India)
	C	# 514/Mr. Krishna Chaitanya Maturi Transformation of Intrusive Weed *Ageratum conyzoides* into a Value-added Product through Rotary Drum Composting(India)	C	# 253/Mr. Yinchao Li Effect of Biochar Combined with a Biotrickling Filter on Deodorization, Nitrogen Retention, and Microbial Community Succession During Composting (China)		#167/ Mrs. Sri Divya Kuravi Nutrient Remediation by *Monoraphidium Neglectum* and *Messatrum Gracile*- A Comprehensive Study (India)
	D	# 538/Ms. Priya Prajapati Quality Assessment of Compost Obtained from Municipal Solid Waste (India)	D	#307 Miss. Huimin Liu / Influence of Biochar Amendment on Antibiotic Resistance Gene Abundance and the Bacterial Community during		#107/ Dr. Md Moshiur Rahman An Assessment on Opportunities of Sewage Fed Aquaculture Practices in Bangladesh: Challenges and Way

				Aerobic Composting of Pig Manure (China)		Forward (Bangladesh)
	E	#148/ Mr. Ranaprathap Katakojwala/ Resource Efficient Sustainable Production of Nanocrystalline Cellulose through Agri-waste Biomass Valorization (India)	E	#131 Miss Yuting Duan/ Biochar Accelerated the Initiation of High-solid Anaerobic Co-digestion System with Pig Manure and Dehydrated Sewage Sludge (China)		#161/ Mr. Scott Yipeng Liu Lead Contamination on Petroleum Degrading Efficiency of Soil Bacteria Isolated from Zhuhai, Guangdong, China (China)
Keynote Session III: (1805-2000) Chair: Prof. Jonathan Wong						
1805-1835	Applied Machine Learning to Predict CO_2 Adsorption on Biomass Waste-derived Porous Carbons, Prof. Yong Sik Ok (South Korea)					
1835-1905	Process Integration for a Cost-efficient Production of Biobased Products, Prof. Solange I. Mussatto (Denmark)					
1905-1935	Macro- meso- and Microplastics in Waste and Others, Prof. Pingjin He (China)					
1935-2000	Closing and Award Presentation					

15 April, 2021 (Thursday)	
Workshop on Composting Process, Compost Quality and Use	
Time	**Event**
0950-1000	Registration and Welcoming Address
1000-1115	Fundamentals on Composting Process and Operation
1115-1120	Break
1120-1220	Comost Quality and application
1220-1245	Compost Standard
1245-1300	Open Discussion and Questions
Virtual Field Trip Event (Host: Mr. Narsi Ladumor, OSCAR Bioenergy)	
Time	**Event (Host: Mr. Narsi Ladumor, OSCAR Bioenergy)**
1430-1500	Pre-treatment system and Q&A
1500-1530-	Anaerobic Digestion process and Q&A
1530-1600	Composting process and Q&A
1600-1605	End of the trip

International Conference on Sustainable Biowaste Management 2021

Keynote Speeches

Sustainable Biowaste Management in Developing Countries

Agamuthu P.*

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This presentation summarizes the current situation of biowaste management practices in developing countries. Biowaste includes food waste, food loss and biomass that are generated from households, food industry and agriculture respectively. With increasing rate of population, urbanization, and economic growth, the waste generation, including biowaste, is also on the rise. From the generated municipal solid waste (MSW), approximately more than 50% of MSW is composed of organic waste in developing countries, whereas less than 40% of organic waste is generated in developed countries. Moreover, approximately 1.3 billion tonnes of food waste and food loss is generated globally every year, of which majority is disposed of in landfills in developing countries along with other constituents of MSW. Effective legislations and policies on biowaste management are either absent, or they are not stringently enforced in developing countries. Consequently, it has resulted in major issues of inefficient waste collection, open dumping and burning, and excessive use of landfills in the case of food waste and food loss. Whereas, majority of the biomass generated is also not utilized in recycling or energy recovering in developing countries. Studies conducted on biowaste management has revealed that reuse is the best strategy for biowaste management followed by anaerobic digestion in terms of resource circulation and environmental protection. However, there are other technologies that can be deployed for the management of biomass including hydrothermal carbonisation, fermentation, gasification and others. In the end, several recommendations are presented to overcome the challenges faced in developing nations for the management of biowaste. Among those are the sustainable development goals that inexplicitly and explicitly encourage sustainable management of biowaste which can be incorporated in national policies to improve the current situation of biowaste management.

Keywords: *Biowaste, Food waste, Biomass, 3R, Sustainable waste management.*

Applied Machine Learning to Predict CO_2 Adsorption on Biomass Waste-derived Porous Carbons

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Biomass waste-derived porous carbons (BWDPCs) are a class of complex materials that have found prominence in sustainable waste management and practical carbon capture. However, their diverse textural properties, the presence of various functional groups, and the varied temperatures and pressures at which they are subjected to during CO_2 adsorption render challenges to understanding their underlying mechanism for CO_2 adsorption. In this study, we employed machine learning to systematically map CO_2 adsorption as a function of the textural and compositional properties of BWDPCs and performed adsorption experiments based on a dataset compiled from literatures. Various tree-based models were devised, where the gradient boosting decision tree (GBDT) had the best predictive performance with R^2 of 0.98 and 0.84 for the training and test data, respectively. The dataset was further classified into regular porous carbons and heteroatom-doped porous carbons, where again the GBDT model had prior and latter R^2 of 0.99 and 0.98 for the training datasets, and 0.86 and 0.79 for test datasets, respectively. Feature importance determination revealed the significance of adsorption parameters > textural properties > compositional properties in the order of precedence for BWDPC-based CO_2 adsorption. ML can accelerate the development of BWDPC-based CO_2 capture application, mitigating climate change and achieving sustainable waste management, simultaneously

Keywords: *Carbon materials, Upcycling, Data analytics, Gradient boosting Decision tree, Low carbon technology, Sustainable waste management.*

Macro- Meso- and Microplastics in Waste and Others

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Plastic is indispensable in contemporary daily life and approximately 50% of plastics are processed for single-use disposable products, which causes huge amount of plastic waste. Plastic waste abandoned in environment can break down into plastic debris, including macro-, meso- and microplastics. Microplastics can enter the food web and be ingested by the human, which may potentially threat ecology, agricultural production and the security of human health. Increasing the recycling and treatment of plastic waste is the main manner to reduce plastic pollution in many countries. However, plastic waste collected in managed waste treatment system may still have the risk to leak plastic debris to environment. Landfill is estimated to store 21-42% of global plastic waste, but has been proved to release microplastics by landfill leachate. Besides, incineration with energy recover accounts for a large proportion of plastic waste treatment. However, unburned material including plastic debris still exist in bottom ash. Organic fertilizer processed from organic waste also contains plastic debris, which is a vehicle for the entry of microplastic into the soil. In rural area, plastic mulching film are widely used for cultivating crops, which may eventually fragment into microplastics with poor recovering strategy. Microplastics will be transported into atmosphere and in aerosols. The state-of-the-art researches about this information relating to microplastics involved in waste management will be presented.

Keywords: *Plastic waste, Landfill, Incineration, Waste Management.*

Resource Recovery from Biowastes: Bioeconomy Perspective for Energy and Environmental Sustainability

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Waste-to-welth (w-2-w) and waste-to-energy (w-2-e) concept has gained much momentum in recent years, as on one hand, it offers unique opportunity to handle and dispose solid wastes (municipal waste as well as agro-industrial wastes), and simultaneously provides alternative sources of renewable energy. Solid waste treatment and management is a major issue worldwide. Several countries lack proper basic waste management infrastructure and awareness. Thus, waste-to-energy could be an attractive solution for resource recovery, which eventually offers potential benefits when works on principles of biorefinery. A biorefinery is a facility that integrates biomass conversion processes and equipment to produce bio-products, including biofuels and chemicals. It is analogous to todays' petroleum refinery. By producing several products, a biorefinery takes the advantages of various components present in the biomass and their intermediates, therefore maximizing the value derived from the biomass feedstock. They also help in complete or near-complete utilization of the feedstock and reduction in solid, liquid or gaseous wastes.

Various wastes such as food wastes, agri-crops wastes, municipal solid wastes, etc offer potenhtial opportunites if used as feedtsock for developing bio-based processes for the production of value-added chemicals and fuels. Potential application of such wastes for the production of liqiud and gaseous biofuels and other products on principle of biorefineries has gained more attention for possibilities of bioethanol, biobutanol, biodiesel and other high-value chemicals production, coupled with industrial waste treatment. Two major pathways for these include thermo-chemical conversion and biochemical conversion. However, process integration is key for the techno-economic success.

Keywords: *Resource recovery, Biowastes, Bioeconomy, Energy and Environmental Sustainability.*

Bioconversion of Organic Wastes to Useful Products

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The rapid urbanisation and industrialisation have increased the demand for food, feed, chemicals, materials and energy that have in turn augmented the use of fossil-based resources. In addition, the increment in waste generation has detrimental impacts on environment and natural resources.
Owning to the characteristics like high abundance, renewability, ease of accessibility around the globe, valorisation of organic wastes serves as an attractive and potential solution for petro-based resources and waste management issues. Lignocellulosic, agro-industrial and food wastes due to their organic- and nutrient-rich composition have been utilised as a feedstock for production of value-added products via microbial fermentation processes. The process consists of the pre-treatment of the waste biomass, production of value-added product in reactors and downstream processing for the recovery of the product. Various useful products such as bioplastics, biofuels, biopesticides, enzymes, organic acids, biomethane, biohydrogen and bio-fertilisers have been derived from wastes.

The integration of new technologies and holistic approaches for organic waste utilisation will also stimulate the transition towards circular economy that will develop resource-efficient and sustainable policies for long-term benefits. Therefore, feasibility and sustainability of production of various value-added products from wastes and by-products streams will be discussed. The key insights on the pre-treatment strategies and various aspects involved in the sustainable production of chemicals, fuels and materials in a biorefinery approach will be presented.

Keywords: *Wastes, biopolymers, Biofuels, Bioconversion, Value-added products, Circular bioeconomy, Biorefinery.*

Separate Collection of Biowaste in Germany - Status Quo and Optimization Potentials

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Since January 1, 2015, biowaste has to be collected separately in Germany according to the Waste Management Act (KrWG, 2012). The EU Waste Framework Directive 2018/851/EU will make the separate collection of biowaste mandatory from 2024.

From the perspective of resource and climate protection, the highest level of sustainability of solid waste management can be achieved by recycling of biowaste with the most comprehensive possible use of its value-adding properties, i.e. by using the energy potential and the nutrient riched compost (organic soil improver and fertilizer), the so-called cascade utilization.

The prerequisite for the highest possible efficiency of the separate collection and recycling system for biowaste is a high collection rate and a low contaminant content. In Germany, separate collection of biowaste has been practiced for almost 40 years. Despite this, the functionality of the system is still in need of improvement and therefore has a high potential for future development.

The current average collection rate for biowaste in Germany is only around 50% and thus significantly lower than that achieved with the separate collection of paper and cardboard as well as glass, with rates over 80%. Collection rates of around 80% can also be achievable with separate collection of biowaste as indicated by the results of the current Germany-wide waste analysis (UBA, 2020).

Detailed analyses of the composition of biowaste in the remaining municipal solid waste itself provide valuable information. Around 88% of the biowaste in the residual waste was kitchen waste, while garden waste makes up the remaining fraction. The following conclusions can be drawn:

- The collection of garden waste via the organic waste garbage can in combination with various bring systems works very well.
- The amount of kitchen waste collected is extremely unsatisfactory.
- The alarmingly high amount of packaged food (18.4%) calls for new strategies to deal with this waste stream.

The content of impurities and foreign matters in the collected organic waste are around 3% but can also reach values of up to 10%. Against the background of the problem of "microplastics", it is imperative that efforts be made to reduce the contaminant load of biowaste.

The presented paper contains the results of a weak point analysis for the determination of defects. Based on these results, solutions are presented to increase the efficiency of the separate collection of biowaste. Many of the optimization approaches are based on findings from best practice separate collection systems.

If it is impossible to increase the performance of separate collection of biowaste, the authors believe that the separate collection of biowaste is at risk.

Keywords: *Biowaste collection in Germany, Status quo, and Optimization potentials.*

Process Integration for a Cost-Efficient Production of Biobased Products

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Due to the increasing need to reduce the environmental footprint and the push towards converting the fossil-based economy into a greener and sustainable economy, biobased technologies have become of increased interest in industrial sectors. Today, lignocellulosic biomass is seen as the main future alternative resource to replace fossil on the production of fuels and chemicals with reduced greenhouse gas emissions. The interest in such raw materials is further enhanced by the fact that they are not only of value for the fuels and chemicals industries, but they can also be relevant for other industrial sectors including food, feed, pharmaceutical and materials, where they can directly provide valuable compounds such as protein, amino acids, oligosaccharides, and phenolics, or can be used to obtain sugars for fermentation purposes. Techno-economic and life cycle assessment studies have shown promising data on the use of biomass-derived sugars in fermentation processes. However, some important points still have to be improved in order to create technologies with enough robustness for implementation in a large scale. Process intensification / integration principles have been considered to improve the techno-economic potential of biobased production. This has been done through strategies such as the use of high solid loading for enzymatic hydrolysis of biomass, simultaneous saccharification and fermentation processes, fermentation with downstream process integration, and fermentation using co-cultivation of microorganisms. Such approaches are seen today as promising strategies able to accelerate the development of new and robust biobased processes.

Keywords: *Lignocellulosic biomass, Biobased products, Process integration, Green technologies, Sustainability.*

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Advance Anaerobic Digestion

Increasing the Efficiency of Mechanical-Biological Residual Waste Treatment through the Fermentation Stage of the Liquid Pressed Organic Fractions

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In 2015, a new fermentation technology to ferment organic household waste was developed by the SUTCO Company. For this purpose, a pilot fermentation plant has been integrated into an existing MBT facility that is operated by EVA. The driven motivation behind the implementation of the pilot scale is to install and prove a new method to treat the residual waste which comprises a high content of biodegradable fractions. The project's long-term goal is to verify and adopt the methods so that it can be integrated into various types of MBAs with different plant layouts or treatment processes.

Organic fractions, food and green waste, comprise more than 50 percent of total waste in low- and middle-income countries. In high-income countries, the organic fractions' share is about 32 percent. However, in Germany, the organic waste in residual bins constitute nearly 42 percent. This corresponds to the 23 percent of the total organic waste quantity nationwide which is disposed of via residual bins. Globally, about 70 percent of waste is disposed of in landfills and dumpsites. Hence, the fermentation technology is an effective method to tackle and treat the huge amount of degradable materials and convert it into biogas. For the present project, a pilot plant has been established in an existing MBT plant where the residual waste is separated into organic and nonorganic fractions. The organic fractions smaller than 60 mm are pressed by employing a screw press to generate liquid press water. Consequently, the press water is fed into a fermentation process consisting of a number of sequential tanks and converted into biogas as the final output. The project objectives are to identify the correlation and influence of incoming residual waste, screw press, digestate and processed water from aerobic treatment on the press water and treatment efficiency such as gas potential and its composition. Meanwhile, other fundamental operation parameters such as temperature and the screw press' perforation are also evaluated.

The determinations obtained from the daily operation experience showed a positive relationship between pressure of the screw press and organic content in the pressed water. On the other hand, the recirculation of digestate onto the organic waste has a negative impact on the quality of the pressed water. The addition of processed water instead of digestate enhances the pressed water quality through increasing the organic content, while decreasing the ash content and ammonium concentration. The optimal flow rate of processed water added was identified to be 1 l/s to prevent a too dry as well as too moist press cake. The results from the lab analyses illustrate the degradation of DOC to over 75 % by implementing 20 days as the effective retention time. The average gas potential over times were 13 m^3, 30 m^3, 2 m^3 per input organic waste onto the press screw, cubic meter of press water, and kg DOC, respectively.

The outcomes from the operation experience and lab experiments present a clear relationship between the three; fresh materials, screw pressure, the water added to the biowaste: and the quality of the pressed water. Furthermore, the gas potential and the methane concentration are significantly influenced by the quality of the pressed water fed into the fermentation process. However, further studies should be conducted to investigate the impacts of the fresh materials and the reduction of H2S through addition of iron hydroxide.

Keywords: *Residual waste treatment, Fermentation, Liquid pressed organic fractions.*

Integration Approach of Anaerobic Co-digestion and Microaeration as an Alternative Solution for Municipal Organic Waste Management

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The organic fraction of municipal solid waste (especially food waste) and sewage sludge have become a huge environmental challenge for the rapidly developing urban area. Among the different technologies for managing organic wastes, anaerobic digestion provides an avenue for valorizing organic waste with concurrent production of biofuel (i.e., biomethane) and organic fertilizer (i.e., digestate). However, issues such as process instability due to volatile fatty acid accumulation (in case of mono-digestion of food waste) and the presence of toxic metals and pathogens (in case of mono-digestion of sewage sludge) adversely affect the biofuel production and land application of fertilizer. We hypothesize that co-digestion of food waste with sewage sludge could eliminate the abovementioned issues by balancing carbon to nitrogen ratio, providing nutrients and sufficient alkalinity, and diluting toxicity. Moreover, strategically supplied controlled amount of oxygen (i.e., microaeration) could further enhance the anaerobic co-digestion of food waste and sewage sludge by improving both hydrolysis of substrates and methanogenesis of intermediate products.

In the first step, biomethane potential (BMP) tests were conducted to exploit the possible synergistic effects (quantified as biomethane yield) of co-substrates at different mixing ratios: i.e., food waste: sewage sludge of 0:1, 4:1, 4:2, 4:3, and 1:0, volatile solids (VS) basis. BMP tests were conducted using a series of 250-mL-serum bottles with the substrate to inoculum ratio of 1.0 and substrate concentration of 1.5 % (VS basis) at the mesophilic condition. The highest methane yield (508.9 NmL/g VS_{added}) of co-digestion at the mixing ratio of 4:1 based on ANOVA test ($p < 0.05$) and Tukey's honestly significant difference test ($\alpha = 0.05$) were further applied to the 6-liters continuous stirring tank reactor. Oxygen gas was fed into the system to raise ORP 25 mV from the reference stage to maintain the microaeration condition. The co-digestion results were evaluated for the steady-state and dynamic performances based on various loading rates compared with mono-digestion. An integration of anaerobic co-digestion with micro-aeration could significantly improve the economic performance of anaerobic digestion technology in managing these waste streams, thereby leading to widespread adoption of this technology in the Asia-pacific regions concurrently addressing the abovementioned environmental, public health, and social issues.

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

The Beginning of Food Waste and Sewage Sludge Co-digestion in Hong Kong

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Anaerobic digestion of sewage sludge has been adopted for many years by the Drainage Services Department (DSD) of the Government of the Hong Kong Special Administrative Region (HKSARG) as the key sewage sludge stabilisation process, from which biogas is generated as a by-product. Alongside the HKSARG's initiatives in investing in environmental infrastructure and waste-to-energy facilities for smart city development and better utilisation of land in Hong Kong, DSD has also been working on new initiatives to explore feasibility of adopting new and emerging sewage treatment technologies including those for sewage sludge treatment and use of renewable energy. In a recent research study conducted by DSD, an innovative initiative to adopt food waste and sewage sludge co-digestion in Hong Kong was outlined with a view to alleviating Hong Kong's food waste problem. This initiative had subsequently found its way to the 2016 Policy Address of the HKSARG, whereby the Government committed to explore the use of existing sewage treatment works for anaerobic co-digestion of food waste and sewage sludge as an additional part of the network of the organic waste treatment facilities to help raise the food waste treatment capability, based on the concepts of circular economy and "smart city". Planning to set up a trial pilot plant for sewage sludge and food waste co-digestion at the Tai Po Sewage Treatment Works (TPSTW) started in 2016 to confirm the technical feasibility and installation requirements of applying co-digestion technology in Hong Kong.

Before the pilot plant trial, DSD commissioned the University of Hong Kong (HKU) to conduct a series of laboratory tests and analysis since 2014 to identify the optimal operating conditions and metagenomics in the co-digestion process. HKU prepared a bench scale set-up in the laboratory with 1-L semi-continuous medium-size reactors (with 800 mL working volume) and 10-L large-size reactors (with 8 L working volume) which were set to operate at mesophilic conditions (~35˚C). In the medium-sized reactors, the key operating parameters to be investigated were ratios of food waste (FW) to sewage sludge (SS), sludge retention time (SRT) and food waste composition, while the effects of mixing intensity were evaluated in the large-size reactors.

Results of the tests using the medium-size reactors revealed that 1) without any alkali solution addition, total solids of FW:SS ratio of 40:60 was the optimal ratio with the highest methane yield and a good volatile solid reduction (VSR) of 57%; 2) the SRTs of 5, 10, 15 days were insufficient for achieving complete methanogenic digestion; and 3) the food waste composition had a significant impact on the co-digestion performance. As to the large-size reactors, the test results indicated that the mixing intensity is also a factor to be considered in the co-digestion process for achieving optimum biogas yield. The results obtained are valuable for taking forward the pilot plant trial at TPSTW.

Since installation of the co-digestion pilot plant at the TPSTW with its operation began in September 2019, the co-digestion process has been closely monitored and found to be working properly. The technical know-how in using such an innovative sludge treatment process in Hong Kong is being identified.

Keywords: *Food waste, Sewage sludge, Co-digestion.*

Rapid Estimation of Higher Heating Value (HHV) and Biochemical Methane Potential (BMP) by using Organic Wastes Characteristics: Application in Tropical Environment

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The increase in the production of organic residues in all countries, especially in the Indian Ocean area, has been noted to date. However, these organic residues (OR) can be recoverable as a new source of biomass for energy production. However, their reasoned use as new resources requires a thorough scientific knowledge of their nature and their impact on the environment.

The aim of our work was to estimate the Higher Heating Value (HHV) and the Biochemical Methane Potential (BMP) of the OR by using their chemical characteristics. Fourteen (14) OR were collected in Réunion Island. On the right hand, measurements of dry matter (DM) and organic matter (OM) contents were carried out by using standardized protocols and on the other hand HHV and BMP were determined by using respectively a bomb calorimeter and an automatic methane potential test system. Firstly, empirical models using DM and OM as predictors from literature were tested to predict HHV and BMP. Secondly, new empirical models for HHV and BMP as a function of their measured constituents' contents (dry matter and organic matter) were developed through multiple linear regressions. The determination coefficient R^2 and the Standard Error Prediction (SEP) were used to compare the different equations.

The new correlations using regression method give accurate results that are closer to measured HHV and BMP. For HHV, the model is HHV = 0,027 DM^2 + 8,794 (R^2= 0.96, SEP= 0.271 $MJ.kg^{-1}$). For BMP, the model is BMP = 0.14792OM + 0.093DM (R^2= 0.93, SEP= 0.016 $l.100g^{-1}dm$).

Keywords: *Waste-to-energy, Prediction, Regression, Dry matter, Organic matter*.

Comparison of Goethite and Activated Carbon on Methanogenesis from Volatile Fatty Acids

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Anaerobic digestion (AD) has become one of the most preferred technologies for recycling energy from biowaste. Nevertheless, AD process is vulnerable to the high organic loading rate and the high concentration of volatile fatty acids (VFAs) tend to accumulate. There are considerable researches aiming to strengthen the anaerobic degradation rate of organics (e.g. acetate, ethanol) by adding conductive iron oxides or carbon materials, such as activated carbon (AC) and biochar etc., in which the strengthened direct interspecies electron transfer (DIET) was suggested to be the main reason. To our best knowledge, there is no previous study comparing the role and function of carbon-based conductive particles and iron oxides in methanogenic process. In present study, the effects of three conductive materials, including AC, iron modified activated carbon (Fe/AC) and goethite (FEOOH), on methanogenesis from VFAs were evaluated. The supplementation of three tested conductive materials could all promote the methane generation significantly as compared to the control reactor without conductive materials addition, especially when high organic acid load was applied. With the initial VFAs concentration of 4 g/L, the maximum methane yield of 266 mL/g-COD was found in the FEOOH reactor, which was 1.6 times higher than that of the control. The differentiation of methane yields could be attributable to the difference of microbial community. AC promoted the growth of the members of *Methanosaeta*, Aminicenantes, and *Smithella*, whereas goethite facilitated the iron-respiring bacteria and syntrophic VFA-oxidizing bacteria *Syntrophomonas* and other unclassified members of *Syntrophomonadaceae*, which perform DIET with *Methanosarcina*. Furthermore, the relationship between microbial community and electron accepting capacity (EAC) and electron donor capacity (EDC) of supplemented conductive materials were evaluated by using representational difference analysis. Results indicated that the higher EDC of goethite compared to AC might be a triggering factor on the selective enrichment of *Methanosarcina* and other electroactive bacteria that are involved in DIET, leading to the improved methanogenic performance under acid stress.

Keywords: *Activated carbon, Conductive particles, DIET, Electron donor capacity, Goethite, Methanogenesis.*

Use of Biogenic Residues for the Production of Biomethane

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In the Pilot-SBG project, previously unused biogenic residual materials, by-products and wastes are to be converted as complementary raw material mixtures to biomethane. The Deutsches Biomasseforschungszentrum gemeinnützige GmbH (DBFZ) is planning the construction and operation of a pilot plant on a technical scale. Concerning the raw materials there are two scenarios planned: In the agricultural scenario, approx. 3 tonnes per year of cattle slurry with fodder residues and straw are utilised; in the urban scenario, approx. 9 tonnes per year of sewage sludge, green cuttings and organic waste are used as raw materials.

The plant concept basically combines anaerobic fermentation with innovative preparation and post-treatment processes such as hydrothermal carbonization (HTC) processes and synthesis-based production of biomethane using the carbon dioxide from the biogas process and additional hydrogen. Further process steps include the treatment of process water and the separation of valuable by-products as well as the implementation of a demand side management system. The project will be complemented by a potential analysis of the raw materials and preliminary tests in the laboratory to optimise the mixture and process parameters for the pre-treatment and fermentation of the raw materials, as well as technical, economic and ecological assessments. Furthermore, a feasibility study will be conducted to address site issues and stakeholder interests for the construction of a demonstration plant.

Biomethane is the main product of the pilot plant (annual production of approx. 200 standard cubic meters in the agricultural scenario and approx. 600 standard cubic meters in the urban scenario) and is to be used as a renewable fuel in the transport sector. Other products from the plant are solid and liquid nutrient fertilisers such as phosphorus fertiliser as well as HTC coal, which can be obtained from fermentation residues, for example.

In the presentation, the overall project with its two scenarios, the German raw material potentials for the wastes, residues and by-products which are to be converted in the plant as well as the balancing of the processes are described.

Keywords: *Biomethane, Pilot plant, Biogenic Residues.*

Efficient Catalytic Production of Levulinic Acid from Starch-Rich Food Waste using a Biphasic System

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Waste biomass such as food wastes is attracting considerable attention as feedstock for biorefinery applications. Catalytic production of sugars and platform chemicals could be an effective technic for recycling a considerable amount of food waste generated across the world. This study investigates the catalytic production of levulinic acid (LA) from bread waste, a common stream of starch-rich food waste generated worldwide. Gamma-valerolactone (GVL) was used as a green co-solvent in binary (GVL/H_2O) monophasic and biphasic systems to investigate LA production; besides H_2O only system served as a baseline. Though hydrolysis of bread waste was efficient in GVL/H_2O (1:1) monophasic solvent (~65 Cmol% in 1 min at 130°C), the maximum LA yield obtained was only ~11-16 Cmol% (150°C, 15-20 min). LA yield and selectivity could be improved by a biphasic solvent system that may facilitate LA production by extracting the target product (LA) in the organic phase. As GVL is completely miscible in H_2O, sodium chloride (NaCl) (30 $wt\%_{(aq)}$) was used as a phase modifier to prepare the biphasic reaction medium. Results revealed that LA yield increased up to ~2.5 times in biphasic system (~28 Cmol%, 150°C, GVL/H_2O (1:1)) compared to the monophasic system (~11 Cmol%) following same reaction conditions. The partition coefficient for LA (LA-organic/LA aqueous) achieved was 4.2 in the GVL/H_2O (1:1) (NaCl) (30 $wt\%_{(aq)}$) biphasic medium indicating LA was effectively extracted in the organic phase. The biphasic solvent system facilitates selective LA production and could be optimised tuning reaction conditions.

Keywords: *Biorefinery, Catalytic valorisation, Platform chemical, Food waste, Biphasic.*

Decentralized Treatment of Biodegradable Municipal Solid Wastes

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India is the fastest developing country in the Asian continent. But development pushes many environmental issues such as water pollution, solid waste problem, air and noise pollution, as well as soil contamination. Management of such problems is very essential function in a country to achieve sustainable development. Solid waste management in India is considered as one of the least prioritized functions during the last decades. Although many governmental programs and schemes came into existence during these period such as Nirmal Bharat Abhiyaan and Swacch Bharat Mission in 2014 but were least success. Amongst different types of solid wastes, India is facing difficulties in managing the organic wastes. The most common ways to manage such wastes in India is either by open dumping and uncontrolled burning. These methods are causing severe environmental pollution and health problems. The current study proposes decentralized treatment of such organic wastes by using the two technologies, i.e., composting and anaerobic digestion. The end product from these technologies are compost and methane gas which are beneficial in many ways in the different sectors such as agriculture and energy generation that helps to maintains the sutainability. The composters and digestors of the different capacities were installed at IITG campus and various parameters studied to identify its efficiency. The results indicated the final compost with nearly 3% nitrogen with sufficient phosphorus and potassium levels beneficial for soil health. The study on anaerobic digestion indicated its capability to produce 60-65% methane gas. The study also recommends that decentralized treatement of such wastes at residential complexes or at commercial places will increase its value and the productivity.

Keywords: *Solid waste, Sustainability, Swacch Bharat mission, composting, anaerobic digestion.*

What Else Do We Need Know about Pretreatment?

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Pretreatments, including mechanical, thermal, chemical and biological treatments, are commonly used before anaerobic digestion (AD). These approaches achieve different levels of success by accelerating the hydrolysis efficiency (the rate-limiting step in AD) and enhancing subsequent biogas productivity. While in the enjoyment of the benefits from the pretreatment, new problems that induced during the pretreatment cannot be overlooked. It should be noted that most of pretreatment not only releases easily biodegradable substances but also releases or generates more recalcitrant, such as humic substances and complex aromatic compounds. More dissolved organic matters, e.g. refractory or inhibitory by-products, are surprisingly present in the centrate from the anaerobic digestor with pretreatment. These residual recalcitrant compounds could be problematic during the mainstream treatment or the side-stream centrate treatment, creating membrane fouling and anammox process inhibition. Thus, attention should be given to reduce and/or remove these recalcitrant compounds during the pretreatment or posttreatment. First, relative mild pretreatment methods (such as biological enzymatic pretreatment and combined physicochemical pretreatment) are recommended to reduce the formation of these refractory substances. Secondly, optimization of anaerobic digestion operating conditions e.g. retention time, pH, temperature, could minimize the refractory compounds. In addition, onside addition of conductive materials can facilitate recalcitrant compounds removal and enhance biogas production, which can be an alternative to the conventional pretreatment. At last, advanced oxidation process (AOP) as post-treatment would help to further degrade or oxidize the refractory substances remained in AD effluent. This talk will highlight the problems and challenges that are introduced by various pretreatment methods and propose potential solutions for mitigation.

Keywords: *Anaerobic digestion, Pretreatment, Drawbacks, Advanced oxidation process.*

Biogas Monitoring Programme III: Energy Efficiency Assessment of 61 Biogas Plants in Germany – Outcomes and Methodological Challenges

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Anaerobic digestion (AD) poses a sustainable source of electrical energy and heat. An important measure to reach the Paris climate goals is not only the reduction of primary energy consumption, but also improving the efficiencies of existing energy producers and consumers. The development of AD plants in Germany was fostered by the "Renewable Energy Sources Act", resulting in more than 8,700 installed plants in 2016 with a cumulated electrical capacity of about 4.5 GW (Daniel-Gromke et al., 2018). Amendments to the act implemented in 2014 led to stagnation in plant construction and steered operators and planners towards improving efficiencies. One of the aims of the developments conducted towards efficiency assessment methods is to identify sources of losses and emissions. The latter shall be identified if coming from poor CHP efficiencies, flare losses or overly fed digestion systems. Furthermore, the presentation gives an overview of the current state of the German biogas plant inventory in terms of plant sizes and layouts, as well as concepts of energy utilisation and feeding regimes.

Reliable data acquisition is vital for precise mass and energy balances of any energy production facility. Experience has shown that measurements on agricultural biogas plants are ever so often more practice-oriented, e.g. measuring substrate inputs in excavator shovels as a unit. Other important numbers are difficult to determine - like the energy conversion efficiency of CHP engines, which usually degrade over time depending on the working principle and the manufacturer. Those inaccuracies leave blank or fuzzy spots in available balancing methods.

The economic assessment reveals a broad range in terms of profitability of current biogas plants. Still being dependent on feed-in tariffs, premiums turn out to be an effective way of influencing the role of biogas plants in the energy system, e.g. by providing net stabilisation through flexible power provision or by stabilising manure.

The project consortium was able to substantiate tabled data from e.g. energy providers by acquiring real world data from numerous technically diverse biogas plants. The most important results thereof will be presented.

Also, the available methods for balancing biogas plants raise hope for shedding light on the currently dark spots in data recording in agricultural surroundings. Furthermore, approaching the biogas plant balance-wise allows for distinguishing between deficiencies in either the biological substrate degradation or the subsequent biogas conversion step.

Keywords: *Biogas monitoring programme, Energy efficiency assessment, Outcome, Challenges.*

Feasibility of Autogenetic Pressure Mediated Two-Phase Anaerobic Digestion System to Improving Methane and its Underlying Mechanisms on Hydrolysis

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Internal H_2 from acidogenic phase instead of external H_2 can be diverted into methanogenic phase to improve methane production. However, when acidogenic gas diverted into two-phase anaerobic digestion (AD) system, low concentration of H_2 has limited its application on methane synthesis. Although applying pressure was proposed to reduce CO_2 and increase H_2 content in acidogenic gas, the impact of pressure on two-phase AD system is not fully understand. Herein, we evaluated the feasibility of autogenetic pressure in this two-phase AD system for increasing methane at first. As compared, the greatly increases in soluble organics and H_2 concentration were obtained in the pressure mediated two-phase AD system, eventually, resulting in that the methane yield was significantly increased by 23%. Moreover, the underlying hydrolytic mechanism induced by headspace pressure in acidogenic phase was investigated applying N_2 pressure. The results of fitting hydrolytic model suggested that the enzymatic hydrolysis was significantly enhance by pressure condition. Correspondingly, the increase in enzyme activities were observed under pressure condition. The proposed mechanism revealed that the effect of headspace pressure on hydrolysis was likely attributed to the enlarged contact of enzyme-substrate. We also evaluated the economic benefit to augment this integrated two-phase AD scheme under pressure control. Our findings demonstrated the benefits of pressure amendment using in-situ gas on strengthening hydrolysis and improving organics conversion, supporting the potential development of pressure mediated AD technologies.

Keywords: *Food waste, Hydrolysis, Pressure, Hydrogen, Methane.*

Manure Management for Methane Mitigation – *in-vitro* Determination of Methane Emission from Manure for Improved Inventory Modelling

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Manure management is associated with the emission of greenhouse gases, with particular regard to methane (CH_4). Even though mitigation options (e.g., biogas treatment) exists, documentation and verification of manure treatment technologies for greenhouse gas (GHG) mitigation is a main barrier towards implementation.

The currently ongoing project *Manure management for methane mitigation - Improved inventory modelling to support policy actions (M4Models)* set out to validate a recently proposed methodology for experimental determination of CH_4 emissions from manure. By integration with country-specific farm models, it could provide estimates of GHG mitigation at farm level, as well as improve estimates of CH_4 emissions and GHG mitigation potentials for national inventories.

The proposed methodology will be briefly presented together with a current status update and presentation will draw attention to the introduction of a market-ready analytical tool using the existing Gas Endeavour® technology platform of BPC Instruments AB (Sweden) to estimate daily CH_4 emissions from manure during storage and the effect of technologies for CH_4 mitigation. This apparatus with automated and high-precision gas monitoring simulates conditions in bulk slurry and allows continuous separation and quantification of CH_4 and CO_2 evolution rates with full kinetic information during the *in-vitro* test in real-time.

Keywords: *Manure Management, Methane Mitigation, Methane Emission, Improved inventory modelling.*

Decentralized Waste Management and Green Economy: A Case Study of Pre-Processed Waste Input to, 25kg/day Kitchen Waste Biogas Plant Established at Pramati Hill view Academy School, Mysuru, India

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The 25 kg/day kitchen waste biogas plant at Pramati Hillview Academy, Mysuru, India, implemented by NIE-CREST (Centre for Renewable Energy and Sustainable Technologies), The National Institute of Engineering (NIE), Mysore has solved the issue of organic waste disposal of the school to an extent of 100% and created a value chain for waste to wealth. The biogas plant, at present, is partially fulfilling thermal energy demand and has achieved zero organic waste and reduced the carbon footprints. Analysis of data indicates that the plant in a year saves 438 kg of LPG used for cooking, reduces 1.32 tons of CO_2 emission and converts 7.9 tons of organic waste to energy and manure, thus achieving decentralized waste management and green economy.

Keywords: *Waste management, Green economy, Kitchen waste, Biogas plant.*

Effect of Wheat Straw Pellet Biochar Addition on Food Waste/Sludge Anaerobic Co-digestion

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Anaerobic digestion (AD) is a widely used sustainable technology in organic waste treatment, allowing the recovery of renewable energy as biogas. Anaerobic co-digestion of food waste with sewage sludge is regarded as a suitable method to treat food waste while also making use of the excess capacity of existing sludge digesters at wastewater treatment plants. Co-digestion overcomes the drawbacks of mono-digestion by balancing the carbon/nitrogen ratios and diluting toxic compounds. However, stable methane production at particularly at high organic loading in co-digestion remains a challenge mainly due to incomplete VFA conversions to methane and consequent VFA inhibition in the system. Thus, as a mitigation measure to the above problems, this study investigated the impact of biochar addition in co-digestion to alleviate VFA inhibition and increase methane production via improved direct cell-to-cell electron transport between microbial groups. Food waste (FW) and sludge co-digestion at 7:1 (w/w, total solids content 6%) was performed in Automatic Methane Potential Test System-II (AMPTS-II) at mesophilic temperature. Eight different types of biochar with varying physical and chemical properties produced at different temperature. Biochar included Soft wood biochar 700℃ (SWP700℃), Soft wood biochar 550℃ (SWP550℃), Oil seed rape biochar 700℃ (OSR700℃), Wheat straw biochar 550℃ (WSP550℃), Bamboo biochar 600℃ (BB600℃), Rice husk biochar 550℃ (RH550℃), *Miscanthus* straw pellets 700℃ (MSP700℃) and Sewage sludge biochar 550℃ (SS550℃), and a control with no biochar addition. The biochar resulting in the highest VFA degradation and methane production was selected to optimize the biochar dosage at 2, 5, 10 and 20 g/L and were established.

Results showed that WSP 550°C supported the highest methane production of 313.9 L/kgVS and VS removal efficiency of 50.4 % among all treatments. Degradation of VFA particularly long-chain fatty acids such as valeric acid, isovaleric acid, isobutyrate, and caproic acid was observed with biochar addition. This also corresponded to an increase in methanogenic favorable substrates including acetic acid (>40%) and butyric acid (~20%) concentrations over the control, especially during 6-9 days of co-digestion. Consequently, increase in overall methane production was obtained with WSP550℃ addition as compared to control with no biochar addition. Further optimization of biochar dosage showed that 10 g/L biochar dosage supported ~28% increase in overall methane production was obtained with as compared to control. The optimized biochar dosage in food waste/sludge co-digestion for feature a unique scenario of optimal VFA observation by biochar while maintaining appropriate VFA bioavailability in methane production which could be a useful strategy to further increase the OLR in anaerobic co-digestion.

Keywords: *Anaerobic co-digestion, Biochar, Volatile fatty acid, Food waste, Methane*.

Effects of Different Conductive Materials on the Anaerobic Co-Digestion of Sewage Sludge and Food Waste and Their Digestate Dewaterability

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The addition of conductive materials (i.e. iron-based materials and carbon-based materials) has a positive effect on the anaerobic co-digestion (CAD) process of sewage sludge (SS) and food waste (FW). However, it still remains unknown which conductive materials could ahived a better improvement of CH_4 generation. In addition to the methane production, the digestate dewatering is needed to be considered, which can lower the operational costs of transportation and disposal. However, the digestate dewaterability of different conductive materials is poorly understood. This study therefore investigated and compared the methane production of adding zero-valent iron (Fe^0), magnetite (Fe_3O_4) and biochar (10 g/L) in the CAD process of SS and FW as well as the digestate dewaterability after the CAD process. The results showed that compared to the Fe_3O_4 and biochar groups, the Fe^0 group was more conducive to the decomposition of organic matters, cumulative methane yield, and daily biomethane yield in the CAD process of SS and FW. The highest cumulative methane yield in the CAD process reached 394.0 mL/g volatile solid (17 days) in the Fe^0 group. The digestate dewatering experiments revealed that the total solids content of sludge cake after the addition of Fe^0 and biochar significantly decreased as compared to the Fe_3O_4, indicating higher digestate dewaterability. Overall, Fe^0 could be considered as a better choice in the CAD process of SS and FW taking account of the much higher methane yield and digestate dewaterability.

Keywords: *Anaerobic co-digestion, Zero-valent iron, Magnetite, Biochar, Methane.*

Effect of Biochar Added on Anaerobic Digestion of Methane from Municipal Sludge and Kitchen Waste

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Urban sludge is rich in organic matter and nutrients. Anaerobic digestion of sludge to recover energy has become a global hotspot. Food waste has high organic matter and nitrogen content, and anaerobic digestion alone is easy to acidify and inhibit ammonia. Therefore, the mixed anaerobic digestion of urban sludge and kitchen waste is the future development trend. In the process of mixed anaerobic digestion of municipal sludge and kitchen waste, gas production efficiency is low and energy consumption is high, and urgently needs to develop and improve anaerobic fermentation enhancement technology. Biochar is a kind of material rich in pore structure and large specific surface area, which can provide suitable environment for microbial reproduction and habitat and enhance electron transfer in anaerobic digestion system, thus improving anaerobic digestion efficiency. In this paper, coco-shell biochar (with a specific surface area of 1050 m2·g-1) was added to the mixed anaerobic digestion system of kitchen waste and urban sludge to study the coupling relationship between interspecific hydrogen transfer (IHT) and interspecific electron transfer (DIET) in the mixed anaerobic digestion system and the methane production effect of biochar with different mass concentration gradients (blank group, 1 g·L-1, 3 g·L-1 and 5 g·L-1). The results showed that the methane production in the system with biochar increased compared with the blank group. Among them, the cumulative methane production of the experimental group with the addition of 1 g·L-1 increased most significantly compared with that of the blank group, with a 12.14% increase in methane production. The addition of biochar can better adjust the pH of the system. The pH change of the 1 g·L-1 experimental group has the smallest floating change during the entire anaerobic digestion cycle. The removal rates of SCOD, TS and VS in all the experimental groups with biochar were improved to varying degrees compared with those in the control group, with the greatest improvement in the 1 g·l-1 group, and the degradation rates of SCOD, TS and VS were increased by 48.95%, 23.26% and 10.20% compared with those in the control group. The bacterial flora in the anaerobic digestion system supplemented with biochar is mainly Thermotogae, Firmicutes and Bacteroidetes. All three types of flora play a very important role in the hydrolysis and acidification stage. The main methanogenic flora of the blank group is Methanosarcina. Methanobacterium and Methanolinea were the main methanogenic agents in the experimental system with biochar. These two types of flora are hydrogen-trophic methanogenic archaea, which dominate the entire anaerobic digestion cycle of the biochar experimental group system. During the entire anaerobic digestion cycle, the addition of biochar relieved the acidification of the mixed anaerobic digestion system，reduced the start-up time of the mixed anaerobic digestive system and enhanced methane production, promoted DIET among methanogens, geobacillus, and other methanogenic flora, and enhanced IHT.

Keywords: *Food Waste, Municipal Sludge, Anaerobic digestion, GAC, Biogas production, Microbial community, Electron transfer.*

Anaerobic Co-digestion of Coffee Pulp and Cattle Manure for Enhanced Biofuel and Organic Fertilizer Production

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Coffee is the second-largest agricultural commodity produced in the world, estimating annual production of 9.2 million tons (cherry basis). Through a wet coffee processing method, coffee pulp (CP) represents approximately 42% of the total waste produced. Disposal of CP requires a sustainably efficient method because of the toxic compounds like caffeine, free phenols, and tannins. Anaerobic digestion has been widely used for recovering resources, especially biofuel (biomethane) and organic fertilizer, from various organic waste streams such as animal manure, sewage sludge, crop residues, food wastes etc. However, mono-digestion of CP decreases digester efficiency due to its low pH, high lignin content, and accumulation of volatile fatty acids. Hence, co-digestion of carbon-rich CP waste with nitrogen-rich cattle manure (CM) could be a novel strategy to enhance biomethane generation through nutrient balance and dilution of inhibitory substances, and aid in nutrient recycling via sustainable utilization of digestate as an organic fertilizer.

Biomethane potential tests were carried out to assess the maximal biomethane production at five different co-substrate mixing ratios (0:1, 4:1, 2:1, 4:3, 1:0, on VS basis) in two different inocula, anaerobically digested cattle manure (ADCM) and anaerobically digested waste activated sludge (ADWAS). A series of 250-mL serum bottles, with substrate to inoculum ratio of 1.0, were operated at mesophilic condition for 50 days. Based on the results from ANOVA test followed by Tukey's honestly significant difference (HSD) for multiple comparison test ($p \leq 0.05$), CP:CM of 1:0 resulted in the highest specific methane yield (SMY), 266 ± 6.22 NmL/g VS_{added}, in ADWAS inoculum among all the combinations. Since the studies on long-term operation of co-digestion of CP with CM are limited, a scale-up study comparing mono-digestion and co-digestion of CP:CM at 4:1 is currently being conducted using bench-top semi-continuous digesters. This semi-continuous study will examine the stability and performance at different organic loading rates for both mono-digestion and co-digestion systems. The findings of this study will enhance the resource recovery from the CP and CM waste, in the form of biofuel and organic fertilizer.

Keywords: *Co-digestion, Coffee pulp, Cattle manure, Biomethane potential test.*

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Bio-nano Technology for Biowaste Recycling

Bioelectrochemical Systems for Wastewater Treatment and Resource Recovery: from Lab to Field Applications

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Microbial electrochemical technologies (METs) has made rapid progress in recent years. METs for wastewater treatment, the microbial fuel cells (MFCs) are currently being up scaled for pilot studies. Already a few demonstrations of microbial electrolysis cells (MECs) are operating globally. Electricity driven bioproduction in the form of microbial electrosynthesis (MES) is gaining ground especially for conversion of carbon dioxide into fuels and chemicals. The key advantage foreseen here is the use of excess electricity that is often generated renewably such as from solar cells and wind mills, all of which cannot be utilized immediately and can be fed into a MES to produce chemical compounds. Results with specific bacteria towards bioelectrochemical conversion of CO_2 to organic compounds will be reported. The dissolution of CO_2 and mass-transfer of reducing equivalents/hydrogen are among the limiting factors for this technology. Improvement on the dissolution and mass transfer rate of CO_2 was explored using gas diffusion electrodes (GDEs). VITO has developed GDEs tailored for systems with aqueous electrolytes and a gas-water interface, which are characterized by controllable pore diameters in the polymer-bound active layer, mechanical robustness and low water permeability. These cold-rolled (VITOCORE®) and phase-inversion based (VITO CASE®) electrodes enable reproducible quality in sizes from 10 cm^2 to 1 m^2. Large-scale VITOCORE® air cathodes were recently developed and tested in 85 L and 255 L MFCs to evaluate the impact of the cathode size on MFC performance. In this presentation, a global overview of the most recent developments in METs for resource recovery will be presented with examples from all parts of the world including India on piloting these systems.

Keywords: *Bioelectrochemical systems, Wastewater treatment, Resource recovery: Lab to field applications.*

Microbial-Electrochemical Reactors for The Treatment of Alkaline and Saline Waste Streams

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Microbial-electrochemical reactors or bioelectrochemical systems (BES) are a promising environmental biotechnology. A key advantage of BES is its effective use of electrodes to stimulate and control microbial degradation of organics from a waste stream. Together with features such as the use of ion selective membranes, the technology can be versatile for various environmental and industrial applications including wastewater treatment, resource recovery (nutrients, energy as fuel gases, metals/ compounds of economic value) from waste streams, and remediation of contaminated environments. BES is also being increasingly explored as an auxiliary technology for augmenting conventional waste treatment processes such as anaerobic digestion. Nevertheless, practical application of BES is often hindered by two inherent properties of the waste stream: (1) low ionic strength causing high internal ohmic resistance; and (2) low pH buffering capacity causing drastic acidification hampering anodophilic activity of microbes. Although these constraints can be easily rectified by dosing chemicals, such an approach is impractical, increases operating costs and may cause secondary pollution. Therefore, it seems rational to develop the BES technology for treating waste streams that are intrinsically saline and alkaline. Here, we explored the use of BES for the treatment of a highly saline and alkaline industrial waste stream associated with alumina refineries. Aluminium is typically extracted from bauxite ores in Bayer processes, where the ores are reacted with caustic liquor (Bayer liquor) under elevated temperature. Since the refining process is suppressed by organics, particularly sodium oxalate ($Na_2C_2O_4$) accumulated in the liquor, effective removal of these organics is crucial. Considering that the refinery liquor typically has a pH of >12 with a high concentration of sodium (~25 g NaCl L^{-1}), we explored the use of a synthetic alumina refinery liquor as a BES feedstock to facilitate the destruction of organics and recovery of caustic soda for reuse. The concept was first tested by starting up a cation exchange membrane-equipped dual chamber BES using activated sludge as the microbial inoculum. The results suggested that a successful start-up of an alkali-halotorant anodic biofilm was achieved with acetate and formate as organic electron donors. However, oxalate was only poorly degraded by the anodic microbial community even after a prolonged period (>300 days) of operation, plausibly due to a lack of an oxalate-degrading microbial group as revealed by the microbial community analysis. To overcome this problem, a new start-up strategy was devised using graphite granules with an active aerobic oxalate-degrading biofilm as the BES anode. Results showed that the aerobic biofilm readily (< 3 days) became anodophilic facilitating a current density of 363 A m^{-3} at a hydraulic retention time of 3 hours (~20 kg oxalate removed m^{-3} d^{-1}). The biofilm also concurrently degraded acetate and oxalate (coulombic efficiency 80%) without apparent preference towards acetate. Further, caustic soda was generated at the cathode with an (electrical) energy requirement lower than figures reported in other studies. Overall, this study suggests that BES is suitable for simultaneously removing organics and recovering caustic soda from alumina refinery liquor. A similar approach can be applied for treating other alkaline and saline waste streams.

Keywords: *Bioelectrochemical systems, Waste treatment, Resource recovery, Alkali-halotorant microbe.*

Structured Carbon Monolith for Gas Adsorption: using Nano-biochar as Precursor

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High efficiency and low-cost adsorption-based gas separation processes have attracted intensive attentions in both industry and research areas. Recently, researchers showed great interest in structured adsorbents due to their significant potential for the improvement of performance and reduction in the cost of cyclic adsorption processes such as pressure swing adsorption. In particularly, by controlling the structure of the adsorbents applied in the separation devices, the parameters dictated by adsorbent loading per unit volume, mass transfer properties, pressure drop, and the thermal management could be optimized, as a result reduce the system cost. In addition, the robust structured adsorbent can significantly reduce the mass loss and minimize the environmental impact. Therefore, developing a structured adsorbent with high mechanical strength and good adsorption properties is highly desired, and have received growing research interest in recent years.

Structured carbon monoliths prepared from carbon-based materials including coal, pitch, CNT, carbon sphere and biomass have been reported with high strength and promising adsorption characteristics display great potential as structured adsorbents for gas storage and separation applications. On the other hand, nano-biochar with its advantages including improved porosity, specific surface area, mobility and other properties as biochar has received much attention recently. Using nanobiochar as precursor for structured carbon monolith will not only take advantages of its excellent performances but also alleviate the controversy about its potential impact on the natural environment.

Keywords: *Carbon monolith, Nano-biochar, Gas adsorption.*

Enhancement of Fuel Properties of Yard Waste through Torrefaction

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Biomass is seen as a viable source for green, sustainable energy to help meet energy demands in the near future. However, the properties of raw biomass, such as high moisture content, pose challenges for energy extraction processes. To overcome these challenges, the biomass must be pre-treated using processes like torrefaction. Therefore, torrefaction was carried out to investigate the effects of carrier gas and temperature on the properties of yard waste. The yard waste consisted of a 30:70 wt% mixture of fallen twigs and leaves, collected from the University of Nottingham Malaysia. Temperature was varied from 170-300oC, and three carrier gases were used, namely pure nitrogen, pure carbon dioxide and a mixture consisting of a 25:75 vol% mixture of CO2:N2 representing flue gas. As temperature was increased, the mass yield of the torrefied yard waste decreased while the HHV increased. The mass yields obtained were in the order of nitrogen<carbon dioxide<flue gas. HHV was in the order of flue gas<nitrogen<carbon dioxide. Energy yield was also calculated to determine losses incurred in the process. Overall, carbon dioxide was shown to be the best carrier gas for energy intensification.

Keywords: *Carbon dioxide torrefaction, Dry torrefaction, Energy yield, Flue gas torrefaction, Yard waste.*

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Bio-nano Technology and Application in Waste Recycling

CO_2 Capture and Microbial Catalytic Conversion to Bioenergy CH_4 in Oil Reservoir Systems

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Carbon dioxide is a major greenhouse gas contributing to the climate change and its storage in the subsurface petroleum oil reservoir systems is one option for long-term management of this gas from industries for a sustainable development. In the oil reservoir system, due to the indigenous microbiota, the fate of CO_2 in such ecosystems is not known and studies were carried out to investigate the indigenous microbiome in subsurface ecosystem, their metabolic capabilities in transforming both the hydrocarbons and also introduced CO_2 to advance the current knowledge on CO_2 capture in oil reservoirs for permanent storage using Illumina sequencing of genomic DNA and transcribed RNA, detection and identification of transformation metabolites, the genes responsible, and also thermodynamics calculation to find out the best conditions for CO2 conversion to bioenergy as a future technology in energy management. Production water of oil fields in China were used in laboratory-based incubation study for determination of the CO_2 and also the responses of microbial community. In addition, another promising strategy to stimulate and accelerate biological transformation of CO_2 into methane as energy was achieved in this study with ZVI as the alternative electron donor into oil reservoir production waters. Enrichment of *Methanothermobacter* spp. supported its competitive role in biomethanation process *via* CO_2-reducing methanogenesis and formate methanogenesis in ZVI-amended cultures. The detected $FeCO_3$ mineral also presents a potential for immobilization of CO_2 in the presence of ZVI under the anaerobic conditions. Biomethane production with high rates (> 61.67 μmol/(l·d)) amended with ZVI detected in this study provided a potential opportunity for value-added CO_2 management technologies and further bioenergy regeneration from CO_2 in EOR and CCS of oil reservoirs. Stable isotope C-13 labelled CO2 was used to trace the transformation and fate of introduced CO2 in the microcosm systems in this study. Results suggest that biotransformation of CO2 to CH4 and also organic fatty acids occur in production water of oil reservoir and the rate of transformation ca be further accelerated by addition of ZVI as an addition a source of electron donor.

Keywords: *Carbon dioxide, Direct microbial transformation, Utilization, Electron donors, Green biotechnology, Value-added products.*

Resource Efficient Sustainable Production of Nanocrystalline Cellulose through Sugarcane Bagasse and Rice Straw Valorization

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Agricultural sector generates huge amount of wastes such as bagasse and straw in processing and these underutilized wastes result in rapid increase in greenhouse gases, ultimately leads to climate change. The biochemical composition of the Agri-waste biomass (30-45% cellulose, 20-30% hemicellulose and 15-25% lignin) reflects its potential to cater as ideal substrate for production of value-added chemicals such as reducing sugars, furfurals, ethanol, xylitol, sorbitol, volatile fatty acids, biogas etc. Amongst these derivatives, Nanocrystalline cellulose (NCC) has received much attention in recent years and emerged as a sustainable and assuring nanomaterial, due to its inexhaustible nature and unique properties, namely high specific surface area, low density, thermal stability, high elastic modulus, optical transparency, simple surface functionalization, biodegradability, and biocompatibility. The present study evaluated with an optimized two-step process for the sustainable production NCC using sugarcane bagasse (SCB) and rice straw (RS). Pretreatment of SCB resulted in extraction of cellulose of 0.34g/g followed by NCC production of 0.25g/g SCB with 62.5% yield of NCC from raw SCB. In case of RS, 0.30g/g cellulose was extracted and 0.21g/g of NCC from raw RS, which accounted 60% yield. For both the feedstocks, conversion of cellulose to NCC was critically assessed with XPS, FE-SEM, SEM-EDX, FT-IR, TGA, DTA and DSC analyses. NCC holds various potential applications as engineering and functional material in paper, paints, biomedical devices, electronic sensors, packaging etc. The evaluation of effective method for NCC production using Agri-waste feedstocks accounts an additional benefit to the existing sugarcane industries and waste management methods in the framework of biorefinery and also evokes the biobased economy.

Keywords: *Resource recovery, Agro-industrial waste, Nanocellulose, Sustainability, Bioeconomy*

The Impact of Heavy Metals in the Wastewater Sludge on Lipid Accumulation of Oleaginous Microorganism

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A large amount of wastewater sludge is generated during domestic wastewater treatment. With the concept of sustainable development, the goal of sludge treatment and disposal has turned from reduction, stabilization, and harmlessness to resource utilization. The sludge contains a large amount of nutrients that can be used by microorganisms. Using sludge to produce microbial lipid is an effective way of resource utilization. However, sludge contains heavy metals which can cause negative impact on lipid accumulation. To investigate the impact of heavy metals in the sludge on lipid accumulation in oleaginous microorganism cultivated with wastewater sludge, metal irons including Ni^{2+}, Cu^{2+}, Zn^{2+}, Cd^{2+}, Cr^{3+}, Cr^{6+}, Pb^{2+}, which are commonly presenting in sludge, have been used to cultivate *Lipomyces starkeyi*. The results showed that 0.55 mg/L Cd^{2+} and 50 mg/L Zn^{2+} had obvious inhibitory effect on the strain. The effects of heavy metal ions on lipid accumulation were investigated separately. It was found that Cd^{2+} inhibited the accumulation of lipid. The lipid content was only 41% w/w when Cd^{2+} was presenting in the medium with a concentration of 0.55 mg/L, which is lower than the control (51% w/w). To eliminate the heavy metal impact on lipid accumulation of *L. starkeyi*, leaching was performed to remove metals from sludge and the residual sludge was used to cultivate the *L. starkeyi*. It was observed that the lipid accumulation was only 25% w/w after metals were removed from sludge, which was lower than that cultivated with the sludge without heavy metal removal (41% w/w). It was predicated that not only the toxic metals were removed from sludge as well as the metals which can enhance lipid accumulation. The study also found that after removing heavy metals from the sludge, the C18 in the biodiesel component significantly increased from 18.82% to 41.49%.

Keywords: *Wastewater sludge, Heavy Metals, Oleaginous Microorganism, Lipid.*

One-Pot Approach Conversion of Fructose to 2,5-Diformylfuran by Carbon-Based Metal-Free Catalysts

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Converting biomass into fuels and chemicals to release the energy and resource crisis has attracted lots of attention in recent years, which is also known as biorefinery. A tremendous amount of effort have been devoted to the development of methods for the transformation of carbohydrates to valuable chemicals. 2,5-diformylfuran (DFF), one of the most high-value products in biorefinery, can be used as a raw material for the synthesis of drugs, anti-decomposers, and biological materials. This work aims at the synthesis of DFF using carbohydrate as a raw material by dehydration to 5-Hydroxymethylfurfural (HMF) and in situ selective oxidation of HMF in a one-pot process, to avoid the energy consumption process of HMF separation and purification. The key factor of this process is the excellent catalytic activity and stability of the catalysts. In this study, carbon nanoplatelets were prepared by a facile method and functionalized to be the bifunctional catalysts for the tandem reaction from fructose to DFF. The outstanding catalytic performance of the catalysts was attributed to the rich oxygen-containing groups on the surface of the catalysts. Compared with active carbon, carbon nanotube based catalyst, higher DFF yield can be achieved in a one-pot and one-step conversion of fructose to DFF with oxygen as the only oxidant at atmospheric pressure. The developed catalyst successfully realized the metal-free production of DFF from carbohydrates, and showed no significant loss in reuse and stability test, indicating its great potential in industrial application.

Keywords: *Biorefinery, One-pot approach, 2,5-Diformylfuran, Carbon-based metal-free catalysts*

Design and Construction of Nanobiocatalysts Consisting of Immobilized Lipase on Nanostructured Clay Surfaces for Conversion of Organic waste to Biodiesel

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Lipase (EC 3.1.1.3) is one of the most important industrial enzymes that has been widely applied to produce biodiesel from organic waste, especially grease-containing waste by biocatalytic transesterification mechanism. Despite their excellent catalytic capabilities, the application of natural lipase is often hampered owing to their susceptibility to environmental factors such as high temperature, extreme pH, high salinity, and tolerance towards organic solvents. Enzyme immobilization is an efficient route for solve these problems, thereby permitting the catalysis under harsh reaction conditions at an industrial scale. The nanobiocatalyst is an emerging innovation that synergistically integrates advanced nanotechnology with biotechnology for improving enzyme activity, stability, capability and engineering performances. An important requirement for enzyme immobilization is that the support should provide a biocompatible, modifiable surface, chemical and mechanical stability and it should not interfere with the native structure of the protein, which could compromise its biological activity. Among a various support matrixs, nanostructured clay particles provide an excellent platform for enzyme immobilization, which can improve the efficiency of immobilized enzymes by reducing diffusional limitation as well as by increasing the surface area per mass unit.

In the present study, we aimed at taking advantage of the surface and interface characteristics of clays to develop superior nanobiocatalyst systems via covalently bound lipase on functionalized natural nanostructured clay mineral of montmorillonite(lipase-Mt) and synthetic aminoclay (lipase-AC). Aminopropyl silane (3-aminopropyltriethoxysilane, APTES) was covalently bonded to Mt surfaces by condensation reaction with the surface Si-OH groups. To prevent lipase leaching, the aminopropyl-functionalized Mt derivative or AC were stabilized by cross-linking them with 1-(3-Dimethylaminopropyl)-3-ethyl-carbodiimide hydrochloride (EDC). Immobilization parameters such as enzyme loading amount, EDC concentration, pH, and immobilization time were investigated in detail. The enzymatic activities of the free and immobilized lipase were compared using hydrolysis of p-nitrophenyl palmitate (p-NPP). The lipolytic activity, kinetic characteristics, thermal stability, and storage stability of the Mt-immobilized lipase were also investigated. Experimental results indicated that the specific activity of lipase-Mt and lipase-AC was nearly 5 and 3.4 folds higher than that of free lipase, respectively, due to the hydrophobically interfacial activation of support toward lipase. The maximum reaction rate (V_{max}) for lipase-Mt, lipase-AC and free lipase were 312.5 mM/L·min, 217.3 mM/L·min and 63.7 mM/L·min, respectively. In addition, the lipase-Mt and lipase-AC with hydrophobic property showed higher thermal stability and reusability than free lipase. The present study has provided a promising way for screening, optimizing and rational design of efficient nanomineral-based enzymatic nanobiocatalyst. The present work was financial supported by the National Natural Science Foundation of China (41672039) and Sichuan Science and Technology Program (2019JDJQ0056).

Keywords: *Nanobiocatalyst, Clay minerals, Enzyme immobilization, Lipase, Biodiesel.*

Biodiesel Production from Marine Algae Nannochloropsis Salina using Waste Egg Shell as a Nanocatalyst

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The needs for energy are increased worldwide; in contrast, the resources are getting depleted. Therefore, it leads to the search for bio-fuel as an alternative energy in order to suppress the fuel crisis. Biodiesel is typically made by chemically reacting lipids from a vegetable oil or animal fat with an alcohol producing fatty acid esters, such as methyl or ethyl ester. The present study aims to produce biodiesel from microalgae by the transesterification process using heterogenous catalyst. The initial part of this project was to separate biomass from the algal culture and extract the oil from biomass. Calcium Oxide (CaO) is a potential heterogeneous base catalyst with low cost, high conversion rate, availability and catalyst reusability. The characterization of catalyst was done by SEM analysis FT-IR and XRD analysis. Marine algae *Nannochloropsis salina* was used as feed stock. Algae fatty acid methyl esters (algae FAME) has been obtained from the following reaction optimized conditions; reaction temperature of 65°C, reaction period of 180 minutes and ratio of oil to methanol at 1:5 with CaO as a catalyst at 4% (wt/v).The confirmation of biodiesel was done by the Ferric chloride test and Hydroxamic acid. The characterization of biodiesel was carried out using GC-MS study.

Keywords: *Nannochloropsis salina, Transesterification, Biodiesel, SEM, FTIR, GC-MS analysis.*

Nanobubble Technology Application in Aquaponics

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Nanobubbles are an emerging gas delivery technology with potential opportunities in the agricultural field. 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 enhance microbial-mediated processes governed by oxygen, especially in aquaculture and aquaponic systems. The perpetual generation of reactive oxygen species could also offer new avenues in pathogen, biofilm, and algal control. With rising population growth and soaring food demand, aquaponics has gained interest in recent years as a sustainable food production system. Aquaponics recycles nutrient-rich aquaculture effluents for vegetables/fruit production. However, in these systems, nitrification is a critical pathway and is often impacted by low dissolved oxygen in the aqueous phase. Low dissolved oxygen levels are also responsible for denitrification, low fish and plant yields, root rot diseases, and the accumulation of toxic forms of nitrogen (e.g., ammonia and nitrite). 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 concomitant improvements to fish and plant yields, and overall water quality. The preliminary study presented examines the overall effects of nanobubbles on the growth of butterhead lettuce (*Lactuca sativa* spp.) and tilapia (*Oreochromis aureus* spp.) in floating raft aquaponics, as well as provides insight on several water quality parameters.

Keywords: *Nanobubbles, Dissolved oxygen, Reactive oxygen species, Agriculture, Aquaculture, Aquaponics.*

Innovative Fast Catalytic Microwave-Assisted Thermochemical Conversion of Bio-wastes for Energy and Fuels Production

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Tremendous amount of bio-wastes are generated from various sources each year, causing serious environmental issues, while they could be a valuable source for renewable, abundant, and cheap energy production if managed properly. This transition calls for novel and more efficient conversion technologies to replace the conventional disposal methods such as landfilling and incineration. One of the promising technologies developed in the author's lab is the fast catalytic microwave-assisted thermochemical conversion technology. With the incorporation of microwave absorbents into the microwave heating process, the heating rate, temperature, and energy efficiency can be significantly improved. Another advantage is its versatility, allowing efficient treatment of various types of solid wastes. Recently, this technology has been implemented on several types of solid wastes, including sewage sludge and waste plastics, among others.

Sewage sludge is a major solid waste generated from municipal wastewater treatment process, a large fraction of which is organic materials. Sewage sludge was pyrolyzed in a lab-scale continuous catalytic fast microwave-assisted pyrolysis (fMAP) system, and the optimal pyrolysis temperature was determined to be 500 C, where 87% of energy was recovered from the sewage sludge. Specifically, most of the energy was stored in the liquid (39%) and gas product (47%), which had a notable higher heating value of 20.61 MJ/kg and 22.5 MJ/Nm3, respectively. The high energy content of gas product could be attributed to the absence of carrier gas in the process, which would otherwise be diluted. In addition, the fMAP process gave a highly porous texture to the produced char, making it a potential source of activated carbon for pollutant removal.

Waste plastics, a major component in municipal solid waste, were also investigated as a feedstock for catalytic fast microwave-assisted pyrolysis. Polyolefin-based waste plastics were first pyrolyzed under a temperature of 500 °C with and without catalyst. The liquid yield obtained was merely 22% (wt.), and 53 % remained as solid residue mainly composed of wax material without catalyst. In contrast, the addition of HY zeolite as catalyst boosted the liquid yield to 47% while reducing the solid yield to 0-5%, indicating a remarkable promotion effect of HY zeolite on plastics pyrolysis. In addition, GC-MS analysis of the liquid product showed all the compounds in the liquid were hydrocarbons, and specifically 73% fell into the gasoline range (C6-C12) with 59% being alkenes.

Furthermore, *in-situ* and *ex-situ* catalysis mode were compared during fMAP of a plastic-paper mixture representing another common packaging wastes. While obtaining a liquid yield lower than that with *in-situ* catalysis (33% vs. 44%), *ex-situ* catalysis with HY zeolite generated a liquid product with more alkenes and light components (C6-C7) and less aromatics and heavy compounds, contributing to the lower viscosity of its liquid product. In addition, *ex-situ* catalysis produced more gases (59% vs. 43%) with higher content of high HHV components such as H2 and C1-C3 hydrocarbons, illustrating an enhanced cracking effect with *ex-situ* catalysis mode. In addition, the *ex-situ* porous SiC foam based structure catalyst seems to have unique advantage in minimizing pressure drop, improving catalytic activity, and prolonging catalyst life.

Keywords: *Microwave, Thermochemical conversion, Solid waste, Foam structure Catalyst, Energy and fuels.*

Functional and Dynamics of Genomic in Eco-Electrogenic Engineered System during Azo Dye Wastewater Treatment

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Synthetic dyes are major classes of compounds used in textile industry. The effluents released thereof are carcinogenic and mutagenic in nature and pose potential threat to all life forms. Novel and hybrid Eco-electrogenic engineered wetland system (EEWS) was designed with three specific conditions integrated in a sequence to treat azo dye-based textile wastewater. Tank-1 containing the free floating and emergent aquatic macrophytes create anaerobic/anoxic microenvironments and facilitates the reduction of the organic compounds and break down the dye molecules. Tank-2 consists of submerged floating aquatic macrophytes create the aerobic microenvironments which direct the oxidation of intermediate carbon compounds and nitro compounds to nitrification. Tank-3 with free floating macro and micro plants and filter feeders is intended to remove TSS, nitrates, phosphates and pathogens. All the three tanks were integrated with electrode assembly to enhances the dye decolorization as well as reduce retention time of the treatment process. The in-situ potentials helps simultaneously to enriches the electroactive bacteria as well as growth of the plants and dye decolorization. Hiseq illumina analysis shows the diverse microbial dynamics with high genus abundance were *Blastochloris, Desulfomonile, Rhodovulum, Oscillochloris*in tank 1 and *Pirellula, Caldilinea, Steroidobacter, Thaumarchaeota* in Tank 2. EEWS have the advantage of no chemical and energy inputs which leads to the reducing the carbon foot prints in dye wastewater treatment.

Keywords: *Hiseq illumina, Aquatic plants, Phytoremediation, Constructed wetland, Microenvironments.*

An Integrated Biotechnology for Gold Recycling from E-Waste using Thiourea with Bacillus and Lysinibacillus Sp. (Hybrid) Combination

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E-waste is the toxic legacy of this digital age with the fastest growth rate than any other type of waste (twice the rate of plastic waste). Nearly 43 million tons of e-waste was generated in 2016 and was 8% more then 2014. Due to the good conductivity and less atmospheric oxidation precious metals (PMs) like Au, Ag, Pd and Pt are in good demand in electronics, mostly for making joints/contracts of circuit boards. Gold recovery from waste can be very attractive because natural gold ores are difficult to mine due to its refractory nature and mining can produce toxic compounds such as cyanide. Some gold mining areas fall under geologically unstable regions.

Hybrid bioleaching method, comparatively a new technique entails the complimentary combination of both- chemical and biological leaching for efficient metal selective extraction from e-waste. It promotes using safer chemicals and metal-specific ligands with compatible microbes for better extraction of selective metals.

For bacterial isolation, soil samples were collected from an e-waste dumping and recycling site and study its tolerance and gold leaching performance in the presence of thiourea. Practically, microbial solution was charged with gold chloride (0.02g) and50 mM thiourea. Potentially compatible microbes were selected from the enrichment culture based on their survival using 16r RNA. Bacillus substilis and Lysinibacillus sp. Combination was found to be support in leaching. 90 days leaching pattern was investigated and it was found that hybrid combination increase nearly 48% leaching compare to individual thiourea.

Keywords: *E-waste, Gold, Hybrid, Bacillus, Lysinibacillus, Thiourea.*

Studies on Bioleaching and Recovery of Metals from Printed Circuit Boards using *Acidophile and Alkaliphile Bacteria*

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Nowadays, waste is not considered as a waste, but, more as valuables which have the potential to be reused or converted to other usable forms by recycling. In recent years, e-waste is considered as one of the fastest growing waste stream. It has been reported that the average yearly rate of e-waste generation in India is about 1.7 million tonnes (MT), whereas, their average recycling rate is only 23.5%, which is very low. Based on the extensive literature review on various aspects of E-waste, it is found that Printed Circuit Boards (PCBs) have the potential to recover various metals from a single source. Further, considering the conventional treatment technologies like pyrometallurgy and hydrometallurgy shows many disadvantages when compared with biohydrometallurgy. Bioleaching in spite of having several advantages is found to be at a nascent state in India and studies at international level, especially; using bacteria that can survive and grow in climatic conditions generally prevailing in India.

Bacteria such as: *Acidiphilium acidophilum* (A.acido) and *Thiobacillus novellus* (T.novellu) were selected for the study. A comprehensive study has been undertaken and several important parameters like: pH, ORP, cell count, PCBs dosages (5-25g), DO content, energy source, etc., were studied to understand their influence on the bioleaching process and recovery of metals. Cu, Zn, Pb, Ni and Al were chosen for the study. Four types of Cases (Case 1 to 4) considering the various probable combinations of adopted / unadopted bacteria and with / without energy source were considered. Acclimatization studies, bioleaching studies and scale-up of bioleaching studies were carried out for various cases and parameters.

Based on the detailed analysis of results and discussion, the following salient conclusions are highlighted here: (i) The variation of pH among the two groups of bacteria; namely, acidophile and alkaliphile bacteria is opposite to one among. (ii) A smooth trend in the variation of cell count in alkaliphile bacteria were observed, unlike in the case of acidophile bacteria, there is slight oscillation. (iii) It is observed that acidophilic bacteria have better metal leaching efficiency than the alkaliphile bacteria during the process. (iv)The morphology of PCBs before and after bioleaching were studied by SEM (v) Cu consistently exhibits the highest metal leaching efficiency (%), whereas, Pb the lowest leaching efficiency (%). Further Al exhibits ‘sensitivity’ to higher PCB dosage (which is alkaline in nature). Finally, the two possible mechanisms have been proposed for the leaching of all metal (considered) from PCBs by the bioleaching process.

It can be stated with confidence that the methodology and selected bacteria chosen for the study are not only suitable for the Indian conditions but also, in countries, similar type of ‘mesophilic conditions’ exist. The method is low cost and environmental friendly and hence better than its informal counterparts such as: pyrometallurgy and hydrometallurgy. Further, bioleaching has a potential for commercialization and industrial applications.

Keywords: *E-waste, PCBs, Bioleaching, Acidophilic bacteria, Alkaliphile bacteria*.

Biosynthesis, Isolation and Quantification of Phycobiliproteins by *Desertifilum sp.* SVMIICT2: Effect of Differential Light Intensities

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Phycobiliproteins are an important group of pigments in cyanobacteria. These pigmented proteins harvests light in cyanobacterial cells and exhibits great potential as biomarkers. In the present study, isolated filamentous cyanobacteria *Desertifilum sp.*SVMIICT2 was studied to evaluate the influence of different light intensities to favor of phycobiliproteins synthesis cultivated in Bolds Basal Media (BBM) for ten days. Phycobiliproteins such C-Phycocyanin (C-PC) and C-Phycoerthryin (C-PE) requires 630 nm and 570 nm respectively. Photosynthetic activity of cyanobacteria at 50 µE/ m^2/sec was measured in terms of Fv/Fm. It measures the photochemical process performance in the Photo system II (PSII). Initial Fv/Fm value of C-PC and C-PE was 0.45 fru (fluorescence relative units). Interestingly during the days progression Fv/Fm decreased in C-PC and increased C-PE. Decreased Fv/Fm favored higher C-PC; purified C-PC is evaluated according to the absorbance ratios at 620 nm and 280 nm. The study achieved C-PC ~ 4 A620/A280 ratios as it is suitable for an analytical grade. Maximum fluorescence (Fm), in C-PC Fm reached on 4^{th} day and in C-PE reached on 8^{th} day. C-Phycocyanin and C-Phycoerythrin have anti-oxidative function, anti-inflammatory activity, anti-cancer function, immune enhancement function, kidney and liver protection pharmacological effects.

Keywords: *C-Phycocyanin, C-Phycoerythrin, F_V/F_M, PS-II, Anticancer agents.*

Duckweed Biorefinery with Dairy Wastewater Treatment

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Duckweed, belongs to Lemnaceae, a potential aquatic plant which is being used as a next generation energy source. Duckweed for the treatment of dairy wastewater (DWW) was studied in an integration with selective fermentation. At the end of DWW treatment the substrate removal was observed to be 74% with simultaneous removal of nitrates (66%) and phosphates (80%) by the end of the cycle (8^{th} day). The increase in duckweed fronds have been noticed with time which increased from 40 g to 50.9 g (wet weight) and from 1.88 g to 3.73 g in terms of dry weight with a frond number (T_i) doubling time of 20% for 8days. The carbohydrates and proteins after treatment of DWW increased to 32% and 10% respectively. The part of duckweed was made into slurry for selective fermentation in which the biomolecules of the duckweed will be fermented on selective basis. The maximum of VFAs of 1120 mg/L, biogas of 275 NmL composition of H_2, CO_2 and CH_4 was obtained. Acid hydrolysed biomass resulted in the reducing sugars of 700 mg/g of biomass which can be used as a substrate for acidogenesis for the production of VFA and biohydrogen.

Keywords: *Selective fermentation, Acidogenesis, Biogas, Bioalcohols.*

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Sustainable Bioconversion of Waste to Resource

Bioconversion of Wastes-to-Resources: Opportunities and Challenges

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The global population is expected to reach nearly 9.7 billion by 2050 from current population of 7.7 billion. The rising population will significantly increase the demand for resources such as food, feed, chemicals, and fuels. with concomitant generation of large quantity of residues and wastes (water). As per the recent World Bank report, nearly 2,017 million metric tons of waste was generated in 2018 worldwide and is expected to increase to 2,586 million metric tons and 3,401 million metric tons in 2030 and 2050, respectively. Nearly 40-50% of these wastes compose of organic matter. With stringent regulation on disposal of organic wastes in landfill coupled with several environmental concerns such as greenhouse gases emissions, surface water and groundwater contamination, odor emanation, transmission of vectors via birds and insects, there have been significant efforts to eliminate or reduce the disposal of organic wastes into landfill. At the same time large amounts of liquid and gaseous wastes are also generated as a result of our increasing demand for resources. Thus, there is a critical need to valorize these waste streams into plethora of useful resources including food and fuels. This presentation will provide highlights of presenter's on-going research on how anaerobic digestion, fungal biotechnology, biochar, insect farming and aquaponics/bioponics among others can be applied for recovery of resources from diverse waste (water) streams. The presenter will also discuss some of the challenges of waste valorization.

Keywords: *Bioconversion, Wastes-to-resource, Opportunities, challenges.*

Integrated Soil and Organic Waste Management as a Resource Recovery Strategy for Resilient Agriculture in Guam

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One of the most threatening factors to soil quality especially in the tropical islands of Micronesia is the low organic matter content. Soil organic matter (SOM) is among the most degradation factor and the cause of poor soil quality in Guam and the other islands of Micronesia. Soil organic matter content are enhanced by effective management activities such as; manipulation of soil environment via conservation tillage and crop rotation practices, and more effectively by land application of composted organic wastes. In our case studies, preliminary results have shown that the application of composted organic wastes increased crop yield and significantly improved the quality of the soils in plots under study. The yield increase was 45%, 38%, and 33% for 30, 60, and 90 tons/ac of application rate as compared to the control (0 tons/ac). Also, the organic matter content of the soils under study increased from 3.4% to 6.3%. In our study, compost was produced from biosolid wastes that otherwise would be discarded in the island's landfills. Compost was produced via mechanical compost turner and applied on soils of agricultural fields as an alternative to commercial fertilizers to provide nutrients and also to enhance the organic carbon content and improve the overall quality of these poor soils of northern Guam. Mature compost was applied on the study plots at the rates of; 0, 30, 60 and 90 tons per acre as soil amendment on the poorly behaved 'Guam soils series' of northern Guam. Corn was planted and monitored for growth performance and yield evaluation. In this presentation, the methodology as well as up-to-date data will be presented to illustrate the effect of land application of composted organic biosolid waste on organic matter content and other soil quality indices as well as crop performance.

Keywords: *Soil organic matter, Biowaste management, Resilient agriculture, Compost and Composting, Guam.*

Integrated Food Waste with Wastewater Management in Hong Kong: Transformation, Energy Balance, Economic Analysis

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Hong Kong is facing an imminent problem of managing its food waste (FW). Each day, approximately 3600 tons of FW are generated in Hong Kong, solely relying on the landfill as the final disposal means. The diversion of FW away from the solid waste stream into wastewater treatment by using food waste disposers (FWDs) is proved viable to relieve the burden of solid waste management. However, the addition of FW may have dubious influences on the operation, energy and cost of the wastewater treatment plants (WWTPs) and sludge treatment in Hong Kong. By using local FW and wastewater data, this study has comprehensively assessed the FW transformation, energy balance and operational cost on wastewater and sludge management in Hong Kong through a plant-wide COD-based transformation model. The results indicate that around 41% of solid and 27% of chemical oxygen demand (COD) in FW could end up in the digested sludge, 13% of COD in the secondary effluent. Overall, the primary and secondary treatment in the WWTPs can remove nearly 59% of solids and 60% of COD in FW. In the short term with the penetration rate lower than 30%, the use of FWDs may pose limited impacts on treatment capacity, effluent quality and sludge production in WWTPs. This could be attributed to the resilience and redundant capacity of systems treating wastewater and sludge in Hong Kong. Although the enhanced potential of energy recovery can be achieved through methane production in anaerobic digestion process and electricity generation from combined heat and power systems, the use of FWDs may result in increases in both net energy consumption and net operation cost due to the biological processes adopted. In addition, given that sludge reduction (by 90% in volume) is the main task of the incineration, limited surplus electricity can not fill up the additional energy required for treating FW in WWTPs. Therefore, the use of FWD could be an alternative for FW management in Hong Kong, particularly for the collection and treatment of household FW, but a trial at a low penetration rate is deemed necessary for preliminary evaluations and further improvement of the sewer system and treatment processes in the WWTPs.

Keywords: *Food waste, Food waste disposer, Wastewater treatment, Sludge treatment.*

The Circular Economy for Organics as a New Paradigm for Advancing Organics Recycling Activities

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'Sustainability' is being increasingly replaced by the concept of the circular economy in the realm of waste management and resource recovery. This is a welcome development as the concept of sustainability had lost credibility – everything was sustainable, yet nobody wanted to foot the bill for effecting real change that would bring us closer to being sustainable. The circular economy on the other hand is an economic system aimed at eliminating waste and the continual use of resources, which will function only if all involved parties receive equitable economic or other benefits, and if somebody pays for it**.**

The Circular Economy for Organics links generators, processors and users of organic residues and will be viable in the long-term only if it is driven by demand and economic advantage for all supply chain partners with additional gains and costs being shard in an equitable and mutually acceptable way.

Organics recycling partnerships with agricultural industries offer long-term win-win solutions for both local governments and the farming sector. This can be achieved if farmers are elevated in the organics recycling value chain, for example by contracting them to provide organics recycling services (co-composting / co-digestion), or by establishing long-term compost use partnership agreements with farmers that stipulate quality requirements and a fair price, while on the other hand guaranteeing the beneficial use of all generated compost. Conversely, it is unreasonable to expect farmers to subsidise urban recycling programs through inflated prices for recycled organic products that reflect neither the value farmers can derive from using these products, nor the risk they might be exposed to. The circular economy for organics will make the organics recycling supply and value chain more transparent, and allow for more equitable and acceptable distribution of costs and benefits associated with organics recycling schemes.

Farmers need to be aware of short and long-term monetary values to crop production and soil health through the use of recycled organic products, considering nutrient and non-nutrient benefits gained from applying these products. This requires the availability of user-friendly tools for farmers that predict benefits for different products, soil types, crops, environments, and farming systems. Various projects, such as the development of a nutrient calculator for users of organic soil amendments are currently undertaken in Australia, supporting the establishment of the circular economy for organics.

Keywords: *Circular economy for organics.*

Developing Sensor-Aided Collection of Source Separated Food Organics

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Introducing the collection, processing and beneficial use of source separated organic residues from residential and commercial sources more than 30 years ago revolutionised solid waste management. Today, the segregation at source of garden and/or food organics is an integral part of waste reduction and resource recovery schemes in many countries and municipalities. The success of all source segregation recycling schemes, expressed as diversion and contamination rates, relies to a large extent on the active support and participation of residents and businesses. Recent Australian data encompassing various kerbside food and garden organics collection systems showed impurity levels that averaged 2.6%, representing contamination rates between 0.04% and 17.8% with plastic, metal and containerized food being the most frequently encountered impurities. Information from Hong Kong indicates that contamination levels can be up to 20%. The level of physical impurities in raw materials can be an indicator for chemical contaminants. Reduction of high impurity levels in raw materials will not only reduce the proportion of physical contaminants in the finished compost, but will also likely result in lower concentrations of some chemical contaminants (particularly metals).

This is a major challenge since source segregation schemes for organics are costly to establish and run, and excessive physical contamination levels in raw materials require additional processing steps and end-product quality is deteriorating. Removal of impurities from compost products has its limits, around 95% in the best of cases. This means that raw materials containing 3% impurities can be transformed into screened compost with around 0.45% (by weight) of impurities, in the best of cases. These contaminant levels probably comply with compost quality standards, but initial investigations into microplastics present in recycled organic products and soil environments are likely to force a reduction of acceptable physical contamination levels in raw materials and finished recycled organic products.

This paper will not only present current knowledge concerning physical contaminants in source segregated food/garden organics and generated products (compost/digestate), impurity limits stipulated in end-product quality standards, and the risk of microplastics, but it will also present attempts of reducing impurities in raw materials and hence in recycled organic products.

Experience shows that collection of source segregated food and garden organics can be achieved more easily in rural/regional areas than in densely populated urban areas with many high-rise buildings. Therefore, increased efforts are required to achieve acceptable diversion and contaminant levels for source segregation organics collection schemes in residential high-rise buildings. The development of sensor-aided collection systems might enable the successful collection of source segregated organics also in high rise buildings.

Keywords: *Source Segregation, Organics recycling, Impurities, Microplastics, High-rise buildings.*

Improving Waste Management Approaches for Small Livestock Farms in Vietnam

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Agriculture which employs more than half of the population is fading as the most important economic sector in Vietnam. The livestock sector in agriculture plays an important role as it is one of the fastest growing agricultural subsectors. There has been growing public concern over the environmental and human health issues associated with livestock production. Contaminants which include nutrients, pathogens, heavy metals, pharmaceuticals, and natural/synthetic hormones from animal waste generated can be transported into surface and groundwater. This review paper deliveries information from field research and various databases, summarize the current status of waste management approaches in the country. Information on local authorities and national regulatory requirements for waste management approaches was collected and reported. Selected technical data was attached into this paper. In recent years, the livestock sector accounted more than 30 percent of gross agricultural output and growing faster year-by-year. The total amount of animal manure generated in the country is around 80 million tons per year. It is recorded over one-third of livestock manure was directly discharged into the water body without proper treatment which caused of such concerns to water quality as well as aquatic ecosystems. By increasing livestock production, waste management problems will continue to increase and become more serious that needed to improve waste management approach from government. There is a big gap between national standards for livestock wastes discharge at livestock farms realities. For those that have already constructed biogas digesters, there is no monitoring to verify if the biogas effluents meet the standards to discharged into the public environment. Even the biogas effluent could used as fertilizer for crops, there is no any regulatory to promote this practice. It is need a long-term strategy for government at all levels to implement effective strategies to manage the livestock waste management in Vietnam.

Keywords: *Environment, Livestock waste, Vietnam, Waste management approach.*

Long-term Safety Assessment of Indirect Agricultural Application of Municipal Sewage Sludge through Net Bags

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The indirect application (IA) of municipal sewage sludge (MSS) via leachate in agriculture can reduce heavy metal pollution from MSS. To explore the long-term safety of IA, a 10-year field plot experiment was carried out for different patterns of use of sewage sludge. Three treatments were tested: direct application of sewage sludge (SS), application of sewage sludge filled in permeable net bags and stacked into crops (SSN), and application of chemical fertilizer (CF). Banana, papaya, and corn crops were planted in different periods. Heavy metals (Cu, Zn, Pb, and Cd) in the soil, crops, and MSS were monitored and analysed. The results showed that, on a 10-year timescale, the concentrations of all four heavy metals tested in soil samples of the SSN treatment did not exceed the soil standard limits. The yields of fruits and grains in the SSN treatment were not significantly different to that in the CF treatment, and the heavy metal concentrations met the required food standards. In contrast, the SS treatment resulted in soil Cd and Cu concentrations that that did not meet China's soil standards in the 3rd and 4th years of the experiment. After IA (SSN) for 6 months, heavy metal recoveries from sewage sludge were 99.9% for Cu, 94.0% for Zn, 94.9% for Pb, and 94.4% for Cd. Most of the heavy metals were retained in the sewage sludge and were mainly present in the residual fraction. Additionally, 26.5% of organic matter, 64.1% of N, and 83.7% of P were also retained after IA. Based on an estimation of the safe application period (years) for the SS and SSN treatments, it was found that SSN substantially prolonged the safe application years of sewage sludge when compared with SS. In conclusion, the IA of MSS through net bags could considerably reduce the pollution by heavy metals in sewage sludge and could safely supply nutrients for crops.

Keywords: *Municipal sewage sludge, Indirect application, Heavy metals, Long-term safety.*

Waste Fed Biorefineries for Sustainable Chemicals and Fuels

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The rapid growth of the global population has been a major challenge causing a significant threat to the finite resources as well as ecological services. These challenges are prompting to chart a novel path towards adapting sustainable production and consumption strategies. This communication tries to depict the importance of biogenic materials as potential feedstock to be transformed into a source of value through waste fed biorefineries. It also explores the scope of implementing 'circular loops' that strategically directs the flow of resources, their use, extracting value in the form of nutrients, energy and materials post-consumption within. The concept of circular economy (CE) that focuses on the reuse and recycling of materials in technical and biological cycles to reduce waste generation is a critical intervention. As the circular economy is gaining momentum around the globe, the biorefinery will play a key role in the framework of sustainability. However, optimized integrations of unit operations across closed loops are much needed with process intensification strategy in the context of resource recovery efficiency as well as sustainability index.

Keywords: *Biorefineries, Sustainable chemicals Sustainable fuels.*

Recycling Use of Organic Wastes: new approach for a developed city in China

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Globally, the annual organic waste generation is huge, the disposal of organic waste is one of the major challenges that humanity is facing in the twenty-first century. Traditional methods, as incineration and landfill might cause unhygienic conditions and threats to the environment and human beings, and would lose large amounts of recyclable resources if still keep this state until 2100. Here, researchers from the Organic Recycling Research Institute of China Agricultural University (ORRI) discuss the main groups of organic waste and the utilization status of recyclable organic waste resources in the world, and also describe the current status of organic waste utilization at Suzhou, China, and we aims to resolve organic waste pollution especially the ktichen waste in the urban and rural area. At present, three closed organic waste treatment processes have been developed such as biological drying, silo composting and continuous dynamic lane (CDL) aerobic composting, that can be applied to various occasions. Compared with composting reactors in other countries, the self-developed "biological drying + continuous dynamic aerobic composting" reactor has increased processing capacity by 25%, reduced energy consumption by 17%, and effectively reduced greenhouse gas emissions by more than 60%. Through advanced biological drying and aerobic composting technology, various organic wastes can be efficiently converted into biological organic fertilizer and soil conditioner within 7 days. China's first urban and rural organic waste treatment and utilization demonstration center project was established near Linhu town by ORRI, the products from it will not cause salinization of the soil, and can maintain the yield of rice. This could benefit to link organic waste recycling and ecological agriculture together to feed more people in 2100.

Keywords: *Organic waste, ORRI, Organic recycling, Aerobic composting, Bio-organic fertilizer.*

Opinion of Waste Management Experts on the Implementation of Smart Waste Management in Tehran

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The advent of the fourth industrial revolution "industry 4.0" has given rise to the growth of cyber-physical systems in various fields such as medicine, engineering, management, and manufacturing. The implementation of modern technologies in waste management has brought about the concept of "smart" waste management in so called smart cities. Iran, as a country whose MSW is primarily composed of organic waste, is a candidate for using technologies such as internet of things (IoT) and image processing for better segregation of the waste. In turn, the biodegradable fraction can be used to generate added value, such as in the form of compost or energy. Currently, about 65% of Iran's MSW is biodegradable but on a national level, only one fourth of this amount is used and the rest is discarded in dumps. In this study, a series of targeted questions have been asked from 27 waste management experts in the country, which include some private company executives, as well as top- and mid-level managers from the municipality and the department of environment. The questions are about the possibility of implementing smart waste management technologies for improving Tehran's waste management situation. Chi squared distribution as well as Spearman's coefficient is used to elicit correlations between various responses and their significance. The results show that most experts consider themselves to be aware of the opportunities and challenges of smart waste management. They are generally optimistic about using these technologies, and on average, have mediocre satisfaction of the current waste management practices in the city. As per the experts' opinions, benefits to the environment such as air pollution and decreased energy use are among the most favorable benefits. Interestingly, the benefits of smart waste management to managing the COVID-19 pandemic did not score highly on the priorities. Overall, interesting trends are observed and it is concluded that according to the experts, smart technologies can be used to improve (bio)waste management in the city.

Keywords: *Waste management, Tehran, Smart cities.*

Bioponics – A Biological Nutrient Recovery Technology in Bio-Circular-Green Economy

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Bioponics is the combination of hydroponics with the biological recovery of nutrient-rich organic wastes. Organic wastes from several agricultural residues and composts can be used as substrates for organic vegetable productions in bioponics. Bioponics also eliminates agricultural wastewater discharged to the environments as plants are grown in hydroponic grow beds where nutrients are recirculated. Bioponics has a high potential as a sustainable indoor and urban vertical farming. In bioponics, biological processes promote the generations of nutrients from biowastes via anaerobic/aerobic microbial biodegradation, thus allow nutrients assimilation by plants (i.e., vegetables). Nutrient recovery in bioponics relies on the symbiotic relationships among bacteria and plants. However, understanding of ecology and nutrient transformations in bioponics is very limited. Several studies showed that nutrient-rich waste streams such as anaerobic wastewater had a high potential to be used as a nutrient supply in bioponic systems. High acetic acid concentrations were reported increase phosphorus solubilizations of organic wastes. However, no such study has conducted in bioponics.

In this study, chicken manure based-nutrient film technique bioponics was used for growing 14 lettuce heads. Each bioponic system consisted of a grow bed for plant growth, and a biofilter for degradation of chicken manure (organic substrates) and nutrient solubilizations/transformations. Effects of acetic acid addition (17-52 g/L/week) on nitrogen and phosphorus transformations and recovery in bioponics were investigated at a manure loading of 500 g dry wt. per bioponic system. The nitrogen and phosphorus concentrations in bioponics were measured weekly to evaluate the nitrogen and phosphorus concentrations released from chicken manure and microbial degradation on organic nutrients of the chicken manure in the biofilter. In addition, to evaluate the ecology of the systems, 16S rRNA gene sequencing was used to examine the microbial communities in digested chicken manure and plant roots in bioponics at the different acetic acid loads. Microbial samples were taken at the end of each experiment.

Results showed that the acetic loadings (17-52 g/L/week) did not significantly affect the nitrogen and phosphorus concentrations in the bioponics. However, low plant yields were observed at high loads of acetic acid additions. This could be due to the acetic inhibition on plant growth; a slow rate of wastewater containing high acetic concentrations must be considered when integrating to bioponics. Results also showed that several microbial genera were associated with biofilm formation (e.g., *Zooglea* spp.), organic degradation (e.g., *Burkholderiaceae*), nitrification (e.g., *Nitrosomonadaceae* and *Nitrospira* spp.), phosphorus solubilization (e.g., *Pseudomonas* spp.), and plant growth promotion (e.g., *Bacillus* spp.). The results show a symbiosis of organic and nutrient transformations, which was beneficial the bioponic systems. Overall, the results suggest that all bioponics had a high capability for lettuce productions at chicken manure of 500 g dry wt. per bioponic system. However, an intermittent overload of high acetic acids (17-52 g/L/week) must be avoided when used/integrated with bioponics.

Keywords: *Bioponics, Nutrient recovery Bio-circular-green economy.*

Urban Waste-based Biorefinery Processes for Transition to a Circular (Bio)economy

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The current global demand of sustainability relies heavily on material and energy efficiency, reduced waste generation and greenhouse gases emissions. This aligns perfectly with the concept of circular economy which has gained momentum in the recent years and is seen more than from a research perspective. Design and adoption of circular economy approaches which account for sourcing, production, consumption, disposal and reuse or recycling of resources is needed to fulfil the criteria of sustainable development. To this end, the biorefinery concept has been envisaged to drive the transition from the current linear economy (extractprocess-consumption-disposal) to a closed loop (bio)economy wherein the value of products, materials and resources is maintained in internal cycles for as long as practically possible. In this regard, bio-based sourcing of high value-added products from non-food and/or waste feedstocks has attracted a great deal of attention in the biorefinery production model. The biowastes generated in urban settings form a great source of such inexpensive and abundant feedstocks which can be valorized to produce valuable bioproducts using microbial cell factories. While fulfilling the criterion of renewability of products, this aspect importantly depends on development of robust production schemes, increased market opportunities, and policies and regulations from government and private institutions. In this talk, the case studies of food waste and textile waste-based biorefinery technologies would be used to present these aspects of a closed-loop waste-based biorefinery model. The conversions of these urban wastes to valuable products such as glycoplipid biosurfactants, microbial enzymes and biocomposites would be discussed.

Keywords: *Waste-based biorefinery, Circular bioeconomy, valuable products.*

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Composting

Resource Recovery from Solid Anaerobic Digestate: A Critical Review on Circular Bio-Economy Perspective

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Anaerobic digestion of organic waste is considered as one of the sustainable solution to recycle waste to produce bioenergy. However, solid by-product of anaerobic digestion, 'digestate' is becoming serious bottleneck to manage due to its distinctive characteristics. Traditional disposal methods including direct discharge of untreated digestate into land, incineration and landfilling are not favorable in economic and environmental aspects. Several environmental issues such as NH_3 emission, greenhouse gas emission, water pollution, eutrophication, alteration of soil microbiota etc. have been reported from digestate disposal processes. In this review, different types of state of the art technologies available for resource recovery as well as the stabilization of solid fractions of digestate will be discussed. Challenges and opportunities of biological (composting, enzymatic hydrolysis, bio drying), physicochemical (palletization) and thermochemical (pyrolysis, gasification etc.) valorization technologies will be discussed pertaining to sustainability and zero waste concept under circular bio-economy perspective.

Keywords: *Resource recovery, Solid anaerobic digestate, Circular bio-economy*.

Nitrifier Denitrification Dominates Nitrous Oxide Production in Composting and can be Inhibited by an Innovative Nitrification Inhibitor: Electric Field

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Aerobic composting of organic waste is an important anthropogenic source of nitrous oxide (N_2O). However, 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. Although bacterial denitrification dominated the N_2O production overall, 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%, although it increased N_2O emission at the early stage. 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. Our results provide evidence that an electric field could be used as an innovative nitrification inhibitor to reduce compost-derived N_2O emissions.

Keywords: *Composting, Electric field, Nitrifier Denitrification, Nitrification inhibitor, N_2O mitigation.*

Biochar as Smart Candidature to Improve the Microbial Communities and Mitigate the Greenhouse Gases Emission during Poultry Manure Composting

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This work aimed to evaluate the influence of biochar combined amendment to poultry manure (PM) + wheat straw feed stock was investigated to assess the impact of biochar during the composting. Nitrogen conservation, greenhouse gases (CO_2 CH_4 and N_2O) emissions, nutrient transformation and microbial dynamics affecting these emissions were examined. Six different dosages of biochar were used to compost PM under aerobic conditions in 130L reactor for a 42-d period. A control treatment was also studied using PM without any amendment. The results showed that all of the composts with biochar + zeolite amendment reached the required maturity standard, and gave the highest maturity. In addition maximum microbial community and enzymatic activity were observed in biochar amended treatment. The biochar addition were significantly reduced the ammonia and GHGs emission emissions, but had also impact on reduction of bioavailability of heavy metals. On the first day of PM aerobic incubation, the presence of biochar resulted in increased porosity, due to its higher nano-porosity and surface area. Furthermore, Scanning Electron Microscopy also indicated that in the biochar-amended PM, the dense microstructure on the PM surface disintegrated into fragments with organic fraction degraded and water lost. Overall our results indicate that biochar combined with microbial consortium addition into PM composting was recommended to emit less total greenhouse gas emission and reached maturity on day 35 than control.

Keywords: *Poultry manure, Greenhouse gases, Biochar, Composting.*

Composting of Food Waste Anaerobic Digestate at ORRC1, Hong Kong

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Hong Kong started its first biological treatment plant for food waste recycling at Organic Resource Recovery Centre 1 (ORRC1) in 2018. OSCAR Bioenergy Joint Venture has been commissioned to carry out the anaerobic digestion (AD) of food waste to produce biogas followed by the treatment of dewatered digestate (DD) by aerobic composting process. The aim of this work is to conduct the tunnel composting of DD to optimize the aeration strategy and composting formulation to produce good quality compost in a short duration.

DD produced at ORRC1 has high ammonium nitrogen ($NH4^+$-N) (~10,000 mg/kg dry matter) and low C/N ratio which makes the composting process difficult. In the preliminary trials, DD was mixed wood chips in 1:1 ratio and composted for 8 days followed by 8 days of maturation with manual and auto blowing. The compost produced from this trial had significantly high ammonium nitrogen (2000-3000 mg/kg DM) which was higher than the prescribed limit of HKORC standard (< 700 mg/kg DM). After testing multiple mixing ratios, it was found that bigger wood chip provides better pile porosity but poorer mixing performance. Thus, a recipe of 30% small wood chip, 17% compost and 53% DD were found to be the best mixture for improved composting performance. Using this recipe, aeration cycle was optimized to achieve thermophilic phase during composting process. An aeration strategy of a 6 h aeration cycle with 30 minutes blowing at 0.6 mbar followed by 5 h 30 min without aeration resulted in a marginal improvement of the compost quality.

A laboratory study suggested that addition of sawdust into the present recipe improves the compost quality significantly. Composting recipe with 50% DD, 25% wood chip, 16.7% sawdust and 8.3% mature compost was used in the recent trial. This recipe produced good quality compost with SGI values of 86-90% within 14 days of composting. Ammonium nitrogen concentration was also reduced to 700-1000 mg/kg DM. This composting recipe will be used for further trials to produce good quality compost from dewatered digestate.

Keywords: *Composting, Food waste, Anaerobic digestate, ORRC1, Hong Kong.*

The Progress of Composting Technologies from Static Heap to Intelligent Reactor: Benefits and Limitations

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Composting technology is widely used and different technologies have been applied from static heap to windrow composting, and to intelligent reactor composting since the rapid development of landless intensive livestock farms and improved awareness to environmental impacts. However, the lack of a systematic analysis has limited the objective evaluation of these different technologies from the perspective of treatment efficiency, and environmental and economic benefit. This study aimed to use quantitative data from full-scale composting systems (static heap, windrow composting and reactor composting with 8 t treatment capacity per day) installed on a commercial pig farm (6000 head) to compare their treatment efficiency, nutrient losses, product quality and investment and operational costs. The results showed that fresh feedstock entered the thermophilic phase in reactor composting much more quickly (within a few hours) than the other composting methods, and maintained a relatively stable high temperature (55~65^{o}C). This improved the biodegradation process and shortened the composting period. Within the first week, the organic matter degradation in the reactor composting treatment reached 35.7%, significantly greater than for the other treatments. Rapid heating and sustained high temperature promoted the removal rates of the antibiotics tetracycline, doxycycline and sulfamethoxazole. More than 90% of these antibiotics were degraded in the reactor composting treatment, and antibiotic resistance gene abundance was significantly reduced by 79% after composting. Nitrogen loss from the reactor composting was 34% less compared with windrow composting. Although the reactor composting has a higher equipment cost and greater depreciation than the other composting technologies, the total investment and operational costs are comparable to windrow composting. Moreover, with low nitrogen loss, high antibiotic and resistance gene removal rates, reactor composting has benefits regarding nutrient use efficiency and environmental impact.

Keywords: *Reactor composting, Windrow composting, Static heap, Composting efficiency, Environmental and economic benefits.*

Biochar as Smart Candidate to Regulate the Fate of Heavy Metals (Cu and Zn) Resistant Bacteria Community during the Poultry Manure Composting

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In this study, the influence of coconut shell biochar addition (CSB) on heavy metals (Cu and Zn) resistance bacterial fate and there correlation with physicochemical parameters were evaluated during poultry manure composting. High-throughput sequencing was carried out on five treatments, namely T1-T5, where T2 to T5 were supplemented with 2.5%, 5%, 7.5% and 10% CSB, while T1 was used as control for the comparison. The results of HMRB indicated that the relative abundance of major potential bacterial host altered were *Firmicutes* (52.88-14.32%), *Actinobacteria* (35.20-4.99%), *Bacteroidetes* (0.05-15.07%) and *Proteobacteria* (0.01-20.28%) with elevated biochar concentration (0%-10%). Beta and alpha diversity as well as network analysis illustrated composting micro-environmental ecology with exogenous additive biochar to remarkably affect the dominant resistant bacterial community distribution by adjusting the interacting between driving environmental parameters with potential host bacterial in composting. Ultimately, the amendment of 7.5% CSB into poultry manure composting was able to significantly reduce the HMRB abundance, improve the composting efficiency and end product quality.

Keywords: *Coconut shell biochar, Poultry manure, Composting, Heavy metals resistant bacterial, Physicochemical properties.*

Effect of Biochar Addition on Food Waste Digestate Composting at Low and High C/N Ratios

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Food waste digestate (FWD) is generated from the anaerobic digestion process. It can be used as a valuable soil fertilizer due to the presence of high nutrient content. However, the high concentration of NH_4^+-N leads to increased risks of odor release by NH_3 emission and potential phytotoxic effects. Hence, post-treatment of FWD in aerobic composting can assure the stability of carbon and produce nutrient rich biofertilizer for agronomic usage. Under the normal composting conditions, higher NH_3 emission was observed which resulted in low quality compost. Biochar could improve composting process efficiency by enhanced degradation of organic matter, and reduced NH_3 emission due to its high absorption capacity. Previous studies have shown that a C/N ratio of 30 and 10% biochar are considered as favorable for FWD composting. However, composting at a high C/N ratio will increase the demand of bulking agent for adjusting the initial C/N ratio of FWD composting mixture. Hence, in our study, FWD composting at a low C/N ratio with biochar was evaluated to understand NH_3 emission and compost quality. The effect of the addition of biochar at different ratios (0%, 10%, 15%) on FWD composting at low (15) and high (30) C/N ratio was investigated, along with carbon mineralization, NH_3 emission, and other physicochemical parameters were in a 42-day aerobic composting experiment. The results showed that biochar as an additive could reduce NH_3 volatilization during FWD composting. The treatment of 10% biochar with C/N 30 improved composting process (better nitrification, shortest mature phase) and the compost quality (higher seed germination index), while 15% biochar showed negative effects. Among low C/N ratio treatments, 10% biochar showed better performance in terms of NH_3 emission reduction, reduced phytotoxic nature (NH_4^+-N $<$ 700mg/kg), and good quality compost (seed gemination index $>$ 80%) in a reasonable duration (28 days). Furthermore, adopting co-composting at low C/N ratios with 10% biochar could reduce the requirement of bulking agent and also produce good quality compost.

Keywords: *Food waste digestate, Composting, Biochar, C/N ratio, NH_3 emission.*

Characterization of the Distillery Sludge based Compost and Vermicompost

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Distillery industrial sludge mixed with cow dung, vegetable waste and saw dust in various proportions was subjected to aerobic composting (with and without earthworms) and vermicomposting (with *Eisenia fetida* and *Eudrillus eugeniae*). It was observed that distillery industrial sludge vermicompost (DSV) and vegetable waste vermicompost (VV) resulted in a reduction in organic carbon and an increase of nitrogen and phosphorous during the vermicomposting process indicating that *Eisenia fetida* and *Eudrillus eugeniae* helped in fast conversion of distillery industry sludge into a value added product in 120 and 42 days respectively.
Micrococcus sp., Klebsilla sp., Pseudomonas sp., Coryne bacterium sp., Staphylococcus sp., Citrobacter sp., Salmonella sp., Enterobacter sp., and Proteus sp., were identified and their enzymatic activities were recorded. *Pseudomonas* sp, *Klebsilla* sp., and *Micrococcus* sp., exhibited amylase activity, *Coryne bacterium* sp., exhibited protease and lipase activity, Pseudomonas sp., *Klebsilla* sp., *Micrococcus* sp., *Coryne bacterium* sp., *Staphylococcus sp., Citrobacter sp., Salmonella sp., Enterobacter sp., Proteus sp.,* showed cellulase activity. Experiments confirmed that both Distillery sludge (DSV2) and Vegetable waste vermicompost (VV1) were good nutrients for plant when compared with others. The sludge conversion was supported by the addition of vegetable waste and sawdust.

Keywords: *Eisenia fetida, Eudrillus eugeniae, Distillery sludge, Vermicompost.*

Performance of Black Soldier Fly Larvae for Manure Composting

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The increasing number of livestock farms has led to a great deal of manure generation, and its improper treatment results in threats to the environment. Black soldier fly larvae (BSFL) was considered as a promising agricultural generator which outputted protein and fat used in livestock production, BSFL manure in agricultural production. Three types of manure [chicken (T1), pig (T2), and cow (T3)] were inoculated with BSFL (1.2:7 ratio on fresh weight basis), three types without BSFL were used as control (T4, T5, and T6), and both were composted for 9 days. The results showed that the BSFL composting reduced the nitrogen by 6.08-14.37% compared to initial materials, but the value of total phosphorous and potassium were increased greatly by the mass concentration. And BSFL could promote the generation of humic acid and compost maturation, only T1 and T2 treatments enhanced the mobilization of Cu and Zn. BSFL decreased the proteinaceous materials and promoted the aromaticity of manure, T1 and T3 treatments were more prone to humifaction than T2. Meanwhile, BSFL amendment were significantly reduced pathogenic bacteria abundance, especially, the genus of *Bacillus* and *Enterococus*. Therefore, the BSFL could be added as a high-efficiency transformation agent for converting organic manure into stable compost, especially in developing countries.

Keywords: *Black soldier fly larvae, Manure, Composting, Humifaction, Pathogenic, Bacteria.*

Cost-Efficient Composting of Food Waste and Garden Waste with Urban Homology: Role of Mixing Proportions and Process Parameters

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In recent years, rapid economic development and population growth have significantly increased food consumption and thus the generation of food waste in urban areas. As a homologous waste with food waste, urban garden waste has also dramatically produced with the increment of urban green land. Co-composting of these two wastes with same source can efficiently overcome the transportation cost challenging that agricultural wastes, such as cornstalk and spent mushroom substrate, need to experience long-distance transportation from rural to urban before composting with food waste. However, co-composting performance of food waste and garden waste is still known.

This study investigated the effects of mixing proportions and process parameters (i.e. moisture, aeration rate and pH) on composting performance during food waste composting with garden waste as bulking agent. Gaseous emissions and maturity were analyzed to evaluate composting performance. Results show that more than 15% of garden waste (wet weight) added into composting materials could efficiently decline the emission of greenhouse and odours gases and maturity during composting. On the other hand, all process parameters designed in this study could pose notable effects on gaseous emissions. A relatively lower emission of methane and hydrogen sulfide was observed for the treatment with medium aeration intensity (0.24 $L \cdot kg \cdot DM^{-1} \cdot min^{-1}$) than low and high aeration treatments. Moreover, the composting materials with 65% moisture content could be considered as an optimal selection to control gaseous emissions, particularly greenhouse gas. Given the characteristic of low pH for the food waste to postpone the composting progress, optimizing initial pH of composting materials was essential. Our results indicated that enhancing initial pH by calcium oxide (CaO) was significantly efficient to accelerate the achievement of thermophilic stage of composting. More excellently, Addition of 1.5% of CaO (wet weight) into composting materials could considerably alleviate greenhouse gas and ammonia emissions. Results from this study provide unique and valuable insights to the cost-efficient and environmental-friendly management of typical unban wastes that food waste and garden waste.

Keywords: *Composting, Food waste, Garden waste, Mixing Proportions, Process Parameters.*

Toxicity and Histopathological Effect of Distillery Industrial Sludge on the Earthworm *Eudrilus Eugeniae*

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Increasing population accompanied by industrialization has increased the solid waste disposal problem in many of the developing countries like India. It is a well-known fact that the disposal of the waste water and sludge produced by anthropogenic sources is becoming a serious problem of concern. The sludge generated in enormous quantity creates the problem of safe disposal. Sludge is an inevitable, hazardous and odorous by-product from waste-water treatment plants and many industries too. One such industry happens to be the distillery industry producing sludge, which requires safe disposal. But the distillery sludge is reported to contain the nutrients, as it is a by-product of the sugar industry. Though it is accepted to be a suitable soil conditioner, higher concentration of heavy metals limits its continuous use for field crops. Hence, in this study we tested the feasibility of the earthworm *Eudrillus eugeniae, commonly called as African night crawler* to detoxify the distillery sludge through Vermitechnology.

Distillery sludge was subjected to vermicomposting after addition of carbon (cow dung) and nitrogen (saw dust) sources. The concentration of Cd, Zn, Fe, Mn and Cu were checked in all the samples. The sludge exposed earthworm was subjected to metallothionein protein estimation and their histology was also studied.

A reduction in the heavy metal (Cd, Zn, Fe, Mn and Cu) content accompanied with its increase in the earthworm tissues was noticed. Following which the metallothionein content also has shown a considerable increase in the tissues of earthworm which worked on distillery sludge. Further damage to the earthworm tissues was confirmed based on the histology reports. The DSV1 (Distillery Sludge Vermicompost set 1) exposed earthworms were highly affected when compared with earthworms exposed to DSV2 (set 2).

Keywords: *Distillery sludge, Vermicompost, Heavy metal, Histology.*

Potentials for Mitigating Greenhouse Gas Emissions through Dietary Changes and Food Waste Prevention: Case Study Macau

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Dietary changes and food waste prevention are significant factors in view of mitigating Green House Gas Emissions. They "can reduce demand for land conversion, thereby potentially freeing land" (IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems Summary for Policymakers Approved Draft Subject to copy edit and layout, 7th August 2019, p.3 and p.20). From 2010 to 2016, global food loss and waste contributed 8-10% of total anthropogenic GHG emissions, and currently, 25-30% of total food produced at the global level is lost or waste (IPCC 2019). Strategies and policies that aim at reducing food loss and waste and influence dietary choices, improve overall food security, serve low emissions trajectories, and thus have the potential to contribute significantly to climate change adaptation and mitigation. Also, the COP 21 Paris Agreement of 2015 aims at reducing per capita global food waste at the retail and consumer levels by 50 % until 2030 (Goal 12.3. https://sustainabledevelopment.un.org/).

The paper investigates the respective potentials of mitigation of GHE by dietary changes and food waste prevention in Macau S.A.R., China. It uses and compares official data regarding consumption and MSW, results of quantitative assessments (e.g. Waste Audit), and systematic qualitative reflection and evaluation in view of mitigation potentials.

Keywords: *Sustainable Development, Dietary Changes, Foodwaste-Prevention, Mitigation.*

Estimation of Greenhouse Gas- N_2O Emission Variation by Denitrification Bacteria during Oxygen Depletion in Bohai Sea of China

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With the extending of coastal and ocean hypoxia area under the impact of anthropogenic activities, the nitrogen cycling relating to the greenhouse gas emission are assumed to be improved under oxygen depletion. Therefore, microbial variations under oxygen depletion is essential for deciphering the related biogeochemical cycling. In this study, a time-scenario sampling was designed along one transect from inshore to offshore in the seasonally-formed oxygen depletion zone of the northwestern Bohai sea from June to August in 2018 at a twenty days interval. Aiming to investigate the N_2O emission process, the diversity and distribution of denitrification bacteria were revealed by high-throughput sequencing, with special focuses on *nos*Z gene in oxygen depletion region. In general, the heterotrophic bacteria became dominant in the bottom water and sediment of Bohai coastal area, where the concentration of nitrate and nitrite were also accumulated. Based on the sampling time scenario, distinct distribution pattern of community composition was observed for June and July, but overlapped in some degree for the two August samples. The vertical pattern displayed a more stable stratification along with the proceeding of oxygen depletion. Environmental parameters including depth, salinity, Chl *a*, nitrite and pH are impacting the distribution significantly, while dissolved oxygen and nitrite are the main impacting factors for the abundance of *nos*Z encoded denitrification bacteria ($p<0.05$), which further confirmed the assumption that the extending of hypoxia will improve the denitrification-related N_2O production. In addition, varied origins of denitrification bacteria were revealed as the OTUs from this study were alignment with OMZ sea water, sediment as well as soil from terrestrial environment displayed by phylogenetic analysis. Our study provides the first inspection into the microbial variations related to N_2O emission under the depletion of dissolved oxygen in Bohai Sea, which may help to understand the consequence of global warming in the ecosystem.

Keywords: *Greenhouse gas, N_2O emission, Denitrification bacteria, Oxygen depletion, Bohai sea.*

Bioconversion of Municipal Solid Waste to Compost

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Composting is frequently utilized for enhancing the quality of the soil through incorporating organic compounds into the soil. Due to various environmental issues associated with municipal solid waste (MSW) the preference of using municipal solid wastes for the process of composting has received a lot of interest in recent years. The continuous increase in waste will proportionally increase the total volume of waste generated which results into loss in biodiversity and elevation in pollution potential of pollutants. Building awareness among the people for utilizing bio products is a considerable need. In this study, we tested traits of compost which was obtained from municipal solid wastes as a raw material. By employing the standard methods assessment of compost was executed. The organic fraction of MSW consists of 26% vegetables, 23% cooked waste, 15% coconut, 7% paper, 12% wood and 8% leaves. The results also revealed presence of heavy metals such as 8.48 mg/kg lead, 2.71 mg/kg nickel, 179.41 mg/kg zinc in the compost. It showed 0.9860 g/cm^3 bulk density and 2.3 dsm^{-1} electrical conductivity.

Keywords: *Municipal solid waste, Organic fraction, Feedstock, Composting traits, Heavy metals.*

Conversion Food Waste and Sawdust into Biofertilizer Employing Black Soldier Fly Larvae (*Diptera: Stratiomyidae*) under the Optimized Condition

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Food waste (FW) was greatly generated by people consumption, which need an urgent method to recycle. The black soldier fly larvae (BSFL) was a quick waste manager with potentially to decrease the financial cost from FW treatment. To assessed the impact of BSFL on conversion FW and sawdust into biofertilizer through the parameters of maturity, nutrient transformation and volatile fatty acids (VFAs). Sawdust was utilized to adjust moisture and make the separation larvae from residue easily. FW and sawdust were employed by BSFL (6.5:0.5:1.2 ratio on fresh weight basis) as T1 and without BSFL called control (T2), while moisture content for FW and sawdust was 86.57% and 5.98%. Results illustrated that BSFL declined the composting time and only 9 days. Compared with initial mixture materials, T1 decreased organic matter (OM), total kjeldahl nitrogen (TKN) and VFAs in 11%, 23% and 46%, which reduced the OM, TKN and VFAs from 97.41 to 85.96%, 23.01 to 17.77 g/kg and 3.12 to 1.69 g/kg. In contrast, the T1 increased the total phosphorous (TP) and total potassium (TK) in 3.8 folds and 5 folds. The value of pH and EC reached at 4.27 and 1100 μS/cm, and the germination index (GI) attained to 70.69%. Therefore, BSFL played a vital role in FW and sawdust recycling, especially reduced conversion time and made the final separation of larvae and substrate easily, saving labor costs.

Keywords: *Black soldier fly larvae, Artificial food waste, Sawdust, Composting, Biofertilizer.*

Elucidating the Optimum Added Dosage of Diatomite during Co-Composting of Pig Manure and Sawdust: Carbon Dynamics and Microbial Community

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In order to investigate the optimum added dosage of Diatomite (DM) during co-composting of pig manure and sawdust, six dosages of DM (0%, 2.5%, 5.0%, 10%, 15% and 20%) were added into initial mixtures for 42 days aerobic composting. Results showed that adding DM was beneficial for reducing CH_4 emission and greenhouse gas emission equivalent (GHGE) value by 15.34−23.95% and 14.33−69.08%, respectively. Meanwhile, the main contributor to GHGE value was N_2O (58.76−75.98%), followed by CH_4 (17.22−29.16%) and NH_3 (6.38−13.36%) in order. Moreover, the maximum values in degradation of total organic matter and formation rate of humic substances were 20.39% and 75.11% in 10% DM added treatment (T3), respectively. Furthermore, the increasement of spectral parameters including the specific UV absorbance at 254 nm ($SUVA_{254}$), the specific UV absorbance at 280 nm ($SUVA_{280}$) and relevant parameters of Fourier transform infrared in control were facilitated by DM amendment. Additionally, the higher values in relative abundance of Proteobacteria (50.98%) and Bacteroidetes (12.73%), and related metabolisms like carbohydrate metabolism and amino acid metabolism, as well as lower value of Methane metabolism reported in T3, supported the difference in CH_4 and humification of two treatments. Concluded together, DM was an eco-practical additive to improve quality of end products and reduce potential risks, and the best one was 10% added treatment based on the dry weight in this study.

Keywords: *Pig Manure, Sawdust, Co-composting, Diatomite, Microbial Community.*

Characterization of Food Waste for Value Creation

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Rapid population growth, combined with increased industrialization, has exacerbated the issue of solid waste generation. Improper management of solid waste has negative environmental consequences, which puts the public health at risk and introduces several other socio-economic problems. Food waste is one of prime solid waste generated. Food waste management is a major concern globally. High moisture content of food waste make it landfill and incineration incompatible, causing secondary ecological footprint and reducing treatment quality. In the effective management of food waste, a set of solutions may be applied and can be evaluated time to time. In a circular economy framework food waste has great potential to be used for value creation such as biofuel, biosurfactants, biopolymers and natural nutrients production. It can be processed through various biological technologies such as anaerobic digestion (AD) and composting. Before using food waste for any process, it is important to characterize it. In this study we have reported characterization of food waste by standard methods for various physiochemical parameters. The food waste showed 83.39% moisture content, 3.07% ash content, 0.31% chloride, 1.03% nitrogen, 7.848% carbon and 0.654% hydrogen. Looking to the results it is concluded that it can be used to prepare compost.

Keywords: *Food waste, Circular economy, Ultimate analysis, Ecological footprint*

Thermophilic Degradation of Vegetable Waste using Rotary Drum Composter and Efficacy of Rotary Drum followed by Vermicomposting

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Vegetables are one of the major requirements of all the communities in both rural and urban bodies, daily almost all the communities face the challenge of managing the produced waste. In rural bodies, the domestic animals will be the consumers majorly for the produces organic waste were as in urban areas it is a major challenge to the governing system. Among all the composting techniques, the rotary drum composting (RDC) requires very little time of 20 days for the aerobic decomposition of the substrate, and the thermophilic degradation was effectively achieved in the initial 7 days of the composting in the batch reactor of 550L. In this study, composting of vegetable waste was studied using the RDC and RDC followed by vermicomposting (VC). firstly the waste was subjected to RDC for a period of 20 days and in the second run, the RDC was used until the active thermophilic degradation and the substrate then fed to VC for further degradation using *Eisenia fetida* earthworms for a period of 20 days post-7-day degradation in the RDC. The temperature rise on the second day was observed to be 51.5^{O}C in the RDC. The temperature was observed to be in the thermophilic range until day 7. The active degradation of waste by bacteria supported by the proper aeration and control of the biomass by the RDC reactor. Vermicomposting produces superior quality compost so for further degradation in the second trial and quality produce this process is best suited. The RDC and combination of VC after the RDC increased the nitrogen content to 2.2 % and 4.15% respectively from 1.4% and the volume reduction of 60±5% was observed by the end of the 27th day of RDC followed by VC, which suggests that the technique suits best for urban bodies in managing huge loads of vegetable waste and to produce nitrogen-rich vermicompost using substrate post-RDC.

Keywords: *Vegetable waste, Rotary drum composting (RDC), Vermicomposting (VC), Bio-waste.*

Transformation of Intrusive Weed Ageratum Conyzoides into a Value Added Product through Rotary Drum Composting

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The major constituents on earth surface are plants, terrestrial weeds, animal kingdoms etc. The majority of the problem lies in managing the terrestrial weeds, as they pollute the habitats of plant kingdom by their allellochemical nature. The study aimed at managing the intrusive weed Ageratum conyzoides biologically through 550 L Rotary drum composter (RDC) in the ratio of 1:1 (substrate : cattle manure). In previous literatures vermicomposting of Ageratum conyzoides was cited and it has its own drawbacks in terms of time constraint. The RDC process of A. conyzoides has took place in 20 days with a fine sieve range of 4mm. The produced compost was analyzed with physiochemical and biological parameters with CO2 evaluation and Oxygen uptake rate as the maturity parameters. In order to access the toxicity parameters, phytotoxicity test was performed in four different stages of composting process using Vigna radiata and Allium cepa as the plant models. The results of maturity parameters suggested to do composting process for 20 days, whereas phytotoxicity assay results revealed that the allellochemicals present in the raw A. conyzoides got reduced significantly in the composting process.

Keywords: *Composting, Rotary drum, Intrusive weed ageratum conyzoides, Product.*

Quality Assessment of Compost Obtained from Municipal Solid Waste

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On a global scale, a rise in population density, as well as the migration of the population from rural to urban areas leads to generation of a large amount of municipal solid waste (MSW), which causes serious economic, social and socio-demographic problems. Awareness in public is essential for proper MSW management techniques. Municipal solid waste can be used as feedstock for biofertilizer and biogas production employing different techniques such as composting, vermicomposting and anaerobic digestion etc. Composting is reported as cost-effective technique to treat organic fraction of municipal solid waste. It is biological process in which degradable part of municipal solid waste is transformed to a steady material with excellent characteristics for application in soil. This study was conducted by performing the analysis of physicochemical parameters of compost obtained from municipal solid waste. The compost analysis was carried out using standard method (Fertilizer Control Order (FCO)-1985). Physicochemical parameters of obtained compost were compared with standards. For the studied compost C:N ratio, total potash, total organic carbon, total nitrogen, total phosphates and moisture content were 16:8, 0.94%, 60.05%, 1.00%, 0.94%, and 20.02, respectively.

Keywords: *Municipal Solid Waste, Total nitrogen, Biofertilizer, Compost, Total phosphate.*

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Biochar and its Application

Food Waste Hydrochar for Catalytic Degradation of Organic Contaminant

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Custom-designed carbonaceous adsorbent/catalyst from 'green' sources with desired functionalities under science-informed conditions is indispensable to promote the sustainable industrial wastewater treatment. In this study, we prepared hydrochar by hydrothermal carbonization (HTC) of three types of pre-consumer food waste (*i.e.*, lettuce, taro, and watermelon peel) with different components at various temperatures (*i.e.*, 180−240 °C). The performance of food waste hydrochar was examined through the adsorptive removal and peroxymonosulfate (PMS)-initiated catalytic degradation of a representative, recalcitrant organic contaminant, 2,4-dichlorophenoxy acetic acid (2,4-D). The $LHC_{180–240}$ derived from fibre-rich lettuce manifested a substantial 2,4-D adsorption (77.4−88.4 mg g^{-1}) possibly due to intensive partitioning and/or chemisorption, which were dependent on the mesoporous carbon structure with low aromaticity and abundant C−O functional groups. In comparison, HTC of starch-rich taro at a relatively low temperature (200 ℃) produced the THC_{200} that displayed a superior catalytic ability (73.5 mg g^{-1}) probably owing to a highly graphitized C domain with low polarity and enriched ketonic (C=O) functionality, which might facilitate radical/non-radical PMS activation. Interestingly, the $WHC_{180–240}$ produced from watermelon peel with moderate-level carbohydrates and low-fibre content presented an improved structure and functional groups (*i.e.*, C−O and C=O), but inhibited the PMS activation for 2,4-D degradation possibly due to interference by its inherent dissolved organic matter. This study provided insightful guidance for tailoring future design of multifunctional hydrochar adsorbent/catalyst for sustainable remediation.

Keywords: *Food waste hydrochar, Catalytic degradation, Organic contaminant.*

Production of Biochar using Biogas Residue and Adsorption of Ammonia-Nitrogen and COD in Biogas Slurry

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Biogas produced by anaerobic digestion of organic solid waste is of triple strategic significance in energy saving, emission reduction and resource utilization. The harmless treatment and resource utilization of biogas digestion residues (biogas slurry and biogas residues) are directly related to the sustainable operation of biogas plant. Biogas slurry is a typical kind of wastewater containing high levels of ammonia- nitrogen and COD. In order to realize an economic profit in biogas plant, the unutilized or underutilized biogas residue can be utilized for the production of biochar and also to adsorb high contents of ammonium and chemical oxygen demand in the biogas slurry.

In this study biochars were produced using biogas residues (straw, pig manure, and chicken manure fermentation substrates) from biogas plants treated through 4 different temperatures pyrolysis and 11 chemical reagents to activate the biochars. The biochars were characterized by scanning electron microscope (SEM), Brunauer Emmett Teller (BET) and Fourier transform infrared spectroscopy (FTIR). The adsorption of ammonia nitrogen and removal COD in biogas slurry by biochars were studied by adsorption kinetics and adsorption isotherm experiments. The surface area of biochars prepared using straw, chicken manure, and pig manure biogas residues processed at 550 ℃ indicated 36.29 m2/g, 33.73 m2/g and 35.28 m2/g, respectively. The removal rate of ammonia nitrogen was about 16% by the three different biochar was recorded whereas the biochar from straw biogas residue revealed for a relatively excellent performance in the removal of COD compared with the other two biochars. In the temperature range of 400 ℃ to 600 ℃, the adsorption performance of biogas residue biochar was increased with the pyrolysis temperature, reaching a maximum at 550 ℃. After pyrolysis at 550 ℃, the biochar from straw biogas residue had a strong adsorption capability for ammonia nitrogen (16.8%) and COD reduction (26.1%).

Different activators affect the specific surface area and pore structure of the biochar, as well as the functional groups on the surface of the biochar, hence affecting the adsorption performance. In this experiment, acid, alkali and metal salts were used to modify the biochars. The alkaline reagent has a good effect on expanding the pores of biochars. The modification of the biochar by the acidic treatment has no obvious change in the adsorption performance. The adsorption equilibrium time (120-300 min), maximum adsorption capacity of ammonia nitrogen (17.34 mg/g) and reduction of COD (15.57 mg/g) in biochar from straw biogas residue prepared and modified by FeCl3 treatment were recorded. By fitting calculation, the FeCl3 modified biochar from straw biogas residue recorded for a maximum adsorption capacity of ammonia nitrogen (110.30 mg/g) and COD (133.88 mg/g). The FeCl3 modified biochar recorded for a removal rate of ammonia nitrogen and COD in simulated biogas slurry by was 28.9% and 52.7% respectively. The adsorption of ammonia-nitrogen and COD by biochar modified by FeCl3 was in line with the second-order adsorption kinetics. The adsorption isotherm was represented by Langmuir model, mainly by electrostatic

adsorption. The overall outcome of this study indicated that the biochar from biogas residue has a great potential in adsorption of high contents of ammonia and reduction of COD in biogas slurry.

Keywords: *Biogas residue, Biochar, Biogas slurry, Ammonia nitrogen, COD, Adsorption.*

Synthesis of Ternary Micro-Electrolytic Fillers Using Biochar from *Lycium Barbarum* L. Branches and its Application in Wastewater Treatment

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Currently, synthesis of iron carbon (Fe/C) micro-electrolytic fillers are based on traditional electrochemistry technology and it has been successfully applied for treating various refractory organic pollutants available in the wastewaters. In addition, biochar derived from pyrolysis of variety of waste biomass is becoming an emerging carbon material. This is not only an approach to reduce environmental pollution contributed by waste biomass, but it has been also proven to be a cost-effective alternative for high-valued applications of traditional carbon materials via its excellent performance. In this study, a novel micro-electrolytic filler was synthesized using biochar produced from the Lycium barbarum L. branches. The physicochemical properties of these micro-electrolytic fillers were modified by adding copper and iron at a high-temperature anaerobic process. A comparative study was conducted using three different kind of fillers (C, Fe/C, and Fe/C/Cu), determined reaction behavior and was characterized by scanning electron microscopy (SEM) and X-ray diffraction (XRD). Further the effect of ternary micro-electric fillers was tested on treating the refinery wastewater. The wastewater was treated with different Fe/C ratio fillers, Fe/C/Cu ratio fillers, and initial pH value and collected the treated wastewater and analyzed for COD，TOC, and Gas chromatography–mass spectrometry (GC-MS). Hence arrived the optimum treatment conditions for treating the wastewater with the novel ternary micro-electrolytic fillers.

A reduction of about 80% COD was recorded after 120 minutes of treatment conditions in the wastewater maintained at an aeration rate of 10 mL/min, with an initial pH value of 4.0, Fe/C ratio of 1:1, Fe/C/Cu ratio of 1:1:1. COD removal efficiencies of these three fillers were recorded as 53.01%, 57.83%, and 77.11%, as well as TOC removal efficiencies of 34.71%, 39.44%, and 68.71% , respectively. The SEM images of these three fillers indicated the presence of a number of pore structures, which facilitated the adsorption of organic pollutants. Differently, Fe/C/Cu filler occurred an aggregation of metal atoms, whereas compared with the polymerization of iron atoms in Fe/C filler, Fe/C/Cu filler promoted the reaction by the addition of copper which made the iron atoms more evenly dispersed. XRD analysis revealed that all the three fillers contained Fe and Fe3O4. Only Fe/C/Cu filler contained Cu, which implied that copper oxide was completely converted to copper during high-temperature anaerobic process. The GC-MS analysis identified that some small molecules formed in effluents as intermediates, for example, carboxylic acid, alcohol, alkane, and acetone, which indicated that a large amount of organic pollutants with high molecular compound available in raw torch wastewater, such as 1,3-Adamantanediacetamide, Naphthalene, 2,5,6-Trimethylbenzimidazole, 2-Ethyl-3,5-dimethylpyridine, were degraded during the micro-electrolytic process. Especially, the least residual organic compounds in effluent suggested that Fe/C/Cu filler had the highest degradation capacity.

The outcome of this study confirmed that Fe/C/Cu ternary micro-electrolytic filler is a novel and effective environmentally friendly material and can be utilized for the treatment of refinery wastewater.

Keywords: *Micro-electrolysis, Lycium barbarum L. branches, Ternary micro-electrolytic fillers, COD, Wastewater treatment.*

Influence of Modified Rice Husk Biochar on Gaseous Emission, Nutrient Status and Microbial Community during Swine Manure Composting Process

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Swine manure is largely composed of abundant organic compounds, which can also cause harm to various aspects of the environment through the release of greenhouse gases or excess nutrients, salt accumulation, growth of pathogenic microorganisms, etc. In this regard, in-vessel composting process with modified black carbon is an effective and economic approach for manure managment. In this study investigated the effect of the modified black carbon (MBC), amendment on swine manure (SM) composting efficiency through physical, physio-chemical, gaseous emissions, microbiological, and phytotoxic analysis during the 50 day process of in-vessel composting. The composting treatments were set-up from three different ratios of black carbon to Swine manure mixed with sawdust (SD)(i.e. SM + SD + 5%MBC (T1), SM:SD + 10 %MBC (T2) and SM:SD + 15 %MBC (T3)), while treatment without black carbon amendment was used as a control, SM:SD (C). The results showed that, compared to the control, biochar amended compost mixtures had significantly reduced ($p \leq 0.05$) C:N ratio, bulk density, organic matter (OM), pathogenic microorganisms and gaseous emissions. On the other hand, biochar amendment mixtures had increased total porosity (TP), water holding capacity (WHC), rapid thermophilic temperature, and nitrate nitrogen. However, with the most prominent effects in terms of nutrient quality and degradation rate of compost mixtures, the amendment of 10% biochar is recommended for poultry manure management through the in -vessel composting process.

Keywords: *Biochar, Swine manure, Nutrient quality, Maturity indices, Phytotoxicity.*

Wet and Dry Torrefaction of Yard Wastes for Bio-Energy Applications

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Yard waste includes grass, leaves, and tree and brush trimmings is either dumped or composed as landfills. Since the yard waste is organic in nature, it can be considered as solid fuel for further pyrolysis, combustion or gasification. The calorific value of yard waste can be improved by wet and dry torrefaction techniques. The present research was aimed to determine the energy efficient conditions for both wet and dy torrefaction of yardwastes. In wet torrefaction, the inherent relationship between fuel properties and operating conditions such as temperature, residence time and biomass/water ratio were investigated. Whereas, the operating variables investigated in dry torrefaction were temperature, residence time and type of gases. Wet torrefaction studies were done in a high pressure reactor and dry torrefaction studies were done in a tubular reactor. The fuel properties of resulted torrefied yardwaste were analysed. The mass yield decreased with the increasing reaction temperature thus reaction temperature is a significant parameter in the wet torrefaction process.

Keywords: *Torrefaction, Yard wastes, Bio-energy.*

Biochar Influences the Impact of Antibiotic in Soil

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Agricultural lands are frequently subjected to contamination of various antibiotics due to the application of manure into the field. Since 30-90% of the administered antibiotics are excreted via feces and urine, a significant portion reaches the environment. Poultry manure contains high concentration of nitrogen and other essential nutrients. However, its addition to soil is marred by the presence of antibiotics such as enrofloxacin. The presence of ENR at low concentration as 4 mg/kg also inhibits the growth of microbes. Despite the fact that enrofloxacin is a wide spectrum antibiotic, its impact on both Gram positive and Gram negative bacteria. It was hypothesized that addition of biochar to the soil could counteract the magnitude impacts of the antibiotics. In addition, it may contribute additional nutrients including traces of soluble organic carbon and other inorganic nutrients. This present study aimed at investigating the impacts of antibiotics on bacterial population in presence and absence of biochar as a mitigation strategy in an incubation study in the absence of plants. The soil, and soil mixed with poultry manure at 5% were mixed with biochar at 2%, and subsequently spiked with enrofloxacin (ENR) at 10, 50 and 100 mg/kg of soil concentrations along with suitable controls. The flasks were incubated in an oven at mesophilic temperature, and the bacterial and populations were monitored for a period of 4 weeks (1, 3, 7, 14, 21, 28 days). In addition, the physico-chemical properties of the initial soil were analysed.

The addition of biochar indeed negated the effects of antibiotics based on the bacterial population while the effects are pronounced at higher concentrations. Bacterial population increased rapidly while whether the community composition was restored is a critical question to be investigated in the future experiments. As such the impact of antibiotic in manure on the legume-rhizobium symbiosis is virtually untouched necessitating systematic investigation. The physicochemical properties like pH, EC, ammonium-nitrogen, total nitrogen, total organic carbon, available nitrogen and available phosphorus also influenced the bacterial population. After initial inhibition by the antibiotics, the bacterial population increased rapidly while whether the community composition was restored is a critical question to be investigated in the future experiments.

Keywords: *Biochar, Chicken manure, Enrofloxacin, Nitrification, Bacterial population.*

Nano-Biochar Production as A Supplementary Sector of Conventional Thermochemical Biorefineries

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Conventional thermochemical biorefineries such as torrefaction, fast pyrolysis, and hydrothermal liquefaction lack attraction for large-scale investment for biofuel production mainly due to their relatively low economic competitiveness compared with the production of other sources of fuels. Bringing the conceptions of nano-biomaterial production into conventional biorefineries is potential to enhance the overall economic gain, whist achieving the near-complete valorisation of biomass feedstocks. Biochar is one of the major products during the thermochemical treatment of biomass. Reducing the size of bulk biochar to its nanoscale to produce nano-biochar is considered as a feasible way for high-value valorisation of conventional biorefining. As an emerging area, the preparation, modification and utilization of nano-biochar is still at its infancy. Prior to a successful integrated nano-biochar and biofuel production, this study is conducted to overview recent advances in: (1) methodologies for nano-biochar preparation; (2) compositions and properties of nano-biochar with comparison to bulk biochar; (3) functionalization and applications of nano-biochar; (4) environmental implications. Perspectives on the integration of biofuel and nano-biochar for near-complete valorisation of biomass are given. This study could serve as a guideline for the upcoming researches in nano-biochar.

Keywords: *Thermochemical biorefineries, Biochar, Nano-biomaterials, Nano-biochar, Near-complete valorisation.*

Upgrade and Transformation for Biogas Plants Based on Efficient Utilization of Heat Energy

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China produces four billion tons livestock and poultry breeding per year, which brings a serious negative effect on environment. Livestock and poultry manure is transformed into biogas with anaerobic fermentation in biogas plants. It is the most common and efficient technique.

Temperature is an important factor affecting the anaerobic digestion process. In order to improve the fermentation temperature, coil heating is extensively applied in the domestic biogas plants. However, it shows low thermal efficiency. To improve the heat-transfer process regarding the slurry, rheological properties were studied, and novel twisted-tube heat exchanger for slurry from biogas plant was invented in our previous work. Here we discussed that the heat energy efficient utilization process of different scale biogas plants. For the biogas plant with less than 1000m³ AD reactor, direct feeding heating method is used. The sensitive analysis of the profit from transformed in biogas plants was carried out. Taking the biogas plant with 300 m^3 AD reactor as an example, on November, December, January, February and March, the surplus biogas produced using the new biogas slurry heat exchanger equals to 3539-14864 m^3 natural gas, and the decreased COD are 1239-5203 kg, which have a significant benefit to the biogas project with scale less than 1000m³.

For the large-scale biogas plants with 10000 m³ AD reactors, biogas boilers are applied in the waste-heat recovery systems. The heat recovered from the biogas slurry is used to compensate the heating load of the front-end regulating pool, which can not only balance the heat demand and emissions of the system, achieve energy self-sufficiency, but also maximize the benefits of the biogas project. The results show that the combination of the biogas boiler and waste-heat recovery can effectively decrease 20-35 % of the consumption of gas in biogas boiler. The biogas saved from the waste-heat recovery can be further used in power generation.

Keywords: *Biogas plants, Heat exchanger, Waste heat recovery, Heat energy utilization.*

The Use of Coconut Husk and Cattle Manure Biochars in Remediating Mine-contaminated Soil Grown with Upland Rice

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Biochar has gained global interest as soil amendment to positively affect properties of soil and subsequently improve crop yields. Numerous research investigations have confirmed that biochars can improve resource use efficiency of the land and remediation protection for any threats. Recently, biochar ability to sequester metals has caught the attention of the mine reclamation sector. Biochar application is promoted to remediate heavy metals in mine-tailing area and improve soil chemical conditions for enhanced plant growth. To study the effect of coconut husk and cattle manure biochar application on the properties of soil from mine tailing site and on the growth and yield of rice grown under upland soil condition a screenhouse pot experiment was conducted. Results showed that adding coconut husk and cattle manure biochar to mine-contaminated soil reduced the concentrations of heavy metals such as copper (Cu) and iron (Fe) in soil and plant tissues such as roots, leaves and stalks, and grains. Cation exchange capacity (CEC), organic carbon (OC), nitrogen (N), and potassium (K) were increased by application of both biochar. Available phosphorus (P) was also increased by applying biochar derived from cattle manure. Plant height, number of tillers, fresh and dry biomass, number of panicles per hill, harvested grain per pot, weight of 1000 grains, percent filled grains, harvest index, and agronomic N, P, and K efficiency were improved by adding coconut husk and cattle manure biochar with the recommended rate of fertilizer.

Keywords: *Cattle manure biochar, Coconut husk biochar, Mine-contaminated soil, Upland rice, Soil degradation, Soil quality.*

Nutrient Recovery using Biochar derived from Agricultural Waste and its Environmentally-safe Reuse

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With the introduction of strategies to improvise global agricultural sector, various challenges faced has to be addressed which includes low productivity (averaging to 60 per cent of the World average), supply chain management and product lifecycle management, and mounting threat to sustainability arising from depleting quality of natural resources, biotic and abiotic stresses, and inefficient use of agricultural wastes. The present research work attempts to narrow down the wide gap existing between the research laboratories and agricultural fields. The release of excess nutrients (nitrogen and phosphorous) through domestic wastewaters and agricultural effluents pollutes the water environment. Thus, not only poses threat to aquatic ecosystem, but also affects human health and other productive activities. The main objective of the present research work was to evolve an appropriate technique not only for the treatment of the wastewater stream but also to ensure recovery of nutrients using biochar and their environmentally-safe reuse.

Biochar as a product has many uses, including water filters and soil improvement properties. Nutrient recovery from agricultural effluents and domestic wastewater using biochar derived from agricultural waste and its reuse in agricultural fields for soil replenishment have the potential to contribute to the better nutrient stewardship and provide some degree of diversification of nutrient supply to help nutrient security in agricultural land. The present research evaluated the performance of utilization of biochar produced from agricultural wastes in the separation of nutrients from synthetic wastewater and actual wastewater (domestic sewage/ agricultural effluent). The characteristics of the biochar derived from agricultural waste before and after the experiments were determined in terms of chemical composition, surface imaging, presence of desirable functional groups, crystallinity due to presence of mineral structures, and the type of micropores. Batch studies using finite volume of mono-nutrient synthetic wastewater and actual realistic wastewater were conducted to study the adsorption behaviour, kinetics and thermodynamics. Further, continuous flow studies were also conducted using mono-nutrient synthetic wastewater and actual realistic wastewater using adsorption columns. The interferences from rest of the pollutants in the wastewater in the adsorptive separation of nutrients were revealed using sophisticated analytical techniques, a supporting mechanism for the adsorptive process was also detected in the case of realistic wastewater. Furthermore, the suitability of the pollutant-laden biochar as environmentally-safe soil replenisher was also evaluated by conducting dynamic leaching tests. A most appropriate reuse or stabilization of the spent adsorbent was also evolved based on the results of dynamic leaching tests.

The results of the research work were highly promising for field application. In addition, the study assessed more accurately the scope for the recovery of nutrients from various wastewater streams for the possible utilization in agricultural fields as soil nutrient replenisher.

Keywords: *Nutrients, Recovery, Wastewater, Biochar, Environmentally-safe reuse.*

Biochar as an Oxygen Activator and Bimetal Disperser for the Degradation of Multiple Organic Pollutants under Oxic Conditions using a Micro-electrolysis Filler

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A micro-electrolysis filler (iron (Fe)-biochar (BC)-copper (Cu)) was synthesized using BC produced from *Lycium barbarum L.* branches, modified by adding Fe and Cu in a high-temperature anaerobic process. To evaluate the applicability of Fe-BC-Cu, the effects of various reaction parameters were systematically investigated. A comparative study was conducted using three different kinds of fillers (BC, Fe-BC, and Fe-BC-Cu) to determine reaction behavior. The results suggested that the addition of Cu could enhance the removal efficiency of chemical oxygen demand, multiple organic pollutants, as well as total organic carbon. The scanning electron microscopy images of Fe-BC-Cu showed that Cu and Fe reunited into loose micro-sized balls rather than dense clusters in the presence of BC, which proved that BC was effective for avoiding bimetallic agglomeration. Meanwhile, under oxic conditions BC played the role of an oxygen (O) activator. Thus, removal by an Fe-BC-Cu micro-electrolysis filler could be explained by the synergistic effects of BC activating O to generate the hydroxyl radical (·OH), Fe/Cu micro-electrolysis and coagulation of iron hydroxide. This study has improved our understanding of the pollutant removal mechanisms in the micro-electrolysis system that occur under oxic conditions. The extraordinary removal performance of multiple organic pollutants has huge potential for the actual industrial application of Fe-BC-Cu micro-electrolysis filler.

Keywords: *Biochar, Micro-electrolysis, Organic pollutants, Bimetal disperser, Oxygen activator.*

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Influence of Biochar Amendment on Antibiotic Resistance Gene Abundance and The Bacterial Community During Aerobic Composting Of Pig Manure

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Livestock manure is often subjected to aerobic composting but little is known about the variation in antibiotic resistance genes (ARGs) during the composting process under different concentrations of antibiotics. This study compared the effects of three different dosage of biochar mixed with bacteria consortium on ARGs and the succession of the bacterial community during composting. Very similar trends were observed in the relative abundances (RAs) of each ARG among the biochar treatments and the control during composting. After composting, the RAs of tetC, tetX, sul1, sul2, and intI1 increased 2–41 times, whereas those of tetQ, tetM, and tetW declined by 48–96%. Biochar addition significantly increased the absolute abundances and RAs of tetC and in tI1, while higher dosage of biochar also enhanced those of tetM, tetQ, and drfA7. The bacterial community could be grouped according to the composting time under different treatments. The highest concentration of biochar had a more persistent effect on the bacterial community. In the present study, the succession of the bacterial community appeared to have a greater influence on the variation of ARGs during composting than the presence of antibiotics. Aerobic composting was not effective in reducing most of the ARGs, and thus the compost product should be considered as an important reservoir for ARGs.

Keywords: *Livestock manure, Antibiotic resistance genes, Biochar, Composting.*

Biochar Accelerated the Initiation of High-solid Anaerobic Co-digestion System with Pig Manure and Dehydrated Sewage Sludge

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The anaerobic digestion (AD) process was traditionally operated at low solids (TS≤8%). Comparatively, high-solid anaerobic digestion (TS ≥15%) has many advantages, such as smaller reactor volume, less energy input for heating, and easy for transportation and land application. Biochar has the characteristics of large specific surface area, rich voids and alkalinity. The use of biochar in AD reactor can alleviate the acidification of the system, increase microbial abundance and improve methane yield at a low cost. However, the dosing method of biochar (i.e. dosage, replenish, and reuse) in high-solid digestion is unclear yet. In this study, the effects of biochar on initiation of high-solid co-digestion with pig manure (PM) and dehydrated sewage sludge (SS) and were investigated.

In this study, the continuous stirred tank reactors (CSTR) under mesophilic condition (35 °C) were fed with SS and PM by gradually increasing TS from 5% to 7%, 10%, and 14%, respectively. The volatile solids (VS) ratio of SS and PM was determined by our previous study and the optimum ratio is 2:5. The TS, VS, soluble chemical oxygen demand (sCOD) of SS were 37.72 ± 0.07%, 16.58 ± 0.06%, 6.30 ± 0.18 mg/g; and PM were 23.11 ± 0.28%, 20.52 ± 0.24%, 8.17 ± 0.07 mg/g. The dosage of biochar in test reactors was set as 4 g/L and the control group without biochar supplementation were also set up. Every two days, 100 mL of effluent was replaced with equal volume of fresh feedstock to realized the o semi-continuous operation. As biochar was discharged with high-solid effluent, the biochar was added along with fresh sample at 4 g/L. The working volume of CSTR was 1.6 L and the hydraulic retention time (HRT) was set as 32 d. Biochar was prepared by using PM as the precursor, which was placed in a hydrothermal reactor at 235 ℃ for 5 h.

At the initial stage of start-up, the system adopted low organic loading rate (OLR) of 1.08 ~ 3.0 VS/(L·d)), volatile fatty acids (VFA) accumulation did not occur and methane production was relatively stable. It might also be attributed to the relatively low dissolved organic matter in dewatered SS. When TS increased to 7%, the methane production of biochar group was 39.38% higher than that of the control group; when TS further increased to 14%, the average methane production and methane production were 496.0 ± 69.2 mL/d and 247.4 ± 35.5 mL/d, respectively. The higher methane yield in biochar supplemented group indicated the promoted microbial stability. The propagation of methanogens and other slow-growing microbial communities might be accelerated by attached growth. Under the condition of high solid content (TS > 8%), the concentration of ammonia in the system presented accumulation trend, which was increased to 716.7 mg/L at TS 14%. When CSTR fed with the TS of 14%, the TS of effluent was reduced to 8.42% and VS/TS is 64.86%, which indicates that there is still some residuary methane production potential in digestate. These findings provide useful guidance for starting high-solid AD system assisted with biochar.

Keywords: *Biochar, Co-digestion, High solid anaerobic digestion, Methanogenesis, Pig manure, Total solids.*

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Bioconversion for Bioproducts

Bio-electrofermentation Coupled Ion Substitution Electrodialysis for Improved Carbon Conversion to Carboxylic Acids

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Waste-derived carboxylic acids (CAs) are gaining interest as alternative platform chemicals for the replacement of petroleum-based products. Bio-electrofermentation (BEF) has been used to overcome the thermodynamic limitations of conventional anaerobic fermentation. However, the emission of acidogenic by-products (CO_2) leads to waste of substrate carbon while accumulation of acid products can trigger product inhibition and deteriorate the micro-environment, thus reducing the production rate and yield of CAs. In this study, ion substitution electrodialysis (ISED) is proposed to separate CAs product from the anode of BEF and to reuse acidogenic CO_2 in the meantime. Mitigation of product inhibition was achieved simultaneously with pH adjustment by coupling ISED to BEF. Production of CAs was enhanced significantly after 24 days of semi-continuous operation, which was 1.06 g COD/g VSS, corresponding to 188% increase over the control. The pH in BEF-ISED integrated system was well controlled within a suitable range (c.a. 4.5-7.0) for CAs production. Additionally, integration of ISED with the anode of BEF induced the shift of bacterial communities towards CAs fermentation species of *Wolinella* and *Clostridium sensu tricot-1* by altering the micro-environment. Carbon conversion efficiency of substrate to CAs reached 90.74%, which is the highest value ever reported within the area of anaerobic fermentation.

Keywords: *Carboxylic acids, Bio-electrofermentation, Ion substitution electrodialysis, Carbon conversion, Micro-environment.*

Characterization and Evaluation of a Natural Derived Bacterial Consortium for Efficient Lignocellulosic Biomass Valorization

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A consortium (HPP) with improved ability in biomass conversion was achieved by adjusting the proportion of *Pseudoxanthomonas taiwanensis* in a natural consortium (HP), but the mechanism behind was unknown. Herein, the diversities of microbial community structure and gene functions of the consortia were analyzed first, and found that HPP had a more balanced microbial structure with enriched gene pathways related to cellular processes, environmental information processing and metabolism. Then, key genes responsible for biomass conversion were further analyzed, finding that their abundance and distribution contributed to HPP's efficient biomass conversion. Finally, consolidated bioprocessing of agricultural wastes by HPP was carried out to verify its enhanced ability, and ethanol with the highest yield that was ever reported was achieved at 0.28 g/g. This is the first study which reported the underlying mechanisms for synergistic effects of microbial consortia, and will guide the artificial construction of complex microbial consortium for specific purpose.

Keywords: *Agricultural residues, Balanced consortium structure, Cellulosic ethanol, Consolidated bioprocessing, Molecular mechanisms*.

Integrated Bioethanol and Bio-crude Production through Two-Stage Yeast Co-Fermentation and Hydrothermal Liquefaction

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Industrial symbiosis can nurture eco-revolution via reciprocal money-spinning technological innovations. Conversely, bioethanol refineries are striving to achieve minimal ethanol selling price at par with petro-fuel. This can be unravelled by a) improvising the bioethanol production process i.e., at the level of feedstock input, renewable sugar release and co-fermentation efficiency, and moderate reactor and material input, and b) through transforming the ethanol process spent streams to profitable bio-chemicals/bio-fuels. This research deals with both these aspects wherein biogenic municipal solid waste (BMSW) is employed as a sustainable feed input to produce ethanol, followed by spent stream valorisation via hydrothermal liquefaction (HTL) to produce bio-crude/ bio-oil. Central composite design (CCD) based response surface methodology (RSM) was employed to enhance and optimize bioethanol titre. The refractory architecture of BMSW was cleaved adopting green depolymerising strategy driven by in-house enzymatic concoction. In an effort to involve pentose sugar stream along with typical hexoses for ethanol production, co-fermentation of sugars was conducted using co-culture of *Saccharomyces cerevisiae* NCIM 3594 and *Pichia stipitis* NCIM 3498. Further evoking industrial symbiosis, HTL of spent feed obtained from ethanol fermentation was conducted to upgrade the waste quality through thermal depolymerisation of residual organics of MSW at high temperature and pressure using subcritical water as the solvent system. The resultant is the high energy density bio-crude similar to heavy oil derived from petroleum refining along with other valuable bio-chemicals such as fatty acids, furfurals, reducing sugars, gaseous products and biochar. Thus this study corroborates the prospect for two-stage microbial ethanol fermentation and HTL of BMSW for enhanced energy tapping in form of biofuels/ bio-chemicals that are sustainable alternatives to finite petro-fuels/petro-chemicals.

Keywords: *Industrial symbiosis, Mesophilic yeast, Sugar co-fermentation, Hydrothermal liquefaction, Bioethanol refinery, Waste valorisation.*

Concomitant Production of Extracellular Polymeric Substances (EPS) and Polyhydroxyalkanoate (PHA) from Isolated *Providencia sp:* Characterization and Composite Preparation

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Owing to their biodegradability and renewability, the biopolymers are extensively being employed in industrial and bio-medical sectors as sustainable alternatives to chemically synthesized polymers. However, the commercialization of these biopolymers is abandoned, as the downstream processing is quite exorbitant. In the present study isolated *Providencia sp.* strain depicted an efficient production of intra and extra cellular biopolymers, medium chain length-PHA (Mcl-PHA) and extracellular polymeric substances (EPS), respectively. The bacterial growth was optimised by varying parameters such as carbon load (20, 30 and 40 gL^{-1}), pH (6, 7 and 8), and C/N ratios, that ultimately enhanced Mcl-PHA and EPS productivity. The maximum yield of PHA (2.62gL^{-1}) and EPS (3.92 gL^{-1}) was observed with carbon load of 30 gL^{-1}(pH 7) at 48h and 72h, respectively. Scale-up studies were performed with the optimal conditions and the extracted EPS and PHA were blended using the biphasic solvents followed by characterization using sophisticated analyses namely FT-IR, FE-SEM-EDX, H^1 NMR, C^{13} NMR, elemental analysis, and fluorescence microscopy. Thus, the present work endeavours the opportunities for the simultaneous production of biopolymers (EPS and PHA), that proficiently substitutes the petroleum based polymers. The composites prepared exhibited better physical and mechanical properties and will have potential applications as drug delivery matrix, food packing materials, cosmetics, etc.

Keywords: *Biodegradable polymers, Process optimization, Sustainable alternatives, Bioaccumulation, Composites production.*

Effect of a Supersized Vortex Fluidic Device on the Mechanical Properties and Microstructure of a Biodegradable Film

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In this study, a process for the production of a biodegradable film with stronger mechanical properties was developed by using shear stress in a thin-film supersized vortex fluidic device (VFD). This allows the formation of a solid brick-style inner microstructure and a smoother surface without porosity in order to improve the mechanical properties, in contrast to the conventional autoclave process, which affords weaker mechanical properties an inner microstructure with cracks, and a rougher surface. Moreover, though the film produced using supersized VFD was stronger, its biodegradability was not compromised, in comparison with the film produced using the conventional autoclave process. Overall, the supersized VFD provides a new, alternative, bottom-up approach for easy, scalable processing of biodegradable films with stronger mechanical properties.

Keywords: *Vortex fluidic device, Biodegradable film.*

Cultivation of Microalgae in a Microbial Fuel Cell for Enhanced Bioelectricity Generation Treating Wastewater: A Comparative Study of *Chlorella Vulgaris* and *Scenedesmus Quadricauda*

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This study employs a microbial fuel cell (MFC) with a micro-algal assisted cathode chamber to supply the oxygen for the cathodic reaction via photosynthesis as a replacement to the traditional mechanical aeration. In this system, both anode and cathode chambers were utilized to treat wastewater with the biological actions of bacteria and microalgae, respectively. The anode chamber was supplied with wastewater containing 1500 mg L^{-1} of COD and the cathode chamber was supplied with wastewater containing 300 mg L^{-1} of NH^{+}_{4}- N. The performance of the cell in terms of wastewater treatment and bioelectricity generation was compared for two pure culture microalgae strains of *Chlorella vulgaris* and *Scenedesmus quadricauda*. The light was provided in continuous mode and alternative 12/12 hours of light/dark cycles. *Chlorella vulgaris* showed better performance with electricity generation reaching up to 0.47 mA when operated under continuous light conditions. Higher dissolved oxygen in the cathode chamber up to 13.0 mg L^{-1} was observed with *Chlorella vulgaris*. The maximum electricity generation obtained with *Scenedesmus quadricauda* was 0.34 mA. Under 12/12 hours of light/dark cycles, the electricity generation of MFC fluctuated due to the drop of the dissolved oxygen in the cathode chamber in dark conditions. The highest biomass productivity and the highest NH^{+}_{4}-N removal efficiency were achieved with *Chlorella vulgaris* under continuous light conditions. In all MFCs, more than 70% of COD removal efficiencies were achieved by anodic bacteria biofilm. *Chlorella vulgaris* showed better performance in MFC applications compared to *Scenedesmus quadricauda* with enhanced bioelectricity generation.

Keywords: *Photosynthetic microbial fuel cell, Bioelectricity, Wastewater treatment, Chlorella vulgaris, Scenedesmus quadricauda.*

Development and Process Optimization of Reactive Extraction for Carboxylic Acid Removal from High Solid Leach Bed Reactor

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Leached bed reactor (LBR) is a hydrolysis-acidification system is suitable for high solid food waste treatment. In LBR initial rapid mixed culture hydrolysis-acidogenesis process of carbohydrate-rich food waste generates leachate having a wide stream of carboxylic acids with dominant amounts of lactic acid. This leads to decrease in the pH and could alter the free energy change of VFA producing and VFA consuming reactions. Overall inhibitory effects of VFA accumulation could not only delay the acidogenesis and methanogenesis process but also increase the requirements of chemical buffering agents. The strategy of removing volatile fatty acids (VFAs) while they are being produced in LBR could help to alleviate this VFA inhibition and improve the acidogenesis and energy recovery process in LBR.

As a first step, reactive extraction (RE) systems were investigated for the extraction of multiple acids towards developing LBR-VFA extraction system. A wide screening of diluents in combination with extractants was performed and VFA extraction efficiencies for different RE systems were investigated. Synthetic solutions containing equimolar concentrations of individual VFAs were prepared. During physical extraction (PE) experiment, diluents including alkanes, alcohols, esters, and ketones were used alone. For RE, these were combined with extractants such as [Tri-n-octylphosphine oxide (TOPO), tri-n-butyl phosphate (TBP) & Aliquat 336]. Since RE is dependent on extractant & solute concentration selected amine-based RE system (Aliquat 336-Butyl acetate/MIBK) from the first experiment was further evaluated using a range of extractant concentration(0.25, 0.5, 1M) for VFA extraction from LBR leachate samples having different lactate (6-12 g/L) and acetate (0.4-1.25 g/L) concentrations. Extraction was carried out using a different time period (1min, 2.5 min, 5 min, 10 min,16h) to check the efficiency of RE.

P-bonded (TOPO-heptane/Methyl isobutyl ketone (MIBK) and amine-based (Aliquat 336-Butyl acetate/MIBK) RE demonstrated higher distribution coefficients (K) and extraction yield (E %) of the VFAs as compared to the PE process. The off-line RE were promising and extraction efficiencies of 65% (Lactic acid), 75% (Acetic acid), 86.2% (Propionic acid) to almost 100% for long-chain fatty acids (eg. butyric acid, valeric acid and caproic acid) were reached using Aliquat 336 with butyl acetate and MIBK. Results depicted that Aliquat 336-MIBK and Aliquat 336-Butyl acetate performed better than other extractants for lactic acid extraction from synthetic VFA mix. In offline optimization study, an increase in the E % and K was observed with the increase in the extractant (Aliquat 336) and solute (acetate and lactate) concentration and maximum extraction efficiency were observed with 1M of Aliquat 336 concentration. The effects of time on RE depicted that, with the increase in time, E% & K of acetate and lactate was increased. 38.7% acetate & 61.8% lactate was extracted from leachate within 10 min using 1M Aliquat 336-MIBK and 1M Aliquat 336-Butyl acetate respectively. Significant effects of solute concentration on RE was observed as the result shows a linear increasing the trend of K & E% for acetic acid and lactic acid using 1M Aliquat 336-MIBK. However, Aliquat 336-Butyl acetate RE was not effective for acetate extraction as only 18% acetate extraction was achieved within 10 min. For lactic acid, the rate of increase in E% was observed maximum at higher lactate concentration (>10 g/L) for both extraction systems. The increase of acetate and lactate concentration in the leachate had increased the E% of acetic acid and lactic acid by 36% and 51%.

Lactate and other short-chain fatty acid extraction from LBR expected to decrease the requirement of chemical buffers and increase acidogenesis efficiency. Overall, this experiment forms the basis for the development of in situ acidogenesis integrated VFA removal model where energy recovery efficiency can be increased by reducing VFA inhibition and improving leachate characteristics.

Keywords: *Acidogenesis, Leachate, Lactic acid, Reactive extraction, Distribution coefficient*.

Hydrothermal Carbonization of Mango Kernels

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Mango which was traditionally eaten fresh has in recent times been turned into a cash crop due to recent advances in processing techniques. Significant quantities of mango fruits are now processed into either dried mango cakes or processed into fruit juice. Mainly grown in tropical areas, mango production has seen a 75% increase in production from 2003 to nearly 43 million tons in 2016 (UNCTAD, 2016). Geographically, Asia accounts for more than 72% while Africa accounts for nearly 17% of the world's production. Processing of the mango fruits leaves in its wake a significant portion of the fruit which constitutes the seed. The mango seed shell and kernel accounts for 30 - 45% of the gross weight of the fruit (Gautam Ganeshan, 2016). Thus about 12 million tons of mango seeds residues are generated annually. Due to the high moisture content of the kernel (40%) and mango endocarp (67%) (Cristian Torres-Leóna, 2019)seed and the fibrous mesocarp which may contain high amount of lignin, direct thermal and biological treatment may be limited. The current study investigated the carbonization of the seeds as potential energy carriers through hydrothermal carbonization under sub-critical conditions. Keeping the mass fraction and particle size constant, the reaction time and the reaction temperature were varied between 4 – 6 hrs and 200 – 240 ^{o}C respectively. The results show that the fuel properties of the carbonized mango seeds improved. The thermal heating value increased from 18.70 MJ/kg (untreated seeds) to about 28 MJ/kg and correlated positively with the severity of treatment. However, a negative correlation was observed between process severity and the mass yield. The yield was observed to decrease with increasing severity of treatment. Further analysis of the fixed carbon content, thermal degradation, and interaction between process parameters and response factors are ongoing. Additionally, analysis of the wastewater to determine the usability or otherwise of the HTC process water is ongoing.

Keywords: *Hydrothermal carbonization, Mango kernels.*

Importance of Sludge Conditioning in Attenuating Antibiotic Resistance: Removal of Antibiotic Resistance Genes by Bioleaching Conditioning and Subsequent Composting

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Conditioning can drastically improve the dewaterability of sewage sludge and thus it is widely practiced in most wastewater treatment plants (WWTPs). In WWTPs, various antibiotic resistance genes (ARGs) present in sewage are concentrated in the sewage sludge, but the effect of sludge conditioning and subsequent composting on ARGs in sludge remains unclear. Here, we investigated changes in 46 target ARGs and *intI1* during the sludge conditioning treatments and the subsequent composting of dewatered conditioned sludge, to find a useful way to attenuate antibiotic resistance genes in sewage sludge. The effectiveness of different sludge conditioning methods (namely chemical conditioning with PAM, chemical conditioning with Fe[III]/CaO, bioleaching conditioning, and chemical acidification conditioning) in removing ARGs and *intI1* from a municipal sewage sludge was compared by using real-time quantitative PCR, and their impacts on the damage of sludge microbial cells and the sludge bacterial community composition were respectively evaluated by using flow cytometry and illumine sequencing of bacterial 16S rRNA genes. The chemical conditioning with Fe[III]/CaO and bioleaching conditioning drastically reduced both the absolute and relative abundances of most ARGs in the sludge via damaging the bacterial hosts carrying ARGs, which could not be achieved by the other sludge conditioning treatments. In addition, the abundances of ARGs were further reduced after the composting of dewatered bioleached sludge, and the mature and stable compost products with low abundance of ARGs were successfully obtained. Therefore, sludge conditioning can be an important sludge treatment process in attenuating antibiotic resistance in sewage sludge, and the combination of bioleaching conditioning and subsequent composting of dewatered bioleached sludge can be employed as an effective conditioning way to reduce ARGs in sewage sludge, potentially limiting their release to the environment.

Keywords: *Sewage sludge, Antibiotic resistance genes, Removal, Conditioning, Composting.*

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 protecctants 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 *Bacillus 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 polyhydroxyakanoate 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.*

Environmental and Health Risk Assessment of Techniques for Anaerobically Digested Manure Centrate: Comparative Investigation between Denmark and China

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Large-scale and intensive livestock industry has globally developed over the last a few decades to satisfy our rising demand on meat, dairy and eggs. This scenario, on the other hand, has resulted in the overwhelming production of livestock wastes, and thus, threatening our sustainable agricultural production. As a well-established technology, anaerobic digestion has been widely implemented for the treatment of livestock wastes with the production of biogas, a source of renewable energy, and digestate, high quality organic fertilizer. In practice, digestate is typically separated into biosolids and highly concentrated liquid, which is also commonly named as digested manure centrate, for effective management. Biosolids are easily handled to produce organic compost, while digested centrate remains challenges, given the imbalance between its continuous production and seasonal agricultural activities.

A series of mature techniques and modes have been applied for the management of digested manure centrate around worlds. These techniques have significant regional features and mainly involve in onsite storage and agricultural spreading, additional concentration for the production of high qualify liquid fertilizer, advanced treatment and clean water reuse or discharge. Thus, this study aims to compare environmental and health risk of techniques and modes that are widely used for the management of digested manure centrate in China and Denmark. Material flow analysis and total life cycle assessment of digested manure centrate from production to application will be performed. Both nutrients and contaminants (i.e. heavy metals and antibiotics) will be included in material flow analysis. Results from this study will provide important advices to advance the management of digested manure centrate depending on local traits.

Keywords: *Livestock wastes, Anaerobic digestion, Digested centrate, Environmental and health risk.*

Polyhydroxyalkanoates (PHA) Production using Bacterial Strains

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Enormous usage of plastics in packaging and other products has been creating major problem in disposal. These non-degradable petrochemical plastics are accumulating in the environment at a rate of 25 million tones/year. In response to this problem and harmful effects on the environment, considerable interest is developed in producing biodegradable plastics. Bioplastics are a special type of biomaterial produced by a range of microbes, cultured under different nutrient and environmental conditions. These polymers are accumulated as storage materials allowing microbial survival under stress conditions. The number and size of the granules, the monomer composition, macromolecular structure and physico-chemical properties vary, depending on the producer organism. The search for biodegradable plastics has led to a number of partially and completely biodegradable products. Amongst all, microbially-formed polyhydroxyalkanoates (PHAs) offer much potential for the preparation of 'bioplastics' which are a group of biologically derived polyesters. A detailed study was performed to evaluate the PHAs production using different bacteria. These PHAs are easily biodegradable and can be considered as one of the tools to clean the environment.

Keywords: *Polyhydroxyalkanoates, Bacterial Strains, Plastics.*

Bioflocculant Production by Newly Isolated Bacteria from Activated Sludge using Fish Market Waste as a Nutrient Source

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The fish market waste is one of the serious environmental concerns due to its higher odor and vigorous microbial growth. Hence the bioconversion of fish market waste (FMW) into valuable bio-products is of the great interest. In this study, several bioflocculant producing bacterial strains were isolated from the activated sludge collected from a domestic sewage treatment plant among them the UKD24 was showing the potential of higher bioflocculant production. The UKD24 utilized glucose as its major carbon substrate while it utilized broad range of nitrogen substrates. Hence the fish market waste was adopted as a cheap nitrogen substrate for the bioflocculant production. The production parameters were optimized by Box-Behnken design. This UKD24 strain was characterized through biochemical and 16s rRNA sequencing analyses. The optimum range of higher bioflocculant production was 6-8. When FMW was supplemented as the nitrogen source the bacteria was able to produce ~ 92% flocculation at 48 hours growth. The best composition for the higher production revealed resonance surface methodology (RSM) was 10 g L^{-1} glucose, 1.25 g L^{-1} and 10% inoculum size. The produced bioflocculant was Ca^{2+} cation dependent which showed it showed its nontoxic nature for waste water treatment applications. Moreover the bioflocculant had polysaccharide as its major backbone which provided the good pH and temperature stability. The FTIR revealed functional groups were mostly related to the protein and carbohydrate residues. Further the excitation emission matrix (EEM) and principle component analyses (PCA) were confirming the composition of the bioflocculant. The obtained results confirmed that the UKD24 is a potential bioflocculant producer and which could effectively utilized the FMW as its nutrient substrate for the production a valuable bioflocculant.

Keywords: *Bioflocculant, Fish market waste, Flocculation activity, Activated sludge.*

Cell Factories for Bulk Chemical Production from Industrial Side Streams

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Carbon efficiency is one of the crucial parameters for the development of sustainable industrial processes. Therefore, any carbon containing side stream of a given process, which is not valorised is problematic. It is not only a waste problem and a potential loss of money, but it also spoils a possibility to increase overall carbon efficiency and thereby compromises efforts to become sustainable.

Microbial processes are one option among others for the valorisation of carbon containing industrial side streams. They offer many advantages as processes involving them are usually environmentally benign and proceed without extreme pressures or temperatures. However, often they suffer from low productivities and low yields. Many industrial side streams are contaminated with substances, which are toxic for microorganisms, aggravating the challenge of low productivities and yield. However, proper purification of the carbon source is costly and therefore most of the times not feasible on economic scale. One process requirement is therefore the identification of microbial cell factories, which can cope with the given constraints.

Lactic acid bacteria are an interesting group of organisms in this context, as they show often a remarkable resistance against inhibiting compounds and conditions. In this contribution we will show case two lactic acid bacterial species – *Enterococcus mundtii* and *Lactobacillus diolivorans*, which have been identified as superior microbial cell factories. One is being established as cell factory for lactic acid production from a wood pulping side stream, the other as base chemical producer from oleochemistry side streams.

Keywords: *Industrial microbiology, Industrial side streams, Lactic acid bacteria, Wood pulping side stream, Spent sulfit liquor, Crude glacerol.*

Extraction of Pectin from Citrus Limetta Peel: An Approach Towards Waste Management

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Pectin is an industrially important compound that is used as a food additive or gelling agent. Extraction of pectin from C*itrus limetta* peel is an economic and eco-friendly approach to obtain pectin while simultaneously reducing the waste management problem. Pectin is a cementing material between plant cell walls, comprising of repeated units of galacturonic acid (GalA). Ultrasound Assisted extraction (UAE) of pectin from *Citrus limetta* peel was investigated and optimised using Response surface methodology (RSM). To optimize the extraction conditions, a five-factorial Box–Behnken design (BBD) was employed with varying process parameters such as pH (1-3), extraction time (5-32 min), duty cycle (5-25 sec), amplitude (40-100), and liquid-solid ratio (14-30). Based on the series of experiments the optimized process parameters for pectin extraction were at pH 1 for 19 min extraction time at amplitude of 70 with a duty cycle of 15:15 and solid liquid ratio of 1:22 g/mL. The maximum yield obtained in the process was 35.582%. The predicted values (27.030%) of BBD were further validated and were found in agreement with experimental yield (25.326%). The moisture content, ash content, and degree of esterification were 8.9%, 2.33%, and 64.03%, respectively. FTIR analysis also confirms the functional groups similarity between commercial and extracted pectin. UAE significantly reduces extraction time, temperatures, and energy consumption of the process. Thus this process can be efficiently employed to meet the global demand of pectin.

Keywords: *Ultrasound; Pectin, Citrus limetta, Valorization, Response surface methodology, Process Parameters.*

Influence of Iron Nanoparticles on *Bacillus subtilis* Growth and Production of Value Added Products in Electrofermentation System

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Environment conditions can play a major role in controlling the metabolic pathways of bacteria and production of value added products (VAP). Both the oxidation states of iron [ferrous (Fe^{2+}) and ferric (Fe^{3+})] has the capacity to act as a catalyst in biological systems. The overall objective of this study was to examine the effect of iron nanoparticles on the growth of *Bacillus subtilis* along with the production of VAP in a single chamber electrofermentation system. The nanomaterials prepared by hydrothermal synthesis was varied from 1 mg/l to 150 mg/l. The results were analysed according to the concentration of the materials and the interaction time between the bacteria at the different concentration. Both positive and negative results were found indicating that iron plays a major role driving the metabolic pathways in bacteria. As the concentration of the materials increased, the growth of *Bacillus* was inhibited as well as biofilm formation reduced. While at low concentration, the production of VAP enhanced signifying iron as a catalyst increasing the electron transport within the bacteria. The diverse functions of iron in bacterial cells namely cell composition, primary and secondary metabolism, catalytic and enzymatic activities is also discussed along with the growth kinetics of bacteria.

Keywords: *Fe nanoparticle, Value added products, Bacillus, Growth kinetics.*

Groundnut Oil Cake: Useful Nutrient for Pullulan Production by Micrococcus Luteus

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Pullulan is one of the most essential exopolysachharides (EPS) of α(Glucan) units in which most commonly α(1→4) linkage predominate. In the present study, four different agro-industrial wastes namely Groundnut oil cake (GOC), Sun flower oil cake (SuOC), Coconut oil cake (COC) and Mustard oil cake (MOC) were evaluated for pullulan production in solid state fermentation by Micrococcus luteus KX261689. Under the experimental conditions, Groundnut oil cake (GOC) resulted in highest concentration of pullulan (45.26 g/L) among the four solid substrates. Optimum initial pH and moisture content and fermentation time for pullulan production were found out to be 6.5 and 40 %, and 6 days respectively. The present peaks in the FTIR spectrum validated that the obtained purified precipitate was composed of pullulan. XRD analysis showed that the produced pullulan had a fully amorphous structure. A face central composite statistical design was conducted to find out interaction between fermentation time, concentration of GOC, and initial pH value. Results from the study are promising for the economic utilization and value addition of these important agro residues, which are abundantly available in many tropical and subtropical countries.

Keywords: *Pullulan, Micrococcus luteus, Solid state fermentation, Groundnut oil cake, FTIR.*

Untangling the Genome of Rare Uncultured Bacterial Species from Plant Biomass Hydrolysing Microbiome

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Reconstruction of genomes from environmental metagenomes offers great prospect to study the metabolic potential of organisms that are resilient to isolation in the laboratory condition. Here, we were able to assemble 12 high quality draft genomes with an estimated completion of ≥90% from cow (NDC_DR) and buffalo (NDB_DR) rumen metagenomic dataset. By clustering genomes based on average nucleotide identity, majority of these metagenome-assembled genomes (MAGs) were broadly classified as Firmicutes and Bacteroidetes. Comparative analysis reveals that nearly 42% of MAGs represented un-sequenced genus and species, not available in current reference databases. A composite bioinformatic analysis of the MAGs scaffolds using multiple databases (SEED, KEGG, dbCAN) provided a detailed information on the functional attributes of the MAGs. Gene prediction led to the identification of 30,359 protein-encoding genes (PEGs) across 12 MAGs, of which only 44.8% (13,611 PEGs) were annotated against a specific functional attribute. 69,000 were projected to be involved in carbohydrate metabolism. A comparatively higher proportion of carbohydrates associated genes in MAGs, comprising 11.28-22.99% of the total SEED annotated genes indicates relatively high enzymatic activity towards carbohydrate metabolism. Further analysis revealed the presence of 985 carbohydrate active enzymes (CAZymes), covering members from more than 50 glycoside hydrolase family and other CAZymes families. Over 90% of which do not have a good match in the CAZy databases. Additional screens and data mining revealed the presence of an exceptionally high frequency of plant biomass deconstructing gene in Bacteroidetes MAGs (especially B1_2 and C1_22 MAG) as compared to Firmicutes, thus establishing their significant role in plant biomass deconstruction. The results strongly indicate that rumen chamber harbours high numbers of deeply branched and as-yet uncultured microbes that encodes novel CAZymes, candidates for potential use in plant biomass-hydrolyzing and biofuels industries. The inclusion of the 12 MAGs presented here will expand the genomic representation of rumen microbial lineages in the public databases which will further improve the annotation of multi-omics data.

Keywords: *Binning, Genome, Firmicutes, Bacteroidetes, CAZyme, Metagenome-assembled genomes (MAGs).*

Deoiled Cake as An Alternate Substrate for Green Energy Production

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Energy is one of the inevitable and ever demanding need of the world. The world today is going through energy crisis as the fossil fuel are at the brink of extinction. This has led to the search for alternate energy sources. Biohydrogen and Methane are two such sources widely studied. Biohydrogen is carbon neutral fuel which produce only water during combustion and thus is most promising fuel. Methane has an advantage over other fuel as it does not produce NOx, SOx and has lower CO_2 emission which makes it environment friendly. Both hydrogen and methane have high commercial interest with energy density. There are many studies on hydrogen production but are not of commercial interest as high cost of the substrate. The low-cost substrate can give a push to the commercialization of biohydrogen as fuel. Organic waste of oil industry which is the solid residue after the extraction of oil from seeds are deoiled cake. These deoiled cakes can be used as an alternate substrate for biohydrogen and methane production as it has high organic content. In this experimental study anaerobic digestion of ground nut oil cake was carried out for biohydrogen and methane production. Total solid content of Groundnut deoiled cake (GDOC) was 91.9 ± 0.23%. It showed pH 7.2 with 94.99 ± 0.18% presence of volatile solids. The reactor for biohydrogen was inoculated with acidogenic organism and observed for 3 days. The reactor for methane production was established with 8% total solids and 1:1 Inoculum to substrate ratio (ISR) was observed for a 60 days solid retention time (SRT). Cattle dung was used as inoculum. The gas produced was measured daily by liquid displacement method. The content of produced gases (biohydrogen and methane) will be discussed as obtained by Gas chromatography technique.

Keywords: *Deoiled cake, Anaerobic digestion, Biohydrogen, Biogas, Gas chromatography.*

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Bioconversion for Biofuels

Biotransformation of Organic Substrates to Biofuel and Bioproducts by *Thermotoga neapolitana*

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The environmental impact of excessive exploitation of fossil fuel reserves has inspired several sustainable neo-carbon-neutral technologies. To that end, biological processes like dark fermentation may be leveraged to bioconvert carbohydrate-rich feedstocks to fuels like hydrogen (H_2) or commercially valuable organic acids like lactic acid. Capnophilic lactic fermentation (CLF) is a novel anaplerotic pathway able to convert acetic acid to lactic acid using CO_2 as a carbon enhancer in the hyperthermophilic bacterium *Thermotoga neapolitana*. In this study, we investigated the effect of temperature (50-90 ^oC), salinity level (0-60 g NaCl/L), buffering agent (bicarbonate, phosphate, MOPS, TRIS, and HEPES), and carbon source (arabinose, xylose, glucose, fructose, lactose, sucrose, starch, carboxymethyl cellulose, and laminarin) on the simultaneous production of H_2 and L-lactic acid under CLF conditions. Batch experiments were performed either in 120 mL serum bottles or with a 3.0 L pH-controlled continuous stirred-tank reactors (CSTR) system. The experimental data showed that *T. neapolitana* grew well at 70 and 80 ^oC whereas no growth was observed below 60 and above 80 ^oC. The largest H_2 and acetic acid production were between 10 and 30 g/L of NaCl, whereas the lactic acid production increased up to 50 g/L NaCl. All buffeting agents showed similar metabolic profiles under CLF conditions except for the experiment without any buffering agent. The study reveals the robustness and flexibility of the CLF-based technology using *T. neapolitana* fermentation under various operating environmental conditions. In this context, the application of microorganisms for the biotransformation of organic waste to renewable energy and valuable chemicals would increase resource recycling and support the circular economy.

Keywords: *Fermentation, Thermotoga neapolitana, Organic waste, Biofuel, L-lactic acid.*

Improvement of Sludge Dewaterability by Anaerobic Digestion and Mechanism Analysis Based on Moisture Distribution

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Anaerobic digestion (AD) has been the main technology of realizing sludge stabilization and reclamation. The degradation process of organic matter limited by the degree to which the moisture combines organic fractions in sludge variation, sequentially influenced the moisture distribution in the sludge, consequently having an effect on sludge dewaterability. The objective of this study was to investigate sludge dewaterability in terms of moisture distribution in sludge and bond energy under anaerobic digestion, and the mechanism of AD enhanced sludge dewaterability. Moisture distribution and bond energy were used to evaluate sludge dewaterability undergoing AD. The impact of moisture distribution and organic fractions in sludge dewatering during an AD process was analyzed. Results indicated that AD altered mechanically bound moisture (MBM) transformed into free moisture (FM); thereby improving sludge dewaterability. The relationship between FM and MBM was studied using low field ^{1}H nuclear magnetic resonance, with statistically significant results (R=-0.912, p<0.01). Correlations between FM/MBM with extracellular protein (extra-PN) were also significant (R=-0.861, p<0.01/ R=0.869, p<0.01). Results presented will provide a better understanding towards having better control of the reduction of sludge.

Keywords: *Moisture distribution, Anaerobic digestion, Dewaterability.*

Production of Xylitol by Immobilized *Candida Tropicalis* Ebl-X39 Cells from Rice Straw Hydrolysate

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Xylitol, a rare pentose sugar alcohol, has received wide global demand due to its unique properties like insulin independent metabolism, anticariogenicity, laxative nature, sweetening power similar to sucrose, low-calories and absence of Maillard reaction. It is approved for usage in food, health and pharmaceutical products in many countries. Currently, most of the xylitol is produced by catalytic reduction of D-xylose in the presence of catalyst Raney nickel under elevated pressure and temperature conditions at industrial scale but this chemical process is complex, laborious, cost and energy intensive. Alternatively, two biotechnological approaches for xylitol production i.e. fermentation process (using whole cells) and enzymatic approach (using xylose reductase) are more promising. The use of whole microbial cells has many advantages over other processes such as low production cost due to absence of purification steps and requirement of moderate conditions. D-xylose, one of the most abundant pentose sugars, is predominantly present in the hemicellulosic sugar of hardwoods and agricultural residues. The abundance and ease of isolation of D-xylose from agricultural residues make it a potential feedstock for the production of xylitol. Keeping in view the above facts and applications of xylitol in addition to abundance of agricultural waste as raw material, the present study has been conducted for the production of xylitol from rice straw hydrolysate using whole cells of an isolated strain of *Candida tropicalis* EBL-X39 immobilized in sodium alginate beads. Various immobilization parameters were optimized to obtain efficient and stable beads for maximum production of xylitol. The maximum utilization of xylose of 68.7% was obtained with xylitol yield of 0.54 g/g (of xylose) after 100 h of incubation under optimized immobilization conditions at pH 6.5 at 30°C. The maximum xylitol yield of 0.72 g/g and 0.54 g/g was achieved when tested under agitation (100 rpm) and stationary conditions, respectively, after 80h and 100 h of incubation. The reusability of the prepared beads was also tested for production of xylitol in batch system using rice straw hydrolysate (obtained after acid hydrolysis using concentrated sulphuric acid). The xylose utilization of 71.4% with yield of 0.63 g/g was obtained in the first cycle and xylose utilization was reduced to 14% with xylitol production of 0.1 g/g during 7^{th} cycle. The ability of immobilized cells for xylitol production was also tested by successfully operating the continuous system in the form of packed bed reactor system for 7 days using rice straw hydrolysate. It is concluded from these studies that agricultural residues like rice straw can be used as raw material for bioproduction of xylitol using immobilized yeast cells.

Keywords: *Xylose, Xylitol, Rice straw, Candida, Bioconversion.*

Effects of Biochar and Maize Stover Mulch on the Physical Properties of a Sandy Loam Soil and Maize Yield

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Field studies on modification of charcoal (CH), maize stover biochar (CMS) and maize stover mulch (UNMS) on soils' physical properties was conducted on a sandy loam soil (Chromic Lixisol). We had hypothesized that: a) the CH and CMS would improve yields of maize by improving the soil physical conditions that affect crop performance, b) the CMS would give a better nutrient and environmental management option than the raw feedstock (UNCMS) used as stubble mulch. The CMS was prepared at 420 ^{o}C using muffle furnace; and at a low heating rate of 0.1 ^{o}C/second from ambient temperature. The experiment followed a randomized complete block design (RCBD) with four treatments replicated three times. The treatments were: a) 5 t ha^{-1} CMS; b) 14.6 t ha^{-1} dried uncharred maize stover mulch (stubble); c) 5 t ha^{-1} CH and d) a control plot. Each of the 12-plot size measured 7.2 m^2 (3 m x 2.4 m), and a distance of 2 m was left between plots of adjacent blocks. The maize was sown at a rate of 12 plants m^{-2}, leaving 60 cm between rows and 40 cm between plants. Mounted on an automatic weather station (AWS), a DL2e data logger from Delta-T Devices Ltd. was used to automatically record and store soil moisture (T_p), temperature (T_m) and surface temperature (T_c) data (half-hourly averages of 30 seconds) from sensors. Three analogue cards were installed giving a total of 36 differential channels to which 12 ThetaProbes – type ML2x, 12 thermistors, and 12 thermocouples were connected for the T_p, T_m and T_c respectively. One of the 12 T_p, T_m and T_c sensors was allotted to each of four treatments in triplicates. The T_c and T_m sensors were installed at 2 cm and 10 cm respectively, and the T_p sensor installed at 10 cm depth below the soil. The stored data were downloaded and analysed. The output of the T_p, in millivolts (V), was converted to a volumetric soil moisture unit (θ_v %) using the formula:

$$\theta_v = \frac{(1.07 + 6.4V - 6.4V^2 + 4.7V^3) - 1.6}{8.4}$$

Data sets obtained were tested for normality, before using ANOVA from GenStat^{TM} statistical software (13th edition) for analysis. The following results were observed:

1. Higher moisture content ($p < 0.001$) in the UNMS amended plot was observed. This was followed by CH plots ($p = 0.009$) as compared to the CMS; and CMS plots more than ($p = 0.028$) control (CTR) plots;

2. UNMS amended plots were warmer at nights, but cooler during the day. On the contrary, CTR plots were cooler at nights but warmer during the day, but CH and CMS plots were warmer at night and cooler in the day compared to CTR;

3. Maize yield parameters (fresh stover, cob, de-husked cop and grain yields) were numerically higher in UNMS amended plots compared to others. This was followed by CH, then CMS and CTR in that order.

From the observations, UNMS presents a better option in terms of the soil's environmental and nutrient management resulting in increased maize yields. However, because it decomposes faster and releases CO_2 into the atmosphere, the CMS would be a better option in terms of carbon capture and storage in the soil, on the assumption that the charred material stays longer in the soil than the feedstock.

Keywords: *Biochar, Maize stover mulch, Maize yield*.

Study on the Migration Behavior of Heavy Metals and Characteristics of Phosphorus-enriched Biochar Prepared by Microwave Pyrolysis of Municipal Sewage Sludge

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Municipal sewage sludge is a kind of typical biomass waste, its output is increasing year by year and the phosphorus content is abundant. It could not only realize the efficient collaborative treatment of municipal sewage sludge, but also realize the recovery and utilization of phosphorus to convert municipal sewage sludge into phosphorus-enriched biochar, which is in line with the sustainable development concept of waste management. However, the heavy metals restrict the utilization of phosphorus-enriched biochar, therefore, it is significant and necessary to clarify the migration behaviour of heavy metals.

In this paper, Microwave Pyrolysis was adopted to produce the phosphorus-enriched biochar. On the basis of exploring the effects of microwave power, temperature and additives on the characteristics of phosphorus-enriched biochar, the influence of individual and interaction effects of different additives on the migration and transformation of phosphorus were deeply studied. In addition, the leaching characteristics, occurrence forms and fixation mechanism of heavy metals were investigated. Finally, the safety of phosphorus-enriched biochar was evaluated via the methods of OPTI and RAC risk assessment.

The results showed that the pH, BET and total phosphorus (TP) contents of phosphorus-enriched biochar increased with the increase of microwave power and temperature, and the maximum TP contents was 42.7 g / kg. ID / IG increased first and then decreased, it reached the maximum when the power was 1600 W and the temperature was 500 °C, respectively. It was found that temperature was an important factor affecting the conversion of amorphous carbon to graphene like structure. In addition, the addition of CaO could effectively promote the transformation of non-apatite inorganic phosphorus (NAIP) to apatite inorganic phosphorous (AP) (mainly $Ca_9Al(PO_4)_7$, $Ca_3(PO_4)_2$, $Ca_3Mg_3(PO_4)_4$, $Ca_{10}(PO_4)_6(OH)_2$). The addition of $MgCl_2$ promoted the conversion of AP to NAIP (mainly $AlPO_4$). When CaO and $MgCl_2$ were added at the same time, they showed antagonistic effect, and CaO played a leading role. Microwave pyrolysis had a good passivation effect on heavy metals in phosphorus-enriched biochar. Under some conditions, the leaching amount of heavy metals was zero. It was found that the increase of aromatic structures, the enhancement of polarity and alkalinity, the formation of crystal structures and complexation reactions, the strengthening of pore structures, and the densification process of phosphorus-enriched biochar surface were the main mechanisms for the immobilization of heavy metals in municipal sewage sludge during microwave pyrolysis.

Keywords: *Municipal sewage sludge, Microwave pyrolysis, Phosphorus-enriched biochar, Heavy metals.*

Assessing Biochars as Bio-products from Slow Pyrolysis of Different Organic Resources and Evaluate Properties as Soil Conditioners

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Biochar application is a rapidly emerging innovative technology to improve the health of intensively cultivated soils. It is also an alternative and beneficial strategy in managing animal manures and plant residues. Biochar properties are highly influenced by pyrolysis conditions and characteristics of organic materials when use in improving soil conditions. A series of comprehensive studies were conducted to produce biochars using slow pyrolysis biochar-producing stove at temperatures ranging from 300 to 650°C. Twelve (12) different organic resources (3 animal manures and 9 plant residues) were prepared for thermal treatments to assess the bio-product process and evaluate biochar properties as soil conditioners. This paper discusses the results of using material imaging techniques (Field Emission-Transmission Electron Microscope for surface morphological changes of biochars; Scanning Tunneling Electron Microscope Analysis in obtaining High Angle Annular Bright Field images and Brunauer-Emmett-Teller Automated Nitrogen Multilayer Physisorption system for physical properties) in ensemble with spectroscopic techniques (Energy Dispersive X-ray analysis on the areas of interest of each biochar samples) to elucidate the chemistry of biochars and the adsorbed nutrients onto them. The elemental analyses of biochars were carried out using conventional procedures. In these studies slow pyrolysis pointed the differences in bio-product production (amounts of feedstocks, residence time and biochar yield) of different organic resources. The concentration of nitrogen (N) in all biochars was relatively low. Varying but all 12 biochars had an alkali pH. Biochars produced from cattle manure resulted to have more carbon (C) and potassium (K) as compared to the biochars from swine and carabao manures. The amount of phosphorus (P), zinc (Zn) and copper (Cu) in swine biochar were found highest among the animal wastes. Amongst the plant wastes, biochar produced from water hyacinth gave the highest concentration of C, N, K, Ca, Mg and Mn. The porosity of all biochars was highly variable. Comparison among the variety of origins, apparent differences were observed on the surface area of biochars derived from coconut husk and cattle manure. Both biochars showed the highest porosity among plant and animal wastes, respectively. The physical and chemical characteristics of biochars influence their effectiveness in controlling the retention/adsorption of nutrients. The micro and nanostructures of biochar are also affected by many of the same parameters influencing the chemical and physical properties, confirming that the structures of biochars are highly heterogeneous and complex. Results such as these concurred with the pyrolytic process of biochar production which properties and mineral agglomerates substantiate that biochars can be used as soil conditioner in the improvement of soil fertility and soil health.

Keywords: *Organic wastes, Slow pyrolysis, Soil amendment, Soil degradation, Soil fertility.*

Multi-Stage Computer Aided-Molecular Design (CAMD) Approach in Bio-Oil Solvent Design to Upgrade Bio-Oil Quality

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As one of the world's largest palm oil producer, a vast amount of oil palm biomass wastes were generated daily in Malaysia, which leads to disposal problem. With fast pyrolysis technology, these biomass wastes can be liquefied into bio-oil through a simple thermochemical process. However, direct application of fast pyrolysis bio-oil as a biofuel is limited due to its undesirable properties such as low heating value, high viscosity, high corrosiveness and storage instability. Solvent addition is a simple way of upgrading bio-oil to improve some properties of bio-oil, which helps for further processing and storage. Current work aims to design optimal solvents that improve the properties of bio-oil while displaying desirable targets properties and minimal environmental impact. Thus, a novel multi-stage computer-aided molecular design (CAMD) approach is proposed. The procedure started with definition of the molecular design problem where the product needs were determined accordingly based on the requirements from regulations and specifications. The identified product requirements are translated into measurable quantitative target properties such as density, viscosity, higher heating value and etc. In this work, ASTM D 975 and EN:590 standards of diesel fuel are taken into account while defining the property targets. Following on, suitable property prediction models are selected to estimate the targeted physicochemical and environmental properties of solvents. However, the property prediction models were expressed in the form of different indexes, especially for environmental properties. Thus, the molecular signature descriptor is introduced and served as a common platform to solve the CAMD problem simultaneously. Due to the combinatorial nature of higher-order signatures, the complexity of CAMD problem increases as the height of signature increases. For this reason, a multi-stage framework is developed to reduce the size of CAMD problem by only generating higher-order signatures that are consistent with each other. After determining all possible solvents, the thermodynamic property, Gibbs free energy of mixing was conducted to evaluate the stability and miscibility of the solvent-oil blend.

Keywords: *Fast pyrolysis bio oil, CAMD, Solvent.*

Refuse Derived Fuel as A Source of Energy Production: A Way Towards Sustainability

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One of the world's most pressing concerns has been the energy crisis. As the country strives to become an industrialized nation, the Municipal Solid Waste amount is expected to go up significantly in the near future. It is desirable that the waste can be used as an advantage to humankind. RDF (Refuse Derived Fuel) is a renewable energy source produced from combustible components of Municipal Solid Waste. RDF possess high calorific value. RDF-derived energy can benefit both the economy and the environment. The RDF can be made using a variety of organic waste present in the MSW. In the present study refuse derived fuel was subjected to laboratory analysis to determine its properties, including its calorific value. The analysis of the samples was carried out and the moisture, volatile matter and gross calorific value were found to be 24.60 ± 5.19%, 50.29 ± 8.24%, 4389 ± 496.39 Kcal/kg. The performed study led to the conclusion that the studied RDF can be used as a source for energy generation.

Keywords: *Refuse derived fuel, Energy and Environment, Proximate Analysis, Municipal Solid Waste.*

Anaerobic Digestion, Volatile Fatty Acids and Membrane Bioreactors

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Anaerobic digestion (AD) is a well-known technology that is used internationally for biogas or biomethane production from e.g. manure, sludge or food wastes. Biogas is normally used for heating, cooking, electricity and car fuels and the residuals have common applications as fertilizers. Although an established industry worldwide, the low market value of biogas and fertilizer, and the challenges with storage and transportation, has made biogas production economically unappealing. The biology of AD shows symbiosis of four categories of bacteria and archaea including hydrolytic organisms, acidogens, acetogens and methanogens. The result of the activity of the first three groups of these microorganisms is the conversion of wastes and feedstocks to volatile fatty acids (VFAs) mainly acetic, propionic, butyric, valeric and caproic acids and hydrogen, while the methanogens convert these intermediate products to methane and carbon dioxide. VFAs have numerous applications as mixed or individual acids, supporting from food and pharmaceuticals industries to wastewater treatment.

Boosting VFAs production by AD and simultaneously inhibiting methanogens result in accumulation of VFAs in the AD culture. There are several factors contributing to this accumulation, where low pH (e.g. lower than 6.0) or high pH (e.g. higher than 10) is among the most important ones. In addition, other factors including inoculum pretreatment (thermal or chemical), feedstock type and loading rate and presence of oxygen that affect VFAs accumulation. We have examined VFAs production from various wastes and residuals such as food wastes, citrus wastes, wastewater treatment sludge, cow manure, chicken manure etc. All these materials can be used to produce VFAs and not methane.

Another challenge to address is removing VFAs from AD culture without disturbing the stability of the biological system. We were successful in in situ recovery of VFAs solution using membrane bioreactors (MBRs). The MBRs were developed using flat sheet membranes in form of immersed Integrated Permeate Channels (IPC) and also external tubular membranes. This presentation covers the results of many years of development of our group in this field.

Keywords: *Anaerobic digestions, Wastes, Biogas, Volatile fatty acids, Membrane bioreactors.*

Improving the Ash Removal Efficiency of Agricultural Residues by Traditional Water Leaching and Microwave-Assist Leaching

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Feedstock quality and pelleting parameters will affect the quality (mechanical durability) of pellets if the residues are densified. Agricultural residues are ideal alternative materials to replace the reducing fossil fuel. However, most agricultural residues have high ash content which will reduce the quality of densified pellets and cause corrosion, slagging and fouling in the furnace.

Water leaching is defined as the removal of water soluble and ion-exchangeable inorganic constituents from solid substrate using water. Water leaching is reported as a low-cost pre-treatment to reduce inorganic constituents in the biomass content. Water leaching is effective for removing water-soluble elements, but the traditional water leaching by low temperature water bath is not effective enough because it always takes a long time to obtain an ideal result. In this study, traditional water leaching by water bath and microwave-assist water leaching were applied to detect the effect of ash removal efficiency of agricultural residues.

Size reduction affects pellet durability as finer particles generally produce pellets that are more durable. Size fractionation will be the first step of the whole pretreatment process. Samples will be grinded by using a hammer mill. Several screen sizes will be tested to determine the size distribution. And the ash content of each size will be test to detect if there are any significant differences in the resulting particle size distribution and hence the ash content of each size fraction. The size of which does not meet the ash content standard will be carried out by the water leaching as the next step of ash reduction treatment.

The wheat straw and corn stalk were used in this study. For each washing, 5g samples were used with the biomass/water ratio of 1:20 and 1:30 respectively. For traditional water bath leaching test, the duration will be set 6 hours and 12 hours and the temperature will be 25 and 45. For microwave-assist water leaching test, three power levels will be applied. The duration will be set as 2min and 3min. All samples will be put inside digestion containers which will make sure the experimental condition is closed.

All biomass samples will be analyzed for the physical and chemical properties, including ash content and element composition, moisture content and heating value. The inorganic composition will be analyzed for a range of elements before and after leaching. The influence of traditional water leaching and microwave-assist water leaching will be compared by the results.

Keywords: *Ash removal, Agricultural residues, Traditional water leaching, Microwave-Assist Leaching.*

Integrated Biohythane Production from Food Waste - Influence of Increasing Organic Loads

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The study focused on the dual stage biosystem for biohythane production in anaerobic digestion from food waste and municipal solid waste. To clearly understand the reactors output with two different cultures at pH-7 in anaerobic fermentation, biosystems were operated at various organic loading rates (OLRs: 30, 40 and 50 g COD/L). At OLR 40 g COD/L, the methanogenic activity was conventional and biohythane production of 3.1 L from PT-7(40 g) with UT-7 (40g) was seen in the dual stage system. Moreover, the higher specific composition of biohythane in the same system showed 0.20 (H_2/(H_2+CH_4)) respectively, compared to other dual biosystems. The average COD removal efficiency after four days of food waste operation was greater than 80% and the maximum production rate was 0.030L/h. After four cycles of operation, the biohythane composition (H_2/(H_2+CH_4)) varied from 0.50 to 0.20 during stabilization. When the OLR was greater than 40 g COD/L, the COD removal efficiency drastically decreased and volatile fatty acids (VFAs) rapidly accumulated in the reactor. The results confirmed that methanogenic dominance has a positive effect on reactor performance and biohythane yield when food waste is supplemented at an OLR of 40g COD/L.

Keywords: *Acidogenic fermentation, Biohythane, Bio-H_2, Bio-CH_4, Volatile fatty acids (VFA).*

Comparative Study on the Biomethane Potential of Terrestrial and Aquatic Weeds

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Extensive usage of cash crops for biogas production followed the food crop crisis in many parts of the world and led to seek substitutes for the feedstocks. A vast portion of weed biomasses are rich in cellulose and hemicellulose and can be a suitable solution. These lignocellulosic weed biomasses are known to cause ecological imbalances, and they need to be managed. These weeds can broadly be classified as terrestrial and aquatic. Their availability in abundance through rapid invasive growth and the need to be controlled makes it a suitable substitute for feedstock. However, due to high lignin content, different pretreatment strategies are employed for better biogas production and efficient methane yield. This study aims to conduct a comparative analysis between the biomethane potential of terrestrial and aquatic weed biomasses. The two most common and aggressive invasive weeds Ageratum conyzoids and Hydrilla verticillata were selected as substrates, representing terrestrial and aquatic weeds, respectively. Four of these weeds are notorious for their invasive nature and the problems that they cause on the native ecosystem. Biomethane Potential Test (BMP) was conducted as a tool to check the feasibility and optimize the Food to Microorganism (F/M) ratio with cow dung as the inoculum. BMP assay revealed that F/M ratio 2 acquired maximum biogas production for terrestrial weed A. conyzoids, whereas for H. verticillata, it was F/M ratio 2.5. The highest methane production was achieved on the 25th day around 205 ± 10 mL CH4/g VS (volatile solids) for A. conyzoids, and cumulative biogas production reached up to 4994 ± 25 mL. For H. verticillata, maximum methane production was observed on 33rd day (180±20 mL CH4/ g VS), and cumulative biogas production reached up to 4857 ± 25 mL.

Keywords: *Anaerobic Digestion, Biogas, Lignocellulosic biomass, Food to microorganism (F/M) ratio, Biochemical methane potential.*

Vaporizing Secondary Sludge of Dairy Industry for Biohythane Production

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The over exploitation of fossil fuel for energy production has compelled researchers to search for an alternative of conventional fossil fuels. Hydrogen and methane are two widely studied alternate energy sources. The biohydrogen studies has been extensively conducted on simple sugars which imposes cost on production. The search for cheap and unconventional sources can certainly give a force for commercialization of biohydrogen production. The conversion of waste into energy can solve two burning issues: (a) environmental problem and (b) energy crisis. The dairy industry secondary solid waste which is increasing day by day is land spread and the energy therein is wasted. In this context dairy secondary sludge was used for biohydrogen and methane (hythane) production in a two-stage process (first biohydrogen and then biomethane production). In this research the valorization of the sludge has been carried out for energy production. The sludge when collected has 2.00 ± 0.05 % Total Solids, and 7.0 pH. The biohydrogen producing reactor was established using acidogenic bacteria as inoculum. The gas was measured for biohydrogen production and then the spent was used for biomethane production in which cattle dung was used as inoculum and with 8% TS. The results of COD, BOD, electrical conductivity and the amount of gas produced, and its Gas chromatography studies would be discussed.

Keywords: *Biohydrogen, Methane, Hythane, Dairy Sludge, Energy crisis, Bio-valorization.*

Comparison of Different Adsorbents for Iodate Removal in Water Environment

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Iodine-131 (I-131) has been a problem, especially during the accidents and failures from the nuclear power plants. These problems have become a main drawback for the nuclear-powered energy production. When exposed to a high oxygenated water environment, the radioactive iodine will take a form of iodate (IO_3^-). The ion enters the food chain, and its radioactive activity is fatal to human and other living things. The challenge in removing IO_3^- is to find suitable biobased adsorbents. Purpose of this study is to employ different kinds of adsorbents to remove IO_3^- from a solution. The selected ones were anion-exchange resin as the fully synthesized adsorbent, alginate cooperated with iron (Fe-Alg) as the synthesized bio-based adsorbent, and pomegranate skins as the fully bio-based adsorbent. The adsorbents were selected based on their possible functional groups, bioavailability, and mechanisms for the removal of IO_3^- from the solution. These are quaternary ammonium in anion-exchange resin, ferric ions in Fe-Alg, and anthocyanin in pomegranate skins. Batch experiments will be conducted for all the adsorbents to determine the optimum condition such as adsorbent dose, equilibrium contact time, equilibrium concentration, pH, and temperature. Results revealed that with 5 mg/L initial concentration, the anion-exchange resin (1 g/L dose) was able to remove 94.3% IO_3^-. The characterization techniques such as Fourier-Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM) with Energy Dispersive X-ray analysis (EDX), and X-ray Photoelectron Spectroscopy (XPS) will be used to confirm and analyze the adsorption mechanisms.

Keywords: *Iodate, Radioactive waste, Anion-exchange resin, Pomegranate, Fe-Alg.*

Development of Sustainable Biodiesel Production from *Madhuca Indica* using Green Chemistry Principles and Techno-Economic Analysis

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The rapid industrialization and increase in the population have led to great energy demand in recent days. Various alternative sources of energy have been explored by researchers. Biodiesel is reported as the best alternative renewable bioenergy. In the present work, Mahua oil is a non-edible source used for effective biodiesel production with green chemistry principles and techno-economic analysis. The manganese doped zinc oxide is used as a heterogeneous catalyst for the production of biodiesel from Mahua oil. The main focus of this study was to reduce the reaction energy consumption and waste generation with the help of green process. The response surface methodology was used for process optimization. The central composite design was performed to analysis three responses: conversion, energy consumption and green chemistry balance. In green chemistry balance consist of five parameters like carbon efficiency, atom economy, reaction mass efficiency, stoichiometric factor and environmental factor. The green chemistry balance was confirmed the biodiesel was highly eco-friendly. Techno-economic analysis of large scale production of 10,000 L of biodiesel from madhuca indica was studied. The economic analysis disclosed that it is possible to produce biodiesel from the modeled plant more profitably.

Keywords: *Biodiesel, Madhuca indica, Green chemistry, Techno-economic analysis.*

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Emerging Pollutants and Fate During Resource Management

Confirmation of Landfill Gases Oxidation in Phytocapping Systems in India using Computational Biological Tools

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Landfill gas (LFG) containing is generally produced by anaerobic degradation of organic waste, which can sometimes lead to poor environmental, degraded hygiene and aesthetics due to the risk of fire and explosion, gas migration in the subsurface soils thus affecting the overall environmental health of surrounding area. This problem can be addressed by alternative landfill covers like phytocaps which allows the landfill gas to oxidize into carbon dioxide with the help of increased bio-availability of oxygen, however due to the low permeability of the landfill cover, no aerobic oxidation occurs inside the landfills. Anaerobic oxidation increases the overall possibility of LFG oxidation thus rejuvenating the site to its natural ecosystem. Plants hold up the soil and moisture in the top cover of landfill cover and thereby alter the permeability of the soil and reduce the emissions of LFGs into the environment. Though plant-soil based phytocap enhances the LFG oxidation, the microbes played a vital role in the process. The microbes growing in synergy with the plants are contributing to the actual LFG oxidation in the phytocaps. Upon the oxidation of the LFGs, occurrence and activity of the microbes must be confirmed. A laboratory-scale phytocapping system is observed for the reduction of LFGs by 86%. The present study focuses on the confirmation of the role of microbes in LFG oxidation using the Computational Biological Tools. The isolated microbes from the various depths of the landfilling systems were sequenced (16S and ITS). After BLAST analysis microbes were identified as *Klebsiella*. The evolutionary analysis of the isolated bacteria and reported microbes will be done by the phylogenetic analysis. Further study of activity of microbes and kinetics of gas mitigation will help in designing appropriate phytocapping cover under Indian climatic condtions.

Keywords: *Landfill, LFG, Phytocapping, Microbial activity, Phylogenetic analysis.*

Strengthening Electron Transfer through Supplementary Electric Field Could Reduce the Potential Environmental Risk of Heavy Metals and Antibiotic Resistance Genes in Aerobic Composting

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Heavy metals (HMs) and antibiotic resistance genes (ARGs) are considered as primary pollutants in livestock manure due to their non-degradability and diffusion. The existing of HMs proved might induce microbial HMs resistance that will further affect the abundance of ARGs due to the co-resistance and cross-resistance mechanism. The application of supplementary electric field (E) or biochar (B) has been reported could strengthening electron transfer in manure composting process through direct or indirect way that will stimulate microbial activity and affecting HMs speciation and antibiotic degradation. However, the synergistic effect of strengthening electron transfer on HMs redox and ARGs removal and their interaction have not been clarified. The aim of this study was to investigate the effect of applying E and B on the fate of ARGs and HMs and their interaction during aerobic composting. To achieve it, HMs sequential extraction, quantitative PCR, and Illumina MiSeq sequencing were used. Results showed that applying E and B enhanced the microbial activity, especially the relative abundance of electroactive bacteria enhanced by 73% and 34% respectively. Compared to control treatment, treatment E reduced the bioavailable factors (BF) of Cu, Cr and As by 18.52-38.34%, meanwhile the relative abundances of *tet* and *sul* resistance genes were reduced by 26.99% and 66.68%, respectively. Network analysis showed that BF was a considerable factor that affected the transfer of ARGs, of which BF of Cu was closely related to the potential hosts of *tetW*, BFs of Cr and As were closely related to the potential hosts of *tetC*, *tetG*, *sul1* and *sul2*. Most of these potential hosts were from *Firmicutes* and *Proteobacteria* on phylum level, the abundance of the two phyla increased and decreased respectively under electric field. Redundancy analysis indicated that mobile genetic element *int1* also played an important role in ARGs diffusing, which can function as a medium mediating the effect of HMs on the transfer of ARGs, and its relative abundance reduced by applying electric field. These findings suggest that the applying E is a prospective way that could potentially lower the environmental risk of ARGs and HMs and mediate their interaction.

Keywords: *Electric field, Heavy metals, Antibiotic resistance genes, Composting.*

Bio-Waste Recycling and Greenhouse Gas Emission Reduction

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Municipal solid waste (MSW) generation, transport and management is one of the largest sources for greenhouse gas (GHG) such as methane (CH_4) and CO_2 emissions in the USA. As of 2018, approximately 292.84 million tons (MT) of MSW are generated i.e., 4.9 pound per day per person. In which, 50% of waste is landfilled (~146 MT) and nearly 50% recycled through different routes e.g., composting, anaerobic digestion, thermal energy recovery, animal feed and direct material recycling, etc. Through the different MSW management approaches, the total GHG emission reduction achieved in 2018 was estimated as 193 million metric tons of carbon dioxide equivalent ($MMTCO_2eq.$), in which 80% reduction (155 $MMTCO_2eq.$) was succeeded only through paper and cardboard recycling. Even though food waste produced to the equal percentage that of paper and cardboards, they are less recycled and more than ~35 MT of food waste ended-up in landfills. Across the United States more than 2629 of landfills are operated that are accounted for ~ 110.6 MMT CO_2Eq of CH_4 emissions in 2018. Food waste is the major bio-waste in landfills that contributing to GHG emissions through anaerobic degradation. Therefore, diverting food waste from landfill could be a possible approach to reducing the GHG emissions and thereby percentage contributions in the national GHG emission sectors. However, there are challenges in storing the food waste for long term or disposal through conventional processes such as anaerobic digestion/composting/thermal conversion methods. In addition, transportation costs and GHG emissions are high for a bio-waste with the high moisture contents.

In this paper, we have proposed a decentralized approach to convert food waste into various end products (e.g., organic acid, hydrogen, compost, etc) through integrated bioprocess technologies. The three different process integration scenarios are developed, techno-economics are calculated and compared. The total GHG emissions for proposed integrations were also calculated in terms of net energy balance calculations, while compared with the food waste landfilling and GHG emissions as base case scenario. In specific, Scenario 1 included a hydrolysis process followed separation of liquid and solids for anaerobic digestion (CH_4) and composting, respectively. In Scenario 2, hydrolysis process followed by aerobic fermentation process (for H_2) and composting of liquid and solid fractions, respectively. In Scenario 3, the hydrolysed food waste used for growing the algae through heterotrophic bacterial-algal polyculture systems and solid residue is used for composting process. The produced bacterial-algal poly cultures are potential source for biofuel production. From the results, integration of bacterial-algal technology (Scenario 3) found to be more promising in processing of food waste in terms of techno-economics and net GHG reductions. However, proposed process integration needs to be tested at lab and pilot scale before commercialization was concluded.

Keywords: *Municipal solid waste, Composting, Anaerobic digestion, Energy Recovery, GHG emission, Techno-economics.*

Development of Nutrient Management Technologies for Sustainable Rice Farming for Mitigating Water and Atmospheric Pollution

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A landfill bioreactor with agricultural wastes can be successfully used to convert available biomass to bioenergy. One of the other main advantages of landfill bioreactors is that the resultant by-products can be utilized for organic fertilizer once the biogas generation ceases. Rice husk charcoal as a coating material to retain N fertilizer is a suitable solution to gradually release nitrogenous compounds. The concept of making rice straw bio gas, rice straw compost and rice husk charcoal is practicable in Sri Lanka, where more than 40% of the farmers are engaged in rice cultivation. In Sri Lanka, out of the total rice production, a considerable amount of rice straw and rice husk goes wasted. Hence, there is a great potential of production of quality compost and rice husk charcoal.

The main objective of the study was to design a lysimeter simulation of a landfill bioreactor to determine possible avenues to produce biogas from agricultural wastes. The study aimed at maximizing methane emission from a mixture of rice straw, cow dung and green materials and evaluating the quality of the resulting compost. Secondary objectives were to produce rice husk charcoal coated urea as a slow releasing fertilizer and to compare the leaching losses of nitrogen, phosphorus and potassium using leaching columns and to evaluate rice husk charcoal coated urea developed in the study as a slow releasing fertilizer and compare the total N,P, K in soil and yield of rice production.

The lysimeter consisted of a liner made of clay-polythene-clay, a gas collection system, leachate recirculation system, and main reactor. The lysimeter performances were evaluated by estimating pH, nitrate nitrogen, phosphate contents, BOD and COD of both leachate and the permeate. Leaching column studies were prepared using 1.2 m tall PVC pipes with a diameter of 15 cm and a sampling port was attached to the bottom end of the column-cap. Leachate (100 ml) was obtained from all four leaching columns. The sampling was done once a week for 3 month period. A pot experiment and a field experiment were carried out in parallel. The soil sampling was done once a week for three months period.

After 200 days of operation, nitrate nitrogen and phosphate of the permeate were 1.23 mg/l and 0.03 mg/l, respectively. BOD increased during the first 14 days and it gradually decreased after 200 days. Quality of the compost was in compliance with the SLS guidelines. The study shows that there is a high potential of producing compost from landfill bioreactor using rice straw. Rice husk charcoal coated urea can potentially be used as a slow releasing nitrogen fertilizer which reduces leaching losses of urea. It also helps reduce the phosphate and potassium leaching. The cyclic effect of phosphate release is an important finding which could be the central issue in defining microbial behavior in soils. The fluctuations of phosphate may have cyclic effects of 28 days. Charcoal coated urea also increased the pH and Eh value of the soil up to the desired levels. Charcoal can be used as a soil amendment and organic fertilizer. In addition, coating is less costly and helps reduce the two third of urea usage and saves 70% fertilizer cost and contribute to mitigate atmospheric greenhouse gas increases as well as pollution of water bodies.

Keywords: *Nutrient management, Sustainable rice farming, Mitigating water and atmospheric pollution.*

Intellectual Property Rights in E-waste Management: Why and How?

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The present century is a century of knowledge indeed a century of mind. The respect and protection of individual property is one of the main fundamental principles of free and just societies. Without the protection of property, a modern society would most probably end in anarchy and distress. Granting and protecting property rights to intellectual achievements is interpreted as a kind of contract between innovators and society. Thus, the temporary exclusive right to market the innovation is an incentive for the innovators to expose the ideas and make it available to others. The disclosure of new ideas enables other individuals or groups to further innovate upon the basis of this new knowledge, which may lead to other innovations. Eventually this guarantees early and broad access to knowledge and innovations and increases the world's knowledge base and therefore innovative capacity.

Electronic and Electrical waste, popularly known as e -waste products, do not decompose or rot away. The information and communication technology (ICT) sector in the last twenty years or so in India has revolutionized life of one and all, ratcheting a viral effect on electronic manufacturing industries leading to phenomenal growth in terms of both, volume and applications. The booming usage of electronic and electrical equipments has created a new but very dangerous stream of waste, called **"**electronic-waste", or simply known as **e-waste**. Electronic waste or e-waste is one of the rapidly growing problems of the world. E-waste comprises of a multitude of components, some containing toxic substances that can have an adverse impact on human health and the environment if not handled properly. In India, e-waste management assumes greater significance not only due to the generation of its own e-waste but also because of the dumping of e-waste from developed countries. This is coupled with India's lack of appropriate infrastructure and procedures for its disposal and recycling. E-waste is much more hazardous than many other municipal wastes because electronic gadgets contain thousands of components made of deadly chemicals and metals like lead, cadmium, chromium, mercury, polyvinyl chlorides (PVC), brominated flame retardants, beryllium, antimony and phthalates. Long-term exposure to these substances damages the nervous systems, kidney and bones, and the reproductive and endocrine systems, and some of them are carcinogenic and neurotoxic.

The environmental protection can improve by promoting innovation in beneficial environmental technology through application and reformation of intellectual property laws. However, there is no need to grasp all the details of these legal areas; an understanding of fundamental principles will suffice. intellectual property law applicable to environmental technology touches on issues of special concern to legal practitioners, regulators, and managers who need to assess their companies' proprietary rights in environmental technology. Trade secrets, patents, and trademarks are considered as international aspects of protecting environmental technology. Voluntary efforts to protect biodiversity are also considered as an example of how proprietary rights can serve the ends of conservation.

The Indian firms account for lesser number of patents for their innovations as compared to their foreign counterparts. The reason is because the investment in R & D activity is small due to lack of capital for trials in innovating product and establishing product in market. There exists a lack of continuity in patenting activity particularly in e-waste.

Keywords: *E-waste, Innovation, Protection.*

Nutrient Remediation by *Monoraphidium neglectum* and *Messastrum gracile*- A Comprehensive Study

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Two microalgae strains *Monoraphidium neglectum* and *Messastrum gracile* belonging to Selenastraceae family was isolated from wastewater. The isolated strains were cultivated under mixotrophic condition to compare its wastewater treatment efficiency and its concomitant effect on nutrient uptake, biomass, photosynthetic activity and biochemical constituents. Several photochemical parameters involving electron transport rate (ETR), Non photochemical quenching (NPQ), quantum yield (Y(II)) and Fv/Fm using Pulse Amplitude Modulator (PAM) were measured for evaluating microalgae photosynthetic performance with respect to light response curves. Comparison and performance evaluation of the two strains with respect to soil fertility and plant growth was studied.

Keywords: *Synthetic dairy wastewater, Fatty acid profile, FAME characterization, Photosynthetic properties, Pyrolysis.*

An Assessment on Opportunities of Sewage Fed Aquaculture Practices in Bangladesh: Challenges and Way Forward

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Bangladesh is one of the world's leading fish producing countries with a total production of 410.34 million MT, where aquaculture contributes 56.44 percent of the total production. Fishes meet the demand of 60 percent animal protein of mass people in this country. Fresh water body like ponds, river, lake and wetland are the main sources of aquatic animals which is the main mean of livelihood for about 1.2 million people. Fishes grow up in this water body naturally. However, fish production in this sweet water decreased as an alarming rate as the volume of such water body declining due to shifting agricultural, industrial and residential infrastructure in Bangladesh. Consequently, the lower income people specially the fishermen of Bangladesh are suffering a lot due to scarcity of fishes for time being. Most of them are intend to change their profession. Therefore, artificial aquaculture become popular and it reached to 56 percent whereas capture fish is 28 percent and marine is 16 percent in Bangladesh. Thus, a crying need appear regarding the supplying of fed for aquaculture. Gradually the sewage fed aquaculture become popular in Bangladesh. This paper aims to assess the opportunities of sewage fed culture which will find out the challenges and recommend the way forward. Both primary and secondary data will be collected. Experience of fishermen who are practicing fed aquaculture will be covered through FGD. Expert opinion will be collected through KII to justify the socio- economic viability of fed aquaculture. As a good number of fishermen around in Bangladesh developed a technique of using domestic sewage for fish culture and this technique is widely used to meet the growing demand for fish in this thickly populated country. The technique is considered to be unique and is the largest operational system in the Asian sub continent to convert waste in to consumable products.

Keywords: *Domestic sewage, Employment generation, Poverty alleviation, Resource*.

Effects of Lead on Petroleum Degrading Bacteria Isolated from Contaminated Soil in Zhuhai, Guangdong, China

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Soil pollution, particularly of petroleum hydrocarbons and lead contamination, has become increasingly severe due to rapid urban development. Bioremediation of petroleum hydrocarbon pollution using bacteria is a promising solution due to the absence of secondary contamination. In this study, three Gram positive strains of bacilli (B-7, B-10, and B-13), with distinctive characteristics were screened from petroleum contaminated soil samples collected in Zhuhai, China. Using 16S rRNA sequencing technique, together with biochemical analyses, B-7, B-10, and B-13 were identified showing high sequence homology to *Bacillus camelliae* 7578-1 (97.08%), *Mycolicibacterium phocaic*um N4 (99.71%), and *Ensifer sesbaniae* CCBAU 65729 (99.85%), respectively. With consideration of evaporation rate and recovery rate, 12.0%±0.0%, 12.2%±0.0%, and 10.6%±0.2% degrading rates were determined by using UV-visible spectrophotometer for B-7, B-10, and B13, respectively, in a five-day interval study. The paper will further discuss the degradation efficiency of these isolates and their consortiums under exposure to different lead concentrations. Due to the rapid development of the Greater Bay Area, the findings of this study will have high ecological significance as it explores the possibilities of employing native microbial species in the bioremediation of petroleum contaminated soils, which often are accompanied with lead pollution.

Keywords: *Bioremediation, Lead Contamination, Petroleum hydrocarbons.*

Production, Characterisation and Applications of Extracellular Polymeric Substances (EPS) using Activated Sludge Fortified with Crude Glycerol

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Extracellular polymeric substances (EPS) are eco-friendly and economical biopolymers with significant role in pollutant removal, bio-flocculation, settling and dewatering of activated sludge. In this study, EPS production by an EPS-producing microbial strain (isolated from wastewater sludge) was studied using activated sludge fortified with glycerol. Crude glycerol characteristics changes with the process of biodiesel production (use of type of oil, type of catalyst, operating conditions and biodiesel purification process). Therefore, the study compared crude glycerol samples as carbon sources from different biodiesel companies (*BIO-LIQ, BIOCARDEL, ROTHSAY)* in Canada and their effect on EPS production and characterisation was observed. The maximum slime EPS (S-EPS) concentration (12.34 g/L) was produced when sludge fortified with *BIO-LIQ* crude glycerol was used, higher than pure glycerol (10 g/L) at 72 h. The S-EPS was enhanced (16 g/L) when purified *BIO-LIQ* glycerol (by acid treatment) was used. It was also observed that more S-EPS was produced when sludge fortified with glycerol was used as compared to only glycerol (no sludge). EPS produced from $Ca(OH)_2$-treated sludge fortified with glycerol was found to be better in terms of protein content, flocculation activity and dewaterability. Structural composition analysis using Fourier Transform Infrared Spectroscopy (FT-IR) revealed the presence of distinct functional groups in the produced S-EPS. The role of produced EPS in the removal of COD, heavy metals and other impurities from landfill leachate was also investigated which depicted its potential in various environmental applications.

Keywords: *Exopolysaccharides; Bacterial polymers; Slime EPS; Crude glycerol; Activated sludge; Impurities.*

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Microplastics in the Environment

Effect of Microplastics on the Greenhouse Gaseous and Ammonia Emissions during Organic Waste Composting

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Microplastic as an emerging pollutant have been widely observed and detected in the organic waste such as sewage sludge, municipal organic waste and manures. Composting and anaerobic digestion accepted as effective means to dispose and recycle the organic waste. Recently, many researches indicated that the microplastic could affect the anaerobic digestion such as carbon and nitrogen transformation. However, the influence of microplastic on the composting process have not been studied. The aim of this study was to investigate the effect of different microplastics on the greenhouse gases and ammonia emission during cow manure composting. Different kinds of microplastics (0.5%PE, 0.5%PVC and 0.5%PHA) were mixed with the initial feedstock materials and composted for 60 days, the mixture without microplastic regarded as control. The temperature, pH, greenhouse gases and ammonia emissions were detected during the composting process. The results showed that the different microplastics presented the various effect on the temperature, pH, greenhouse gases and ammonia emissions. The PVC and PHA could apparently prolong the thermophilic phase (7-10 days) as compared to the control (4 days), while the PE have no obvious effect on the temperature variation. Compared to the control, the PVC decreased the 7.42% CH_4 emission, while the PE and PHA improved the CH_4 emissions by 7.79% and 8.15%, respectively. For N_2O emission, the existing of PE could significantly improve 62.67% emission, while the PHA and PVC decreased 12.93% and 0.71% N_2O emissions. Meanwhile, the PHA and PE obviously promoted the NH_3 volatilization (by 20.87% and 33.90% respectively.), but the PVC decrease the 30.44% NH_3 emission. Overall, the current study indicated that the PVC presented in organic waste could mitigate the greenhouse gases (CH_4 and N_2O) and ammonia emissions, while the PE and PHA could enhance the secondary pollution during composting process.

Keywords: *Organic waste, Composting, Microplastics, Greenhouse gases, Ammonia.*

Occurrence of Microplastics in Commercially Harvested Blood Cockles in Thailand

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Microplastic pollution is becoming a substantial environmental problem and have been found in most of the oceans. Due to widespread contamination of microplastics in water environment, they have a high potential to be uptaken by bivalves. Recent studies have indicated that the bivalves are bioindicators for microplastic pollution, since they are filter feeders, and accumulate microplastics during their feeding process. This study focused on the investigation of microplastics in blood cockles (*Tegillarca granosa*) from aquaculture farm and market in Thailand to investigate microplastics accumulation in organisms. Samples were randomly collected from an aquaculture farm and Khlong Dan market in Bang Bo District, Samut Prakan, Thailand. The organic tissues were digested by 30% hydrogen peroxide solution (H_2O_2) with Iron (II) ($Fe2^+$). Density separation was conducted using a sodium iodide (NaI) solution. The remaining particles after the density separation were separated into different sizes by sieving. The particles were filtered on membrane filter paper (0.45 μm, cellulose nitrate, Whatman) and dried at 60℃ for 24-48 hours to determine the total mass. Abundance of microplastics was identified by using optical microscope for particles bigger than 0.5 mm and fluorescence microscope with Nile red tagging for particles smaller than 0.5 mm. Different types of microplastics were analyzed by Fourier-transform infrared spectroscopy (FTIR) and micro-Fourier-transform infrared spectroscopy. The result of this study showed that blood cockles were contaminated by microplastic with an average size of 100 micrometers. The abundance of microplastics found in the supermarket sample was relatively higher compared to the aquaculture farm sample. The presence of microplastic found in blood cockle from Khlong Dan market (18 particles/10 grams blood cockles) and aquaculture farm (10 particles/10 grams blood cockles). These findings showed that microplastics have contaminated organisms cultivated for human consumption. The accumulation of microplastics in the marine organisms can lead to the biomagnification of microplastics along the food chain and impact food safety and human health.

Keywords: *Microplastic, Blood cockle, Aquaculture, Market, Human health.*

Biodegradable Plastics - Pros and Cons Bioplastics

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Due to many good (but also bad) characteristics and flexible workability, plastics are an important part of our everyday life. Bioplastics are regarded as a possible alternative to conventional plastics. Currently, bioplastics account for less than 2% of global plastics production. A further increase is expected in the future.

However, biodegradable plastics and their waste are controversially discussed. For example, biodegradability is seen as an opportunity in the fight against littering of the environment, but also as a risk for the increased input of plastics into the environment. As a result, there are different views on the ecological benefits of biodegradable plastics and different approaches to dealing with such waste. Against this background, different strategies and disposal concepts for biodegradable plastics will be compared.

Bioplastics are biodegradable, bio-based or both. The term biodegradable describes a chemical process in which microorganisms present in the environment convert the material into natural substances such as water, carbon dioxide and compost. According to European Standard EN 13432, in order to be described as "biodegradable", no more than 10% of the test materials used should be found as residue after a good 12 weeks of composting and subsequent sieving through a 2 mm sieve. In this experiment, this means that the mass loss of sample material after 12 weeks must be at least 90%.

In Germany, the use of bioplastics is a controversial issue. It does not always make sense to replace conventional plastics. Bioplastics are mainly discussed as an alternative material for single use plastics. Even then, the question remains whether it makes sense to use bioplastics only once and whether they should be disposed of correctly - as a plastic together with all other plastics or as a biodegradable material together with the biowaste?

Of course, bioplastics can be used in many different ways. Meaningful and less meaningful applications are presented and evaluated.

Own tests on bioplastics on a laboratory scale (0.8 m³ reactors) and in composting plants are presented and recommendations for practical and sensible use are given. Regional, political and practical differences in different countries will be presented.

Keywords: *Biodegradable plastics, Bioplastics, Composting, Bio-waste.*

Composting as a Sustainable Technology for Conversion of Municipal Solid Waste to Biofertilizers: Road Blocks and Perspectives

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A huge amount of solid waste is produced through domestic, agricultural and industrial activities which results in giving rise to atmospheric diversities and contamination which sooner or later disrupts the whole environmental structure. Municipal solid waste is one of the major concern of researchers globally. In recent years, because of adaption of different lifestyles and speedy development in economy, immense growth in urbanization and population growth took place. Enhancement in waste production results into high quantity of wastes, high amount of pollution and loss of various species. Due to variety of environmental impacts the utilization of bio-based products has received a high amount of attention all around the world. Bioconversion of wastes into bioproducts such as biofertilizers has been into demand. It is essential to raise social consciousness about the advantages of using bioproducts. There are a lot of methods used for synthesizing the biofertilizers from solid waste such as composting, vermicomposting, and anaerobic digestion. Composting is a natural procedure for degradation of raw materials such as yard wastes, food wastes, plants, manure and urban wastes to organic materials. Composting is considered as a primeval method which can be executed at small scale as well as on a large scale. Compost was made from municipal solid waste. In laboratory assessment compost characteristics were analysed. The compost examination was carried out by using existing protocol of Fertilizer Control Order (FCO -1985). The compost contained 1.24% total nitrogen, 1.08% total phosphate, 15.84% total organic carbon, and 0.99% of total potash. Final results of compost characteristics were equivalent to the recommended criteria of Fertilizer Control Order. The obtained results represent that the prepared compost can be used as fertilizer.

Keywords: *Biofertilizer; Bioconversion; Sustainability; FCO -1985; Bio-products.*

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Alternative Biowaste Utilization

Improvement of Mechanical, Thermal, and Barrier Properties of Cassava Starch-Based Cast Films using Natural Fibres

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Cassava (Manihot esculenta) is a tropical starchy root crop mainly used in food applications, but its high starch content and compatibility with other polymeric material makes it a useful feedstock for high-value applications such as plastics and composites. The resultant plastics have advantages such as biodegradability, but mechanical, thermal, and water resistance properties are inferior compared to their petroleum-based counterparts. In order to overcome these drawbacks, cassava starch was formulated with a range of additives to prepare neat polymers. Also, natural fibres were included in the polymer matrix to improve the mechanical and thermal properties of the cassava starch-based plastic films. Various combinations of chitosan, polyvinyl alcohol (PVA), gelatine, nanocellulose, and cinnamon essential oil were used as additives in preparation of cast films. Film microstructure and transparency had been improved with the increasing concentrations of PVA. The films formulated with chitosan showed an increase in tensile strength and thermal stability. The oxygen transmission rate and water vapor permeability could be reduced significantly with the inclusion of chitosan and nanocellulose in the formula. Cinnamon essential oil and chitosan helped significant reduction of microbial activity of the films, but the mechanical properties were negatively impacted by the inclusion of essential oil. Water resistance and mechanical properties of cast films could be improved significantly using chitosan, PVA, gelatine and nanocellulose in various combinations. Also, an increase of glass transition temperature and melting point could be observed with the addition of natural fibres in preparation of cassava starch-based cast films.

Keywords: *Cassava starch, Cast films, Natural fibres, Bio-based plastics.*

Application of Coffee Hull Fiber in Thermoplastic Composites

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At present, more and more attention has been paid to the use of wood fiber from crop straw to replace the scarce wood fiber to strengthen biological composites. As a solid waste, coffee shell can be used to reduce environmental pollution. In this paper the potential application of coffee hull (CH) of the reinforced polyethylene (PE) matrix composites was studied for the first time. The mechanical properties, hygroscopicity, thermogravimetric analysis, fiber treatment and microstructure of CH reinforced composites were studied. The results show that incorporation of coffee hull markedly improved the mechanical properties of the reinforced high density polyethylene (HDPE) matrix composites. Micrographs show a strong interfacial adhesion between the CH fiber particles. This property may be the main reason for the stability between composites. At the same time, the effects of different treatment methods on the mechanical properties and water absorption of the composites were studied. Calcium hydroxide ($Ca(OH)_2$), silane coupling agent (SCA), maleic anhydride grafted polypropylene (ma-g-pp), stearic acid (SA), ethylene bisstearamide (EBS) and their mixtures (ma-g-pp, SA, EBS) were used to treat the fiber surface. The results show that ($Ca(OH)_2$) treatment is the best way to improve its properties. It may be due to the removal of surface active functional groups (-OH) and the induction of hydrophobicity of CH fiber, which improves the compatibility with polymer matrix. Therefore, the application of coffee shell in composite materials has important industrial significance.

Keywords: *Coffee hull Fiber, HDPE, Thermoplastic Composite, Mechanical Properties, Fiber Treatment.*

Environmental Assessment of the Transformation of Food Waste to Animal Feed via a Solar Drying Unit in Greece

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It is estimated that 90 million tonnes of food waste is produced every year in the EU, equivalent to 180 kg per person. Besides its financial, social and environmental implications, food waste generates pressures for the municipal biowaste management systems. Biowaste and its separation at the source is a key priority in the management of municipal solid waste. Since separation of food waste at the source and their collection is easier, cheaper and more efficient when applied in catering businesses, they are the first to be required to implement the relevant actions.

In order to tackle the aforementioned issue, an EU based partnership has been formed in order to implement the Life+ F4F (Food for Feed) project. The main aim of the project is to evaluate, through a pilot-scale demonstration, an innovative and simple technology, and a low-emission process that enables the safe transformation of food waste, mainly from hotels (and more generally from the hospitality industry and restaurants), into animal feed. The first step of the process will be the collection from selected hotels of separated food waste. The collected food waste will be transferred to the presorting unit, where it will be cleaned via means of manual hand selection. Then, the preselected food waste will be mashed and transferred via a pump to one of two drying channels of the solar drying greenhouse. The dried product will be the raw material for the production of animal feed.

The goal of the manuscript is to present the environmental impact assessment of the infrastructure required to transform the separated food wastes into animal feed utilizing an altered solar drying process. The scope of the study includes the infrastructure of the pilot drying unit. More specifically, the scope of the study includes: (i) Excavation works and construction of the presorting unit and the drying greenhouse; construction of an underground tank for wastewater collection in addition to the hydraulic and electrical infrastructure of the presorting and solar drying units. (ii) Infrastructure of the drying greenhouse: metallic structure, polycarbonate greenhouse covers, a transfer belt, a pump for the transfer of the mashed material, a submerged pump for wastewater. Moreover, the solar collectors, the floor heating pipes needed for drying and two refrigerating units. (iii) Operation of the presorting unit and the drying greenhouse: the electricity and water use required for the operation will be assessed.

The results of the life cycle assessment indicate that the major environmental impacts of the solar drying unit for the transformation of food waste to animal feed are generated by the infrastructure of the solar drying unit and not from the electricity required for the operation of the solar unit.

Keywords: *Life cycle assessment, Food waste, Solar drying, Animal feed, Hospitality.*

Material Utilization of Biomass and the Development of Straw/Plastic Rattan Composites (SPRC)

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Innovation in bioresources, which includes biomass resources, genetic resources and also bioinformation resources, is currently one of the most active areas in China. Bioresource science has undergone tremendous growth in recent years as the search for environmentally safe and renewable raw materials to replace petroleum for the production of energy, chemicals and other products continues. Bioresource science and engineering has become a true multidisciplinary field combining traditional areas of chemistry, biology, chemical and biochemical engineering, agricultural sciences and other fields with new developments in biotechnology, genetics and bioengineering. New innovations in both materials and their applications have been a driving force as the engineering of bioresources strives to serve industry through use of cheap, sustainable, safe and renewable raw materials. Herein, some examples of the application and industrialization of bioresources are presented. The development of straw biomass into novel materials for industrial use is of huge, and in fact, limitless, potential. For example, over 700 million tons of straw can be collected each year from main crops in China.Industrial utilization is the most reasonable way to solve the straw problem as an agricultural by-product. New materials and new products made from straw have led to the formation of new industries and huge markets, and form a new industrial model, the basis of which is 'not making waste translate to other waste'. Straw biomass from agricultural sources contains a considerable amount of natural plant fiber, and it has high strength and modulus. As a type of natural polymer reinforcing material, straw fiber has a number of advantages, including better characters, being cheaper, easily acquired, widely sourced, green or environmentally benign, and renewable.

A novel imitation rattan was firstly developed, and it was found that this new rattan has the characteristics of durability, mold-proof and moth-proof, anti-aging and green environmental protection. Straw-polyethylene rattan (SPER) with modified wheat straw powder was fabricated and tested for its mechanical properties. The composite with 5% modified fiber content with tensile strength (15.72MPa) was about the same as that of pure polyethylene (15.25MPa), while the elongation at break value(612.80%) was better than that of pure plastic rattan (573.53%). The physical appearance of the composite rattan resembles natural rattan, with better apparent quality and texture. Thus provides powerful evidence for the potential industrial use of SPER. As a promising mean of biomass management, a wide range of biomass, including food processing by-products, wooden packing items, and even coffee residue could be utilized for making a wade range of new materials.

Keywords: *Bioresource Innovation, Straw biomass, New material, Imitation rattan.*

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Advance Bioconversion

Exploration on the Best Preparation Schemes of Activated Carbon from Solid Waste in Sugar Refinery

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Activated carbon was prepared from waste bagasse and filter sludge produced by sugar factory. Zinc chloride, potassium hydroxide and phosphoric acid were used as activators to investigate the effects of impregnation ratio, activation temperature and activation time on the pore size distribution, pore size and specific surface area of the prepared bagasse activated carbon and activated sludge activated carbon. The effect of pore size and specific surface area were characterized by scanning electron microscopy (SEM), thermogravimetric analysis, nitrogen adsorption desorption, BET specific surface area algorithm, methylene blue adsorption on bagasse activated carbon and filtered activated carbon. Through thermogravimetric analysis data, the pyrolysis temperature of sugar factory waste bagasse is between 200℃ and 800℃. The results showed that with zinc chloride as the activator, the adsorption amount of methylene blue in bagasse activated carbon increased continuously with the increase of temperature. When the activation temperature is 700℃ and the impregnation ratio is 1:2, the bagasse activated carbon is obtained. The maximum adsorption value of methylene blue is 250.4991mg/g, and when the activation temperature is 600℃ and the impregnation ratio is 1:2, the yield of activated carbon is up to 70%. With potassium hydroxide as the activator, when the activation temperature is 400 ° C and the impregnation ratio is 1:2, the methylene blue adsorption value of the bagasse activated carbon is up to 45.269mg/g, and the activation temperature is 500℃, and the impregnation ratio is 1:0.5, the carbon yield is up to 40.2%, and the BET specific surface area value of the bagasse activated carbon is 17.439m^2 at 700℃ and the impregnation ratio is 1:0.5 by BET determination of activated carbon of bagasse activated by zinc chloride as an activator. BJH adsorption cumulative specific surface area 20.451m^2/g, BJH desorption cumulative specific surface area 29.820m^2/g and single point average pore radius of 106.8A. When the activation temperature is 800℃ and the impregnation ratio is 1:0.5, the BET specific surface area of the activated carbon with bagasse is 175.331 m^2/g, the adsorption and accumulation specific surface area of BJH is 28.043m^2/g, and the desorption and accumulation specific surface area of BJH is 38.465m^2/g, and the single-point aperture radius is 15.0A.

Keywords: Activated carbon, Solid waste, Sugar refinery.

Selective Photocatalytic Oxidation of 5-Hydroxymethyl-2-Furfural to 5-Formylfurancarboxylic Acid Using Vanadium Doped Carbon Nitride

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Although photocatalysis has been widely used for the degradation of an array of environmental pollutants in the past, the selective transformation of organic compounds to value-added products is yet to be entirely explored. 5-Hydroxymethyl-2-furfural (HMF) is a versatile platform chemical derived from cellulose. It is one of the most coveted chemical building blocks due to the presence of alcohol and aldehyde functional groups on the furan ring. This structure can act as a precursor of several high-value chemicals for the polymer industry such as 2,5-furandicarboxaldehyde (FDC), 5-formylfurancarboxylic acid (FFCA), 2,5diformylfuran (DFF), and 2,5-furandicarboxylic acid (FDCA). These partially oxidized products can be used as a monomer to synthesize heterocyclic ligands, polymers, adhesives, binders, antifungal agents, and resins. Graphitic carbon nitride (g-C_3N_4) has emerged as a promising catalyst for converting HMF to beneficial products due to its valence band potential, which restricts the formation of hydroxyl radicals due to water oxidation. However, carbon nitride has some limitation, such as rapid recombination rate of photoinduced electron–hole pairs, poor quantum efficiency, and few adsorption and active sites, limiting its photocatalytic efficiency. Herein, we synthesized V-doped C_3N_4 for the conversion of HMF to FFCA under UV/visible irradiation. C_3N_4 was prepared by a facile molten salts method. Vanadium was then incorporated by calcination of C_3N_4 and ammonium monovanadate. The physical and chemical characterization confirmed the successful incorporation of vanadium into C_3N_4 structure. The photocatalyst improved the light absorption property and increased the charge separation and transfer, resulting in enhanced photo-oxidation efficiency. Photocatalytic studies demonstrated that optimized V-doped C3N4 compared to pristine g-C3N4 showed a considerably higher HMF conversion with desirable FFCA yield and selectivity.

Keywords: *Photocatalytic, HMF, Vanadium Doped Carbon Nitride.*

Selective Oxidation of 5-hydroxymethylfurfural over a Molybdenum Carbide Quantum Dot Catalyst

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In this study, the chemical-platform compounds of 2,5-diformylfuran (DFF) were obtained from the renewable biomass-derived carbohydrates and in situ selective oxidation of 5-hydroxymethylfurfural (HMF). We have demonstrated the thermal catalysis biomass derived HMF selective oxidation to DFF, using molybdenum carbide quantum dots for the first time. Thoroughly characterized and detailed experimental results, the excellent catalytic performance of the molybdenum carbide was attributed to the abundant active sites and rich oxygen-containing groups on the surface of the catalysts, that facilitate the electron transportation and HMF activation. A DFF selectivity of more than 80% can be achieved by converting fructose to DFF under atmospheric conditions. This work provides a novel, scalable, and cost-effective route to the hybrid of transition-metal-based compounds and carbonaceous nanomaterials as high-performance for the conversion of fructose to DFF.

Keywords: *Biomass-derived, HMF oxidation, Molybdenum carbide, DFF.*

Catalytic Fast Pyrolysis of Rice Husk for the High Quality Liquid Fuels Production

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Bio-oil derived from biomass fast pyrolysis can be used as a candidate to replace fossil fuels or feedstock to produce renewable chemicals. In this study, the pyrolysis was conducted in a lab-scale fluidized bed reactor with a feeding rate of 100-500 g h^{-1}.The pyrolysis system can be divided into three parts: the feeding system, the reactor system and the condensation system. The maximum higher heating value of the bio-oils was 23.95±0.55 MJ kg^{-1} under 450ºC. The catalyst can significantly decrease the water content of bio-oil and reduce the ash content, solid content and viscosity of bio-oil. Despite the diversity of biomass sources, there are only three main components: cellulose, hemicellulose and lignin. In the process of biomass fast pyrolysis, the cellulose, hemicellulose and lignin were pyrolyzed to monomers or units. Then some chemicals were produced from these monomers through a series of reactions to form the end products. In catalytic pyrolysis, the active site of the catalyst acts as a deoxidizer. Hydrocarbon radicals' pool was formed through monomers thermal cracking.

Keywords: *Fast pyrolysis, Catalytic pyrolysis, Rice husk, Liquid fuels, Pyrolysis mechanism.*

Regulatory Influence of Conductive Materials on Interspecies Electron Transfer and Carbon Flux during Electromethanogenesis

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Single chambered Electromethanogenesis (EM) systems (Total/Working volume-0.5L/0.4L) were operated using graphite electrodes and designed synthetic wastewater (20g/l; 48h) to comparatively analyze the effect of conductive materials (CM; Activated charcoal (AC) and Algae biomass char (AB)) under both closed circuit (CC; 100Ω) and applied potential (AP; -0.8V) to analyze their role as intermediates for electron transfer during microbe-electrode interactions towards enhancing methanogenic activity. Three phase experiments were performed, control (without electrodes, CC/AP and AB/AC), CM control (with electrodes with CC/AP) and CM system (with electrodes, CC/AP and AC/AB). Comparatively, results showed higher biogas/methane production of 7.35/4.4 L with conversion efficiency of 60% under influence of conductive materials. The study provides a specific strategy for increasing the overall biogas/methane yields with influence of conductive materials on bacterial electron transfer rates, while driving towards overcoming the limitations of methanogenesis process.

Keywords: *Microbial-electrocatalyzed system, Biogas upgradation, Oxidation-reduction reactions, Biofilm, Renewable energy, Direct interspecies electron transfer (DIET).*

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