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Waste Management and Valorisation for a Sustainable Future

October 26 (Tue.) – 28 (Thu.), 2021

9:00 KST (Seoul) | 20:00 EDT OCT 25 (New York) | 1:00 BST (London) | 8:00 CST (Shanghai)

LG Science Park, Seoul, Korea

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Korea University

Korea University is one of the oldest universities in South Korea which was established in 1905. It is a most prestigious higher education institute in Korea and consists of two main branches as Seoul campus and Sejong campus. Korea university is the home to over 36,000 students from all parts of Korea and every corner of the world. In the QS World University Rankings 2020 by Quacquarelli Symonds (QS), Korea University climbed 14 places to 69th place, a notable improvement from the previous year. Korea University has maintained its status as the first among local private universities for six consecutive years.

OJEong Resilience Institute, Korea University

Established in 2014, the OJEong Resilience Institute (OJERI) is the center of the Asia resilience research network. OJERI aims to improve ecological resilience for addressing social-ecological changes that threaten the quality of life for humanity, and to contribute to a sustainable society. OJERI cooperates with a 'Institute of Environment and Ecology', a 'Environmental GIS/RS Center', a 'Wild Resource Plant Seed Bank' and a 'Korea Biochar Research Center' to develop new theories and techniques for estimating quantitatively ecological resilience and analyzing impact of the human activities to the ecological resilience.

APRU Sustainable Waste Management

The APRU Sustainable Waste Management Program hosted by the Korea University (Prof. Yong Sik Ok) offers a timely opportunity for knowledge exchange among professionals from all over the world to assist the formulation of an efficient sustainable management agenda for biological waste and remediation of soil, water and air in the local context, which satisfies the environmental compatibility, financial feasibility and social needs. It will deliberate on state-of-the-art treatment technologies, advanced management strategies, and political issues pertaining to recycling and recovery of organic waste.

Nature Sustainability

Launched in January 2018, Nature Sustainability is an online-only monthly journal publishing the best research about sustainability from the natural and social sciences, as well as from the fields of engineering and policy. All editorial decisions are made by a team of full-time professional editors.

Nature Electronics

Launched in January 2018, Nature Electronics is an online-only monthly journal publishing the best research from all areas of electronics, incorporating the work of scientists, engineers and researchers in industry. All editorial decisions are made by a team of full-time professional editors.

Nature Nanotechnology

Nature Nanotechnology is a monthly journal publishing the best research from across nanoscience and nanotechnology. All editorial decisions are made by a team of full-time professional editors.

Contents

Welcome Messages

Welcome to the conference Waste management and valorisation for a sustainable future, which is organized in partnership between Nature Sustainability, Nature Nanotechnology, Nature Electronics, Korea University, and APRU Sustainable Waste. The development of sustainable waste management strategies is a major global challenge. This conference will explore the barriers and opportunities of developing sustainable waste systems to achieve a circular economy with a focus on the recycling and recovery of waste material. It will examine the problem of — and potential solutions to — microplastics in the environment and electronic waste. It will also consider the reduction, recycling and recovery of agricultural and food waste, as well as biomass valorisation. Finally, it will explore the design and operation of waste management systems, and the economic and policy implications of managing such systems sustainably. The event brings together researchers (virtually and in-person) from across the world and across disciplines — from academia and industry to environmental organizations and government — in order to exchange ideas and formulate integrated solutions. We hope you enjoy the conference.

Monica Contestabile (Chief Editor, Nature Sustainability)
Yong Sik Ok (Chairman, Nature Conference & Korea University, Korea)
Fabio Pulizzi (Chief Editor, Nature Nanotechnology)
Owain Vaughan (Chief Editor, Nature Electronics)
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Min-Kyu Oh	National Research Foundation of Korea, Korea
Ho-Jung Ryu	Korea Institute of Energy Research, Korea

Conference Overview

TITLE	2021 Nature Conference on Waste Management and Valorisation for a Sustainable Future
DATE	Tuesday 26 - Thursday 28 October 2021
VENUE	ISC Building, LG Science Park, Seoul, Korea
FORMAT	Hybrid (online & onsite)
LANGUAGE	English (Interpretation not available)
PARTICIPANT	Approximately 1500 (International 800, Domestic 700)
WEBSITE	https://conferences.nature.com/event/ 3d762144-0d84-4f87-be38-f6f901f6cae7/summary
ORGANIZERS	고려대학교 KOREA UNIVERSITY · APRU · nature sustainability · nature electronics · nature nanotechnology
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Program at a Glance

	Day 1 **Tuesday, 26 October**	Day 2 **Wednesday, 27 October**	Day 3 **Thursday, 28 October**
09:00	Registration	Registration	Registration
09:30	Opening and Welcoming Remarks	Session III **Electronic Waste and Circular Economy**	Session V **Biomass Valorization : Waste to Resources**
10:00	Session I **Sustainable Waste Management**		
10:30			
11:00			
11:30			Poster Session C with Refreshment
12:00			
12:30			
13:00	Lunch and Network	Lunch and Network	Lunch and Network
13:30			
14:00	Session II **Micro(nano)plastics in the Environments**	Session IV **Reducing, Recycling and Recovery of Agricultural and Food Waste**	Session VI **Governmental Policy on Waste Management and Valorization**
14:30			
15:00			
15:30			
16:00			
16:30	Poster Session A with Refreshment	Poster Session B with Refreshment	
17:00		**Meet the Editor!**	**Meet the Editor!**
17:30			Concluding Remarks
18:00			
18:30		Conference Banquet	

PROGRAM

Tuesday, October 26, 2021

* =Virtual Presenter

09:00 - 09:30 Opening and welcoming remarks — Convergence Hall, 5F, LG ISC Building

Fabio Pulizzi (Chief Editor, Nature Nanotechnology)
Yong Sik Ok (Chairman, Nature Conference)
Lim Hyesook (Minister, Ministry of Science and ICT, Korea)
Jin Taek Chung (President, Korea University, Korea)
Woo Kyun Lee (Director, OJEong Resilience Institute, Korea University, Korea)

09:30 - 12:30 Session I : Sustainable waste management — Convergence Hall, 5F, LG ISC Building

Chairs: **William Mitch** (Stanford University, USA), **Woo Kyun Lee** (Korea University, Korea)

09:30 - 10:30 ***Dilemma's in waste management and resource reuse***
*Keynote: Marian Chertow (Yale University, USA)

10:30 - 11:00 ***Beneficial uses of waste materials in the built environment***
*Elsa Olivetti (Massachusetts Institute of Technology, USA)

11:00 - 11:30 ***Moving towards circular materials management in coastal cities***
*Jenna Jambeck (University of Georgia, USA)

11:30 - 12:30 **Oral Presentations**

11:30 - 11:45 ***Re-thinking electrochemical systems for water treatment: reductive systems, inexpensive materials, and high concentration targets***
William Mitch (Stanford University, USA)

11:45 - 12:00 ***Global sustainable waste management***
Jörg Rinklebe (Bergische University of Wuppertal, Germany)

12:00 - 12:15 ***Creating new value of iron slag as soil amendment to mitigate methane emission and Improve Rice Cropping Environments'***
Pil Joo Kim (Gyeongsang National University, Korea)

12:15 - 12:30 ***Feasibility demonstration of decentralized waste plastic pyrolysis and biomass heating cogeneration process***
Boris Brigljević (UNIST, Korea)

12:30 - 14:00 **Lunch and network** — Courtyard by Marriott

14:00 - 16:30 Session II : Micro(nano)plastics in the environments — Convergence Hall, 5F, LG ISC Building

Chairs: **Jörg Rinklebe** (Bergische University of Wuppertal, Germany)
In-Joo Chin (Inha Technical College, Korea)

14:00 - 14:30 ***Recent advances in plastic waste recycling and valorisation: Case studies from Asia***
*Carol S.K. Lin (City University of Hong Kong, Hong Kong)

14:30 - 15:00 ***Small(er) plastics, big(ger) problem? Fate, transport and implications of nano- and microplastics in the environment***
*Denise Mitrano (ETH Zurich, Switzerland)

15:00 - 15:30 ***Aligning recycling and manufacturing: SMaRT MICROfactories™ creating sustainable materials and products from plastic waste***
*Veena Sahajiwalla (UNSW Sydney, University of New South Wales, Australia)

15:30 - 16:30 **Oral Presentations**

15:30 - 15:45 ***The prominent benefit of furanoates as a substituent for biodegradable terephthalates***
Jun Mo Koo (Korea Research Institute of Chemical Technology, Korea)

15:45 - 16:00 ***Bio-based macro and micro plastics designed for specific industrial applications***
Dongyeop Oh (Korea Research Institute of Chemical Technology, Korea)

16:00 - 16:15 ***Fast microplastics (0.3-5 mm) identification as potential option for monitoring studies***
*Cristiane Vidal (University of Campinas - UNICAMP, Brazil)

16:15 - 16:30 ***Sustainable super engineering plastics from biomass-derived isosorbide against bisphenol- a based plastics for overcoming various properties***
Jeyoung Park (Korea Research Institute of Chemical Technology, Korea)

16:30 - 18:00 Poster Session A with Refreshments — Lobby, 5F, LG ISC Building

PROGRAM

Wednesday, October 27, 2021

* =Virtual Presenter

08:50 - 09:00 **Welcoming remarks**: **William Mitch** (Stanford University, USA)
Yoon-Seok Chang (Pohang University of Science and Technology, Korea)

09:00 - 12:00 Session III: Electronic waste and circular economy — Convergence Hall, 5F, LG ISC Building

Chairs: **Stéphane Guilbert** (Montpellier SupAgro, France)
Hankwon Lim (Ulsan Institute of Science and Technology, Korea)

09:00 - 09:30 ***Sustainable management of an evolving e-waste stream***
*Callie Babbit (Rochester Institute of Technology, USA)

09:30 - 10:00 ***Sustainable material solutions that scale toward zero E-Waste***
*Oladele Ogunseitan (University of California, Irvine, USA)

10:00 - 10:30 ***Global energy transitions and innovation mechanisms for a sustainable economy***
*Jessika Trancik (Massachusetts Institute of Technology, USA)

10:30 - 11:00 **Coffee Break** — Lobby, 5F, LG ISC Building

11:00 - 12:00 **Oral Presentations**

11:00 - 11:15 ***Fully biodegradable electronics for achieving zero-waste***
Seung-Kyun Kang (Seoul National University, Korea)

11:15 - 11:30 ***Sustainable policy framework of emerging E-wastes in Korea during the transition to the fourth industrial revolution***
Jungkeun Oh (National Institute of Environmental Research, Korea)

11:30 - 11:45 ***Impedance based prognostics as an efficient way for sorting and echelon utilization of spent lithium batteries***
Vijay Mohan Nagulapati (UNIST, Korea)

11:45 - 12:00 ***Effect of rice husk biochar on lead dynamics and bacterial phylotype composition in solar cell waste-contaminated soil***
Pavani Dissanayake (Korea University, Korea)

12:00 - 14:00 **Lunch and network** — Courtyard by Marriott

14:00 - 16:30 Session IV : Reducing, recycling and recovery of agricultural and food waste — Convergence Hall, 5F, LG ISC Building

Chairs: **Johannes Lehmann** (Cornell University, USA)
Sang-Hyoun Kim (Yonsei University, Korea)

14:00 - 14:30 ***Circular economy in urban food systems toward net-zero carbon cities: case studies from USA & India***
*Anu Ramaswami (Princeton University, USA)

14:30 - 15:00 ***Circular economy driven sustainable composites***
*Amar Mohanty (University of Guelph, Canada)

15:00 - 15:30 ***A sustainable carbon-neutral future aided by waste management and AI***
*Xiaonan Wang (Tsinghua University Beijing, China)

15:30 - 16:00 ***Waste to resources towards environmental sustainability in Megacities***
*Yinghong Peng (Shanghai Jiao Tong University, China)

16:00 - 16:30 **Oral Presentations**

16:00 - 16:15 ***State-of-the-arts technology for food waste valorization***
Sang-Hyoun Kim (Yonsei University, Korea)

16:15 - 16:30 ***Sustainable urban food systems with optimum reduction and recycling of food waste: A foresight 2035 study to bring out the research priorities***
Stéphane Guilbert (Montpellier SupAgro, France)

6:30 - 17:00 **Poster Session B with Refreshments** — Lobby, 5F, LG ISC Building

17:00 - 18:00 **Meet the Editor!** — Convergence Hall, 5F, LG ISC Building
Monica Contestabile (Chief Editor, Nature Sustainability),
Owain Vaughan (Chief Editor, Nature Electronics)

18:30 - 20:30 **Conference Banquet** — Forest Hall, 2F, Courtyard by Marriott

Thursday, October 28, 2021

* =Virtual Presenter

08:50 - 09:00 **Welcoming remarks**: **Kim Chan-Woo** (Ministry of Foreign Affairs, Korea)
Christopher Tremewan (APRU)

09:00 - 11:30 Session V: Biomass valorization: waste to resources
Convergence Hall, 5F, LG ISC Building

Chairs: **Ange Nzihou** (RAPSODEE Research Center, IMT Mines Albi, France)
Dong-Kwon Lim (KU BK21 FOUR R&E Center for Bio-Innovative-Advanced Materials, Korea)

09:00 - 09:30 ***Innovative approaches to turn agricultural waste into ecological and economic assets- The NOAW Project***
Natalie Gontard (INRAE, France)

09:30 - 10:00 ***Unravel mechanisms between the carbon and metal species towards biographenic-like materials***
Ange Nzihou (RAPSODEE Research Center, IMT Mines Albi, France)

10:00 - 10:30 ***The role of LCA in sustainable waste management***
*Thomas H. Christensen (Technical University of Denmark, Denmark)

10:30 - 11:30 **Oral Presentations**

10:30 - 10:45 ***Environment vs Health: The cruel choice in the midst of the pandemic***
Jaewook Myung (KAIST, Korea)

10:45 - 11:00 ***Hybrid based composit phase change materials-integrated latent heat storage system for sustainable future***
Dimberu Geremew Atinafu (Yonsei University, Korea)

11:00 - 11:15 ***Food waste biochar as a renewable fuel: A case study of Korea***
Yoonah Jeong (Korea Institute of Construction Technology, Korea)

11:15 - 11:30 ***Development of high-selectivity caproate production and residual carbon source recovery platform***
Byung-Chul Kim (Seoul National University, Korea)

11:30 - 12:30 Poster Session C with Refreshments
Lobby, 5F, LG ISC Building

12:00 - 14:00 Lunch and network
Courtyard by Marriott

14:00 - 17:30 Session VI : Governmental policy on waste management and valorization
Convergence Hall, 5F, LG ISC Building

Chairs: **Natalie Gontard** (INRAE, France), **Joo Young Park** (Korea University, Korea)

14:00 - 15:00 ***Circular Bio-Nutrient Economy: sustainability at the nexus of fertilizer-food-feces***
Johannes Lehmann (Cornell University, USA)

15:00 - 15:30 ***Overshot and overwhelmed global waste management policy system: How to address global waste valorisation challenges in the COVID19 era?***
*Keynote: Nazia Mintz Habib (University of Cambridge, UK)

15:30 - 16:00 ***Urban waste futures***
*John E. Fernández (Massachusetts Institute of Technology, USA)

16:00 - 17:00 **Oral Presentations**

16:00 - 16:15 ***Research on resource circulation policies in the post -COVID-19 era***
Sora Yi (Korea Environment Institute, Korea)

16:15 - 16:30 ***Prospect of South Korea's new plastic waste management policy after the COVID-19***
Youngyeul Kang (National Institute of Environmental Research, Korea)

16:30 - 16:45 ***An improved resource circulation strategy for effective waste management toward a circular economy in South Korea***
Namil Um (National Institute of Environmental Research, Korea)

16:45 - 17:00 ***The Anthropocene worldview scale: conceptualization and development***
Donghun Kang (KAIST, Korea)

17:00 - 17:30 **Meet the Editor!** Convergence Hall, 5F, LG ISC Building
Fabio Pulizzi (Chief Editor, Nature Nanotechnology)

17:30 - 18:00 **Concluding Remarks** Convergence Hall, 5F, LG ISC Building

POSTER SESSION (IN-PERSON)

POSTER SESSION A

PA-001	ECONOMIC AND ECOLOGICAL EVALUATION OF PROCESSING SCHEMES FOR THE ENZYMATIC RECYCLING OF PLASTIC WASTE **Tommaso De Santis (Austrian Centre of Industrial Biotechnology, Austria)**
PA-002	FABRICATION OF BIODEGRADABLE POLYCAPROLACTONE (PCL) OIL ADSORBENT REMOTELY CONTROLLED VIA EXTERNAL MAGNETIC FIELD **Junhyeog Eom (Jeonbuk National University, Korea)**
PA-003	SIMULTANEOUS TREATMENT OF NITROGEN AND PHOSPHORUS FROM SYNTHETIC WASTEWATER BY SYNERGISTIC INTERGRATION OF MEMBRANE CONTACTOR AND HYDROXYAPATITE CRYSTALLIZATION **Yoonmi Jang (Seoul National University, Korea)**
PA-004	KINETIC STUDY OF MUNICIPAL WASTE PLASTIC PYROLYSIS USING A DISTRIBUTED ACTIVATION ENERGY MODEL **Yong-Seong Jeong (University of Seoul, Korea)**
PA-005	EFFECT OF BIOCHAR ON ENVIRONMENTAL CHANGE IN SMALL-SCALE BURIAL WITH CHICKEN CARCASS **Se-Won Kang (Sunchon National University, Korea)**
PA-006	MICROWAVE-ULTRASOUND ASSISTED LEACHING OF NI, CO AND CD FROM WASTED NI-CD BATTERY VIA GLYCINE IN SUBCRITICAL WATER **Ishtiaq Hossain Khan (Chonnam National University, Korea)**
PA-007	UPCYCLING WASTE-PET INTO METAL-ORGANIC FRAMEWORKS FOR INACTIVATION OF HARMFUL ALGAL BLOOMS **You Jin Kim (Korea University, Korea)**
PA-008	HIGHLY EFFICIENT AND RECYCLABLE POLYOLEFIN-BASED MAGNETIC SORBENT FOR OILS AND ORGANIC SOLVENTS SPILL CLEANUP **Heongoo Kim (Jeonbuk National University, Korea)**
PA-009	FACILE MODIFICATION OF PHYSICO-CHEMICALLY ROBUST AND SUPER-HYDROPHOBIC FeOOH-PVDF MEMBRANE FOR STABLE AND ANTI-WETTING MEMBRANE CONTACTOR SYSTEM **Wooram Lee (Seoul National University, Korea)**
PA-010	EVALUATION OF PROPERTIES FOR HIGH-STRENGTH CONCRETE USING COMPOSITE SLAG FINE AGGREGATE **Lee, Sanghyun (LOTTE E&C R&D Center, Korea)**
PA-011	SOLAR-DRIVEN ELECTROCHEMICAL ADVANCED OXIDATION PROCESS USING CuO-CuFeO2 PHOTOCATHODE WITH PROTECTIVE TiO2 OVERLAYER **Hyoung-il Kim (Yonsei University, Korea)**
PA-012	PREDICTION OF SOIL HEAVY METAL IMMOBILIZATION BY BIOCHAR USING MACHINE LEARNING **Kumuduni N. Palansooriya (Korea Biochar Research Center, APRU Sustainable Waste Management Program & Division of Environmental Science and Ecological Engineering, Korea University, Korea)**
PA-013	SEAWATER BATTERY DESALINATION WITH A REVERSE OSMOSIS MEMBRANE FOR SIMULTANEOUS BRINE TREATMENT AND ENERGY STORAGE **Sanghun Park (Ulsan National Institute of Science and Technology, Korea**

PA-014	PYROLYSIS OF MIXED PLASTIC CONTAINING PVC TO PRODUCE CHLORINE-DEFICIENT OIL **Ki-Bum Park (University of Seoul, Korea)**
PA-015	A FACILE METHOD OF OIL SPILL REMOVE WITH RECYCLING DISCARDED MASK **Sejin Park (Jeonbuk National University, Korea)**
PA-016	OXYGEN VACANCY MODIFICATION OF COMMERCIAL ZNO TO ENHANCE THE PHOTOCATALYTIC ACTIVITY for MICROPOLLUTANT DEGRADATION IN WATER **Alireza Ranjbari (Ghent University Global Campus, Korea)**
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PA-018	NEURON-INPIRED ENERGY CONVERSION USING SALINITY GRADIENT ENERGY **Wooyoung Shim (Yonsei University, Korea)**
PA-019	A NOVEL METHOD TO DETECT AND QUANTIFY MICROPLASTICS IN WATER **In-cheol Choi (National Institute of Environmental Research, Environmental Research Complex, Korea)**
PA-020	MICRODISK LASER INDEX SENSOR WITH META-HOLE PATTERNS **Haerin Jeong (Korea University, Korea)**
PA-021	MXENE(Ti3C2TX) SURFACE PLASMON RESONANCE SENSOR IN THE SHORT-WAVE INFRARED WAVELENGTH **Han-Na Kim (Korea University, Korea)**
PA-022	RELEASE OF MICROPLASTICS TO WATER AND WASTEWATER FROM DAILY PRODUCTS: QALITATIVE AND QUANTATIVE ANALYSIS USING MICRO-FTIR **Jieun Lee (Busan National University, Korea)**
PA-023	A COMPARATIVE STUDY ON AGGREGATION BEHAVIOR OF POLYSTYRENE AND POLYMETHYL METHACRYLATE NANOPLASTICS IN AQUEOUS ENVIRONMENT **Byoung-cheun Lee (National Institute of Environmental Research, Korea)**
PA-024	MICROPLASTICS CONTAMINATION IN BIOWASTE COMPOSTS – A CRITICAL ANALYSIS ON POSSIBLE PATHWAYS AND ILL-EFFECTS **Muthusamy Govarthanan (Kyungpook National University, Korea)**
PA-025	PRECISE CONTROL OVER THE SILICA SHELL THICKNESS AND FINDING THE OPTIMAL THICKNESS FOR THE PEAK HEAT DIFFUSION PROPERTY OF AUNR@SIO2 **Wonseok Yang (Korea University, Korea)**

POSTER SESSION (IN-PERSON)

POSTER SESSION B

PB-001	A GREEN PROCESS FOR RECOVERY OF HIGH PURITY RARE EARTH ELEMENT FROM NDFEB WASTE MAGNET OR SCRAP **Kyeong Woo Chung (Korea Institute of Geoscience and Mineral Resources, Korea)**
PB-002	ALL SOLUTION-PROCESSED VAN DER WAALS THIN-FILM ELECTRONICS WITH HIGH PERFORMANCE AND LOW-POWER OPERATION **Su-Yeon Joung (Korea University, Korea)**
PB-003	RECYCLING STRATEGIES FOR THE HYDROMETALLURGICAL TREATMENT OF RARE EARTH PERMANENT MAGNETS IN NON-AQUEOUS MEDIA **Rina Kim (Korea Institute of Geoscience and Mineral Resources, University of Science and Technology, Korea)**
PB-004	SELF-ASSEMBLED NANOPARTICLES FOR COLORIZATION AND COOLING **Hyeon Ho Kim (Korea University, Korea)**
PB-005	SEPARATION OF SILICON PV MODULE USING DELAMINATION **Jongwon Ko (Korea University, Seoul, Korea)**
PB-006	A COMPARATIVE STUDY ON RECYCLING OF WASTE LITHIUM-ION BATTERIES CHLORINATED POLYMERS IN SUBCRITICAL WATER **Theoneste Nshizirungu(Chonnam National University, Korea)**
PB-007	CO2-ASSISTED CARBOTHERMIC REDUCTION PROCESS OF LI[NI0.8CO0.1MN0.1]O2 AS AN ECO-FRIENDLY AND EFFICIENT PRETREATMENT FOR RECYCLING SPENT LITHIUM-ION BATTERIES **Sanghyuk Park (Sejong University, Korea)**
PB-008	THE EFFECTS ON GREENHOUSEs GAS OFFSETTING THROUGH REFRIGERANTS RECOVERY FROM THE WEEE **Jihwan Park (Korea Electronics Recycling Cooperative (KERC), Korea University, Korea)**
PB-009	TOWARDS SUSTAINABLE ORGANIC ELECTRONICS **Clara Santato (Polytechnique Montreal, Canada)**
PB-010	VERIFICATION OF MOLD TREATMENT EFFECT IN HYDROPONICS DRAINAGE OF MICROBUBBLE OXIDATION SYSTEM USING FUSARIUM OXYSPORUM F. SP. LYCOPERSICI **Jae Kyung Jang (National Institute of Agricultural Sciences, Korea)**
PB-011	OPTIMIZATION OF MEDIUM THROUGH APPLICATION OF SUPERNATANT LIQUID FROM SEWAGE IN SYNGAS FERMENTATION PROCESS **Mungyu Lee (Gwangju Institute of Science and Technology, Korea)**
PB-012	ANALYSIS OF WASTE HEAT RECOVERED IN LIQUID-COMPOSTING FERMENTATION HEAT OF LIVESTOCK MANURE **Ryugap Lim (National Institute of Agricultural Sciences, Korea)**
PB-013	FUNGI AND BACTERIA TARGET SPECIES IDENTIFICATION FOR DRAINAGE WASTEWATER REUSE IN A HYDROPONICS HORTICULTURE FACILITY, SOUTH KOREA **Jinkwan Son (National Institute of Agricultural Sciences, Rural Development Administration, Korea)**
PB-014	AN AI LIFE CYCLE ASSESSMENT TOWARD A SUSTAINABLE FOOD SUPPLY CHAIN **Sam Van Haute (Ghent University Global Campus, Korea)**

PB-015	IMPROVING THE ECOLOGICAL UTILIZATION OF EARTHWORMS AND EARTHWORM FECES IN ORGANIC FARMING **Hong-Shik Nam (National Institute of Agricultural Sciences, Rural Development Administration, Korea**
PB-016	OPTICAL FOURIER VOLUME FOR SOLAR CONCENTRATOR **Daegyum Yang (Korea University, Korea)**

POSTER SESSION C

PC-001	SCENARIO ANALYSIS FOR UTILIZATION OF LANDFILL GAS IN PRODUCTION OF HYDROGEN AND ELECTRICITY IN ECONOMIC and ENVIRONEMTNAL ASPECTS **Manhee Byun (Ulsan National Institute of Science and Technology, Korea**
PC-002	GREEN HYDROGEN FROM AIR GASIFICATION OF WOOD BIOMASS USING A TWO-STAGE FLUIDIZED GASIFIER **Jong-Woo Kim (University of Seoul, Korea)**
PC-003	CARBON DIOXIDE GAS UTILIZATION FOR THE SLAGGING AND FOULING ALLEVIATION OF FOOD WASTE BIOCHAR FUEL **Ye-Eun Lee (Water and Environment Research, Korea)**
PC-004	BIOPOLYMER SYNTHRSIS FROM WASTE ACTIVATED SLUDGE VIA ACIDOGENIC FERMENTATION WITH PRETREATMENT **Alice Muhorakeye (Yonsei University, Korea)**
PC-005	CATALYTIC DEPOLYMERIZATION OF KRAFT LIGNIN INTO PHENOLIC MONOMERS OVER Ni-Pd/HZSM-5 **Masud Rana (Chonnam National University, Korea)**
PC-006	RECOVERING RAW SULFATED POLYSACCHARIDES FROM WASTE ACTIVATED SLUDGE **Di Wu (Ghent University Global Campus, Korea & The Hong Kong University of Science and Technology)**
PC-007	PRODUCTION OF BIOCHAR USING FLEXIBLE COUNTER FLOW MULTI BAFFLE (F-COMB) TECHNOLOGY **Jiho Yoo (Korea Institute of Energy Research (KIER), Korea)**
PC-008	DESIGNER BIOCHAR WITH ENHANCED FUNCTIONALITY FOR EFFICIENT REMOVAL OF AQUEOUS 137Cs AND 90Sr **In-Ho Yoon (Korea Atomic Energy Research Institute, Korea)**
PC-009	APPLIED MACHINE LEARNING FOR PREDICTION OF CO2 ADSORPTION ON BIOMASS WASTE-DERIVED POROUS CARBON **Xiangzhou Yuan (Korea Biochar Research Center, APRU Sustainable Waste Management Program &, Korea University, Korea)**
PC-010	OCCURRENCE OF AFRICAN SWINE FEVER PANDEMIC ALONG THE KOREAN DEMILITARIZED ZONE AND COUNTERMEASURE ON CARCASS DISPOSAL **Jinwon Seo (National Institute of Environmental Research, Korea)**

POSTER SESSION (VIRTUAL)

VIRTUAL POSTER SESSION A

VPA-001	DEVELOPMENT OF CATALYTIC HYDROGEN PRODUCTION TECHNOLOGY USING AMMONIA RECOVERED FROM WASTEWATER **Seon Young An (Seoul National University, Korea)**
VPA-002	INTEGRATION OF CLOSED-LOOP SUPPLY CHAIN MULTIOBJECTIVE OPTIMIZATION AND LIFE CYCLE ASSESSMENT: A CASE STUDY OF LEAD-ACID BATTERIES **Catherine Azzaro-Pantel (Université Toulouse, France)**
VPA-003	MICROALGAE BASED NUTRIENT RECOVERY FROM SOURCE SEPARATED URINE: PERSPECTIVES TOWARDS LOW CARBON CIRCULAR BIOECONOMY **Bunushree Behera (National Institute of Technology Rourkela, India)**
VPA-004	SUSTAINABLE MANAGEMENT OF AGRICULTURAL AND FOOD WASTE IN DELHI NCR REGION OF INDIA USING CIRCULAR ECONOMY FRAMEWORK **Hemant Bherwani (CSIR-National Environmental Engineering Research Institute & Academy of Scientific and Innovative Research, India)**
VPA-005	CATALYTIC PYROLYSIS atalytic Pyrolysis of Municipal Plastic Waste: A REVIEW **Bauyrzhan Biakhmetov (University of Glasgow, United Kingdom, & The Saken Seifullin Kazakh Agricultural Technical University)**
VPA-006	LINKING TOURISM AND SUSTAINABLE WASTE MANAGEMENT: THE CASE STUDY OF THE CAMINO LEBANIEGO IN CANTABRIA (SPAIN) **Cristina Campos (University of Cantabria, Santander, Spain)**
VPA-007	EFFICIENT SUSTAINABLE GREEN STRATEGY FOR BIOREFINING OF DISTILLERY WASTE FOR FOOD APPLICATIONS **Sreemoyee Chakraborty (Jadavpur University, India)**
VPA-008	MINERAL WASTERS TO RESOURCES RECYCLING USING AN ARSENIC BIO-LEACHING SYSTEM **Jin-Soo Chang (Biological & Genetic Resources Institute (BGRI), Korea)**
VPA-009	BIOCHAR AS GREEN AGGREGATE IN CEMENT-BONDED PARTICLEBOARDS **Liang Chen (The Hong Kong Polytechnic University, China)**
VPA-010	NOVEL PROCESSING AND RECYCLING TECHNIQUES FOR POLYETHYLENE TEREPHTHALATE (PET) BOTTLES **Yu-Wen Chiao (National Taiwan University, Taiwan)**
VPA-011	WASTEWATER TREATMENT THROUGH ISOLATION OF MICROALGAE FROM ALGRICULTURAL, DOMESTIC, AND INDUSTRIAL WATERWASTE STABILIZATION PONDS **U.H.B.Y. DILSHAN (Wayamba University of Sri Lanka, Sri Lanka)**
VPA-012	COMMUNITY DIVERSITY METRICS, INTERACTION AND METABOLIC FUNCTION ANALYSIS OF PIRANA MUNICIPAL SOLID WASTE LANDFILL AT DIFFERENCE LIMEN OF AGE **Himani Gandhi (Saurashtra University, India)**
VPA-013	WATER WASHING AS PRE-TREATMENT FOR ENHANCING THE BIOLEACHING OF METALS FROM BOF SLAG **Neha Garg (Indian Institute of Technology, India)**

VPA-014	NOT WASTE, SAND: ADDRESSING GLOBAL SAND SUSTAINABILITY CRISIS AND CHALLENGES IN MINE WASTE MANAGEMENT **Artem Golev (The University of Queensland, Australia**
VPA-015	STARFISH DERIVED COLLAGEN PEPTIDE-ENCAPSULLATING ELASTIC NANOLIPOSOMES FOR THE COSMETIC APPLICATION **Seong-Beom Han (Korea University, Korea)**
VPA-016	BREAKDOEN OF CO2 BY USING ARTIFICALLY DESIGNED CHLOROPHYLL ARTICIALLY DESIGNED CHLOROPHYLL TO MITIGATE GLOBAL ENVIRONMENTAL WASTE **Faruque Hossain (Kennesaw State University, USA)**
VPA-017	IMPROVING BIOGAS PRODUCTION FROM SEWAGE SLUDGE THROUGH MAGNETIC BIOCHAR SUPPLEMENTATION **Mingyu Hu (University of Edinburgh, UK)**
VPA-018	BIODEGRADATION OF PLASTICS USING THERMOPHILIC BACTERIA FROM THE AUSTRALIAN GREAT ARTESIAN BASIN TOWARDS SUSTAINABLE PLASTIC WASTE MANAGEMENT **Louisa James-Pearson (Queensland University of Technology, Australia)**
VPA-019	MAGNETIC MICROPARTICLE AND RAMAN-BASED ASSAY FOR HIGHLY SENSITIVE VIRUS NUCLEIC ACID TARGET DETECTION WITH ATTOMOLAR SENSITIVITY **Ah Seong Jang (Korea University, Korea)**
VPA-020	ASSESSMENT OF RESOURCE EFFICIENCY TOWARDS A CIRCULAR ECONOMY IN SOUTH KOREA **Seungmin Ji (Chungnam national university, Korea)**
VPA-021	WASTE PET PLASTIC BOTTLE-DERIVED METAL-ORGANIC FRAMEWORKS FOR ARSENATE REMOVAL FROM WATER **Pandi Kalimuthu (Korea University, Korea)**
VPA-022	A REVIEW ON ALUMINA RECOVERY FROM BAUXITE RESIDUE (RED MUD) **Manish Kumar Kar (Indian Institute of Technology - Kharagpur, India)**
VPA-023	KEEP MANURE FRESH, GET MORE! **Dong-Hoon Kim (Inha University, Korea)**
VPA-024	SUSTAINABLE BIOGEOCHEMICAL BEHAVIOR STUDY USING GEOMICROORGANISMS FROM ARSENIC CONTAMINATED MINE **Won-Seok Kim (Research Institute, NCSQUARE & POSTECH, Korea)**
VPA-025	CLOSING THE PHOSPHORUS LOOP THROUGH INTEGRATED STRUVITE CRYSTALLIZATION AND MICROALGAL CULTIVATION **Nageshwari Krishnamoorthy (National Institute of Technology Rourkela, India)**
VPA-026	FEASIBILITY OF NON-THERMAL PLASMA GASIFICATION FOR A WASTE-TO-ENERGY POWER PLANT **Serang Kwon (Korea University, Korea)**

POSTER SESSION (VIRTUAL)

VPA-027	ARE THEY ON THE SAME PAGE? EXPLORING KOREAN CLOTHING REVERSE LOGISTICS SYSTEM USING NATURAL LANGUAGE PROCESSING AND NETWORK ANALYSIS **Jinsook Lee (Korea University, Korea)**
VPA-028	UPCYCLING OF WASTE POLYETHYLENE TEREPHTHALATE PLASTIC BOTTLES INTO POROUS CARBONS FOR CO2 CAPTURE **Ki Bong Lee (Korea University, Korea)**
VPA-029	GREENER CHEMICAL REACTIONS ENABLED BY DOMAIN KNOWLEDGE INTEGRATED MACHING LEARNING **Jiali LI (National University of Singapore, Singapore)**
VPA-030	BIO-SOLID FUEL PRODUCTION FROM ORGANIC SOLID WASTE USING FRY-DRYING AND TORREFACTION **Young-Il Lim (Hankyong National University, Korea)**
VPA-031	DECISION ANALYSIS FRAMEWORK BASED ON GAME THEORY AND MCDM METHOD FOR SLUDGE MANAGEMENT **Yue Liu (The Hong Kong Polytechnic University, China)**
VPA-032	AIR STRIPPING SYSTEM USING WATER SPRAY REACTOR FOR AMMONIA REMOVAL AND RECOVERY **Miratul Maghfiroh (University of Science and Technology, Korea & Kompleks Cibinong Science Center, Indonesia)**
VPA-033	THE LOOMING PROBLEM OF WIND TURBINE BLADE WASTE IN CHINA: EXPLORING OPTIONS FOR RECYCLING BLADE WASTE **Fanran Meng (University of Cambridge, UK)**
VPA-034	ECUADORIAN SYSTEM OF INTEGRAL MANAGEMENT FOR USED TIRES (NFU) SEGINUS **Jacinto Monserrate Godoy (Powered by SAMBITO, Ecuador)**
VPA-035	STABILIZATION ASSESSMENT OF MERCURY CONTAMINATED SOIL USING STARFISH **Deok Hyun Moon (Chosun University, Korea)**
VPA-036	A CHEMOMETRICS APPROACH TOWARDS IMPROVING PLASTIC WASTE SORTING **Edward Ren Kai Neo (University of Warwick, Coventry, United Kingdom & Singapore Institute of Manufacturing Technology, Singapore)**
VPA-037	LIFE CYCLE ASSESSMENT OF WASTEWATER TREATMENT - THE POSITION OF THE AFRICAN CONTINENT **Charles Amarachi Ogbu (Czech University of Life Sciences Prague, Czech Republic)**
VPA-038	ALL-ORGANIC SUSTAINABLE POLYMER NANOCOMPOSITES BY IN SITU PREPARATION STRATEGY FOR IMPROVED MECHANICAL PROPERTIES **Jeyoung Park (Korea Research Institute of Chemical Technology (KRICT), Korea)**
VPA-039	TURNING WOOD DUST WASTE INTO SUBSTRATE SOIL BASE FOR ORGANIC OYSTER MUSHROOM FARMING IN GHANA **Mihee Park (Penn State University, USA)**

VPA-040	VALORIZATION OF WHEY FOR PRODUCING SUSTAINABLE HYBRID AMYLOID FIBRILS BIOPLASTICS **Mohammad Peydayesh (ETH Zurich, Switzerland)**
VPA-041	RECONSTRUCTING SOILS FROM WASTE: A PROTOCOL FOR IMPROVED SOIL SUSTAINABILITY AND CARBON OFF-SETTING **H. Kate Schofield (University of Plymouth, UK)**
VPA-042	OCCUPATIONAL EXPOSURE TO VOLATILE ORGANIC COMPOUNDS FOR DELIVERY PERSONS IN TWO-WHEELERS AT GHAZIABAD, INDIA. **Abinaya Sekar (National Institute of Technology Calicut, India)**
VPA-043	THE REUSE OF BEVERAGE PLASTIC BOTTLES FOR SUPPRESSING EVAPORATION FROM THE WATER SURFACE **Maram Shalaby (Damanhour University, Egypt)**
VPA-044	HOMEGARDENS: A SUSTAINABLE OPTION FOR ORGANIC WASTE MANAGEMENT IN ASSAM, INDIA **Rashmita Sharma (Jawaharlal Nehru University, India)**
VPA-045	THE IMPACT OF THE CIRCULAR ECONOMY INITIATIVES ON MNCs TEXTILE FIRM'S PREFORMANCE **Francisco-Manuel Somohano-Rodríguez (Universidad de Cantabria, Spain)**
VPA-046	THE DEVELOPMENT OF A SOLID WASTE SAFETY PLAN : CASE STUDIES FROM SERBIA AND GHANA. **Giovanni Vinti (University of Brescia, Italy)**
VPA-047	STOICHIO METRIC CARBOCATALYSIS ON SULFUR DOPED BIOCHAR: INTERFACIAL $^1O_2$ GENERATED THROUGH EPOXIDE-LIKE C–S–O CONFIGURATION **Zhonghao Wan (The Hong Kong Polytechnic University, China)**
VPA-048	REASSEMBLY OF COAL FLY ASH DERIVED ANALCIME INTO SSZ-13 ZEOLITE VIA INTERZEOLITE CONVERSION FOR NH3-SCR OF NO **Bing Wang (Taiyuan University of Technology, China)**
VPA-049	A NOVEL PROCESS COMBINED MICROPLASTICS SEPARATION AND SUBSEQUENT CARBONIZATION FOR SYNTHESIS OF IRON/CARBON NANOCOMPOSITE AS HETEROGENEOUS CATALYST **Chongqing Wang (Zhengzhou University, China)**
VPA-050	APPLICATION OF MAGNETIC BIOCHAR/QUATERNARY PHOSPHONIUM SALT TO COMBAT THE ANTIBIOTIC RESISTOME IN AQUATIC RESISTOME IN AQUATIC ENVIRONMENTS **Fang Wang (Chinese Academy of Sciences & University of Chinese Academy of Sciences, China)**
VPA-051	HOLLOW MICRO-NANO REACTOR CONSTRUCTED BY COAL TAR TOWARD ENHANCED ADSORPTION OF CO_2 **Jiancheng Wang (J. C. Wang) (Taiyuan University of Technology, P. R. China)**
VPA-052	TURNING WASTE POLYTHYLENE TEREPHTHALATE (PET) WATER BOTTLES INTO VALUABLE ACTIVATED CARBON FOR HIGH-PREFORMANCE ELECTROCHEMICAL WATER DESLINATION **Jhen-Cih Wu (National Taiwan University, Taiwan)**

POSTER SESSION (VIRTUAL)

VPA-053	ADIPOSE-ON-A-CHIP: A PATHOLOGICAL ADIPOSE MODELING FOR ENDOTHELIAL CELL DYSFUNCTION IN OBESITY **Heejeong Yoon (Ulsan National Institute of Science and Technology, Korea)**
VPA-054	RECYCLING OF DISPOSABLE BABY DIAPERS FOR ENHANCING THE GROWTH AND SURVIVAL OF EUCALYPTUS SEEDLINGS SUBJECTED TO DROUGHT **Madiha Zekry (Damanhour University, Egypt)**
VPA-055	SCIENCE-INFORMED DESIGN OF A SUSTAINABLE FE-BIOCHAR CATALYST FOR MICROWAVE- INDUCED CATALYTIC DEGRADATION OF REFRACTORY ORGANIC CONTAMINANTS **Qiaozhi Zhang (The Hong Kong Polytechnic University, China)**
VPA-056	THE ROLES OF BIOCHAR AS GREEN ADMIXTURE FOR STABILIZATION/SOLIDIFICATION OF MUNICIPAL SOLID WASTE INCINERATION FLY ASH **Yuying Zhang (The Hong Kong Polytechnic University, China)**
VPA-057	MICROPLASTICS CONTAMINATION OF HUMAN SALIVA FROM FACE MASKS **Jan Halfar (VŠB-Technical University of Ostrava, Czech Republic)**
VPA-058	BIODEGRADATION OF BIOPLASTICS BY MARINE PHOTOBACTERIUM sp. **Yuri Hong (Pohang University of Science and Technology (POSTECH), Korea)**
VPA-059	SELF-CHARGING MASK FILTER FABRICATION VIA MULTI-STACKED PVDF NANOFIBER MEMBRANE ON PA6 MESH SUBSTRATE FOR THE HIGH EFFICIENT PM0.3 FILTRATION **Dong Hee Kang (Chonnam National University, Korea)**
VPA-060	INTRODUCTION ON THE ANALYTICAL TECHNIQUES FOR INTENTIONALLY ADDED MICROPLASTICS IN CONSUMER CHEMICAL PRODUCTS IN KOREA **Jaewoong Lee (National Institute of Environmental Research, Korea)**
VPA-061	DISTRIBUTION OF MICROPLASTICS IN ORGANS RELATIVE TO THE BODY SIZE OF COMMON CARPS FROM THE HAN RIVER IN SOUTH KOREA **Jangho Lee (National Institution of Environmental Research, Korea)**
VPA-062	EVALUATION OF SPATIO-TEMPORAL DYNAMICS OF MICROPLASTICS DEVELOPING A PROCESS-BASED ECO-HYDROLOGY MODEL IN JAPAN **Tadanobu Nakayama (National Institute for Environmental Studies (NIES), Japan**
VPA-063	THE CURRENT STATUS OF MICROPLASTICS IN THE BOTTLED DRINKING WATER **Inbo Park (Korea University, Korea)**
VPA-064	QUASI-3D PARTICLE TRACKING SIMULATIONS FOR ANALYSIS OF MICROPLASTIC BEHAVIORS IN OPEN CHANNEL FLOWS **Inhwan Park (Seoul National University of Science and Technology, Korea)**
VPA-065	PRELIMINARY ASSESSMENT OF ASPERGILLUS TERRUS AND ENGYODONTIUM ALBUM FOR THE DEGRADATION OF POLYPROPYLENE **Amira Farzana Samat (The University of Sydney, Australia)**

VPA-066	FORENSIC SITE INVESTIGATION FRAMEWORK FOR MARINE MICROPLASTICS **Ashwini Suresh Kumar (National Institute of Technology Calicut, India)**
VPA-067	MICROPLASTIC CONTAMINATION IN A STORMWATER DRAIN : CASE STUDY OF DELHI **Mansi Vaid (Guru Gobind Singh Indraprastha University, India)**

VIRTUAL POSTER SESSION B

VPB-001	FROM FOOD WASTE TO CIRCULAR MATERIALS FOR DESIGN : EXPERIMENTING WITH UNCONVENTIONAL SOURCES **Luca Alessandrini (Politecnico di Milano, Italy)**
VPB-002	SiOx NANOROD SWITCHING DEVICES FOR ARTIFICAL MEMRISTIVE NEURON AND ITS ENERGY-EFFICIENT COMPUTING APPLICATIONS **Sanghyeon Choi (Korea University, Korea)**
VPB-003	WHAT IS THE IMPORTANCE OF RECYCLING SILVER FOR THE MANUFACTURING OF SOLAR MODULES TO ACHIEVE NET ZERO BY 2050? **Pablo R Dias (University of New South Wales, Australia; Universidade Federal do Rio Grande do Sul (UFRGS), Brazil)**
VPB-004	CUSTOMERS BEHAVIOR IN PRICISING DECISIONS OF WEEE MANAGEMENT: A COMPREHENSIVE LITERATURE REVIEW **Rui Guo (Nanyang TePchnological University, Singapore)**
VPB-005	EFFECT OF CARBON LOADING AMOUNT IN AQUEOUS ZINC-BROMINE BATTERY ELECTRODES: USE OF HOLLOW NANOPOROUS CARBON **Jisue Kang (Gwangju Institute of Science and Technology, Korea)**
VPB-006	ESTIMATION OF SOLAR PANEL WASTE BYw POPULATION BALANCE MODEL IN SOUTH KOREA **Donghyeon Kim (Chungnam national university, Korea)**
VPB-007	SUSTAINABILITY AND RESILIENCE OF CIRCULAR ECONOMY BUSINESS MODELS BASED ON DIGITAL LEDGER TECHNOLOGIES **Nallapaneni Manoj Kumar (City University of Hong Kong, China)**
VPB-008	SUSTAINABLE SCALE BOUNDARIES OF E-WASTE MANAGEMENT **Abhishek Kumar Awasthi (Nanjing University, China)**
VPB-009	WORKING TOWARDS ANTIBIOTIC RECOVERY FROM WASTEWATER TO FUEL A CIRCULAR ECONOMY **Aoife Quinlivan (University of Nottingham, UK)**
VPB-010	AI-ASSISTED SUSTAINABLE ROBOTIC SENSORS THROUGH CARBON BLACK **Haitao Yang (NUS, Singapore)**

POSTER SESSION (VIRTUAL)

VPB-011	SOIL BIOSOLARIZATION- A FURTURE SOURCE-LINK FOOD WASTE SOLUTION **Yancui Liang (Guangdong Technion-Israel Institute of Technology, China)**
VPB-012	EFFECT OF THE FOOD WASTE COMPOST ON RICE YIELD AND NITROGEN USE EFFICIENCY WITH VARYING NITROGEN APPLICATION RATE **Song-Rae Cho (National Institute of Agricultural Sciences, Korea)**
VPB-013	ASSOCIATION BETWEEN URINARY 3-PHENOXYBENZONIC ACID CONCENTRATIONS AND DIABETES IN KOREAN ADULTS: KOREAN NATIONAL ENVIRONMENTAL HEALTH SURVEY 2012-2017 **Yun-Hee Choi (Korea University, Korea)**
VPB-014	NUTRITIONAL-BASED TOOLS AND STRATEGIES FOR MINIMIZATION AND VALORIZATION OF FOOD LOSS AND WASTE **Ana Fernández-Ríos (University of Cantabria, Spain)**
VPB-015	FABRICATION OF SUSTAINABLE AND BIODEGRADABLE CHITIN MICROPARTICLES FOR SUBSTITUTION OF MICROBEADS **Sungbin Ju (Pohang University of Science and Technology(POSTECH), Korea Research Institute of Chemical Technology (KRICT), Korea)**
VPB-016	CHARACTERIZATION OF METABOLIC CHANGES OF TOMATO AND LEAFY PERILLA UNDER DIFFERENT ENVIRONMENTAL CONTROL (MINERAL AND WATER SUPPLY) **Yangmin X. Kim (National Institute of Agricultural Sciences, Korea)**
VPB-017	CELLULOSE-BASED BIOPLASTIC REPLACEMENT OF SINGLE USE PLASTIC BAGS IN THE COLLECTION AND TREATMENT OF FOOD WASTE VIA ANAEROBIC DIGESTION FOR A ZERO-WASTE CIRCULAR ECONOMY. **Jonathan T.E. Lee (National University of Singapore, Campus for Research Excellence and Technological Enterprise (CREATE) Singapore)**
VPB-018	NEW PERSPECTIVES FOR THE USE OF PHOSPHOGYPSUM AS A SUSTAINABLE BUILDING MATERIAL **Tathiana Moreira (Federal University of Pelotas (UFPel), Brazil)**
VPB-019	Hydrothermal processing of agricultural plastic waste **Roy Posmanik (Newe Ya'ar Research Center, Israel)**
VPB-020	FUNGAL CONTROL IN CROPLAND FIELDS VIA ENHANCING BELOWGROUND FUNGAL GRAZE WITH WASTE COCONUT HUSKS **Haoyang Shen (The University of Tokyo, Japan)**
VPB-021	BIOREMEDIATION OF ARSENIC USING MICROALGAE BIOFILM GROWN ON BANANA PSEUDOSTEM ORGANIC SUBSTRATE **Santhana Kumar V (ICAR-Central Institute of Fisheries Education (Deemed University), ICAR- Central Inland Fisheries Research Institute, India)**
VPB-022	SCALE-UP STUDY FOR PRODUCTION OF VALUE ADDED PRODUCT 'EXOPOLYSACCHARIDE' FROM FRUIT WASTE BY BACILLUS sp. SRA4 **Avni M Vaishnav (Gujarat University, India)**
VPB-023	INCORPORATING TRADITIONAL PRACTICES FOR EFFICIENT WASTE SEGREGATION FOR SYNERGETIC URBAN AND RURAL DEVELOPMENT **Anurag Verma (Nalanda University, India)**

VIRTUAL POSTER SESSION C

VPC-001	AVAILABILITY AND POTENTIAL OF TEFF (ERAGROSTIS TEF) STRAW FOR BIO-REFINING; AN OVERVIEW **Eniyew Abebaw Tsegaye (Addis Ababa University, Ethiopia.)**
VPC-002	APPLICATION OF ARTIFICIAL INTELLIGENCE ON PREDICTING BIOFUEL PRODUCTION OF BIOMASS AGRICULTURE WASTE THROUGH A THERMOCHEMICAL CONVERSION TECHNIQUE **Ria Aniza (National Cheng Kung University, Taiwan)**
VPC-003	MICROALGAL BIOCHAR PRODUCTION VIA MICROWAVE TORREFACTION ENHANCED WITH THE USE OF METAL OXIDE AS CATALYST **Arjay A. Arpia (National Cheng Kung University, Taiwan)**
VPC-004	COMPREHENSIVE ARTIFICAL NEURAL NETWORK MODEL FOR GASIFICATION PROCESS PREDICTION **Simon Ascher (University of Glasgow, UK)**
VPC-005	FORMULATION AND OPTIMIZATION OF NOVEL CARBON CAPTURING PHOSPHORUS FERTILIZER **B. B. Basak (ICAR-Directorate of Medicinal and Aromatic Plants Research, India)**
VPC-006	VALORIZATION OF RURAL ABATTOIR WASTE AS FERTILIZER FOR SUSTAINABLE AGRICULTURAL PRODUCTION AND SOCIO-ECONOMIC DEVELOPMENT **Shantanu Bhunia (Jadavpur University, India)**
VPC-007	BIOCHAR PRODUCED FROM THE MAJOR AGRICULTURAL RESIDUES IN THE PHILIPPINES AS ADSORBENT FOR CARBON DIOXIDE **Jhulimar C. Castro (University of Santo Tomas, Philippines)**
VPC-008	FORMULATED BIOCHARS TO OPTIMISE CARBON CAPTURE AND SOIL FERTILITY BENEFITS **Tim Charlton (University of New South Wales, Aqua Firma Solutions Pty Ltd, Australia)**
VPC-009	HIGHER PERFORMANCE IN TOUGHNESS OF ISOSORBIDE BASED POLY(ARYLENE ETHER KETONE) THROUGH IN-SITU POLYMERIZATION WITH CELLULOSE NANOFIBER **Seonghyun Chung (Pohang University of Science and Technology(POSTECH),Korea Research Institute of Chemical Technology (KRICT), Korea)**
VPC-010	'IN-SITU' PREPARATION OF TISSUE PAPER DERIVED POROUS CARBON/POLYTHIPHENE COMPOSITE ELECTRODE FOR ASSYMETRIC SUPERCAPACITOR APPLICATION **Prashant Dubey (CSIR- National Physical Laboratory (CSIR-NPL), Academy of Scientific and Innovative Research (AcSIR), India)**
VPC-011	VALORISATION OF VARIOUS TYPES OF PAPER WASTES FOR LEVULINIC ACID PRODUCTION **Shanta Dutta (The Hong Kong Polytechnic University, China)**
VPC-012	ANAEROBIC CO-DIGESTION OF AGRICULTURAL RESIDUES AND SELECTED ORGANIC WASTE MATERIALS FOR BIOGAS PRODUCTION IN EGYPT **Mohamed M. Eisa (Ain Shams University, Egypt)**
VPC-013	ECONOMIC, ENERGY AND ENVIRONMENTAL ANALYSIS OF SWINE WASTE USE IN BRAZIL: OPPORTUNITIES AND CHALLENGES **Geraldo Jose Ferraresi de Araujo (University of São Paulo–USP, Brazil)**

POSTER SESSION (VIRTUAL)

VPC-014	MANAGEMENT OF TOXIC PAPER MILL WASTES THROUGH VERMITECHNOLOGY: A COMPREHENSIVE ECOTECHNOLOGICAL INSIGHT TOWARDS WASTE VALORIZATION **Ram Kumar Ganguly (Vidyasagar University, India)**
VPC-015	RECOMBINANT PROTEIN PRODUCTION YIELD INCREASED BY FLAGELLA SYNTHESIS MUTATION IN ESCHERICHIA COLI **Jae-Ho Han (Korea University, Korea)**
VPC-016	CATALYTIC CO-HYDROTHERMAL CARBONIZARION OF FOOD WASTE DIGESTATE AND YARD WASTE FOR ENVIRONMENTAL/ENERGY APPLICATIONS **Mingjing He (The Hong Kong Polytechnic University, China)**
VPC-017	ENGINEERED HIERARCHICAL POROUS CARBON FROM BIOMASS WASTE AS A HIGH-PERFORMANCE ELECTRODE FOR CAPACITIVE DEIONIZATION **Chia-Hung Hou (National Taiwan University, Taiwan)**
VPC-018	ENVIRONMENTAL SUSTAINABILITY OF EMERGING FOOD WASTE BIOVALORIZATION PROCESS: A DYNAMIC LIFE CYCLE ASSESSMENT (dLCA) APPROACH TO GUIDE THE SUSTAINABLE SCALE-UP OF WASTE-DERIVED SOPHOROLIPID PRODUCTION **Xiaomeng Hu (City University of Hong Kong, China)**
VPC-019	A UNIVERSAL STRATEGY FOR PREPARATION OF CARBON SUPERSTRUCTURES FROM BIOMASS **Xun Hu (University of Jinan, China)**
VPC-020	ASSESSMENT OF STARFISH (ASTERINA PECTINIFERA) DERIVED BIOCHAR FOR THE REMOVAL OF Pb, Zn, Cu AND Cd IN CONTAMINATED SOLUTION **Ha Rin Jang (Chosun University, Korea)**
VPC-021	BIOLOGICALLY ENHANCED BIOCHAR FOR BIOLOGICAL WATER TREATMENT **Anjali Jayakumar (University of Edinburgh, UK)**
VPC-022	WALNUT SHELL-DERIVED BIOCHAR VALORIZATION FOR ECO-EFFICIENT REMOVAL OF ARSENIC FROM INDO-GANGETIC SUB-TROPICAL SILTY LOAMS: PROMOTING SUSTAINABLE MANAGEMENT OF ARSENIC POLLUTION **Abhishek Kumar (Birla Institute of Technology, India)**
VPC-023	STRUCTURE-PROPERTY RELATIONSHIP OF THERMOPLASTIC POLYURETHANE COMPOSITES WITH INCLUSION OF MODIFIED MICROCRYSTALLINE CELLULOSE **Seoku Lee (Inha University, Korea)**
VPC-024	DECISION SUPPORT SYSTEM FOR FOOD WASTE VALORIZATION BASED ON DATA-DRIVEN OPTIMIZATION FOR NEGATIVE CARBON EMISSIONS **Jie Li (National University of Singapore, Singapore)**
VPC-025	THE GLOBAL POTENTIAL OF RENEWABLE AND NEGATIVE EMISSION TECHNOLOGIES TOWARDS CLIMATE NEUTRALITY **Lanyu Li (National University of Singapore, Singapore)**
VPC-026	BIOMARKER OF PYROGENIC ORGANIC MATTER AND INTERMEDIATE DEGRADATION PRODUCTS **Biqing Liang (National Cheng Kung University, Taiwan)**

VPC-027	LIFE CYCLE ASSESSMENT ON MIXED COMBUSTION OF INDUSTRIAL SOLID WASTE WITH HIGH HEATING VALUE AND MUNICIPAL SOLID WASTE **Yuhao Liu (Huazhong University of Science and Technology, China)**
VPC-028	INSIGHT INTO MECHANISMS OF BALL-MILLED BIOCHAR ADDITION ON SOIL TETRACYCLINE DEGRADATION ENHANCEMENT: PHYSCIOCHEMICAL PROPERTIES AND MICROBIAL COMMUNITY STRUCTURE **Honghong Lyu (Hebei University of Technology, China)**
VPC-029	VALORIZATION OF WASTE PLASTICS INTO STIFF CARBON FOAM **Kenneth Mensah (Egypt-Japan University of Science and Technology, Egypt)**
VPC-030	BIOPLASTIC FILM PRODUCTION USING KAPPAPHYCUS ALVAREZII AND ITS DEGRADATION STUDY USING DEEP SEA MARINE MICROORGANISM CONSORTIA **Sudhakar M.P (Saveetha University, India; Ministry of Earth Sciences, India)**
VPC-031	LIGNIN DERIVED ACTIVATED CARBON FOR THE MOISTURE DRIVEN ENERGY HARVESTING APPLICATIONS **Muhammad Ajaz Ahmed (Pyeongchang campus Seoul National University, Korea)**
VPC-032	PRODUCTION OF TRICHODERMA VIRIDE CONIDIA-BASED BIOCONTROL AGENT FROM CORN COB: SOLID-STATE FERMENTATION IN AN EARTHEN VESSEL **Janabai Narwade (Institute of Chemical Technology, India)**
VPC-033	GENERALIZED ADDITIVE MODELS PREDICT BIOCHAR ELEMENTAL COMPOSITION DETERMINED BY DIFFERENT METHODS **Christopher Nzediegwu (University of Alberta, Canada)**
VPC-034	LIGNIN-FIRST BIOREFINERY FOR THE ENHANCED PRODUCTION OF AROMATICS FROM BIOMASS **Oseweuba Valentine Okoro (Université Libre de Bruxelles (ULB), Belgium)**
VPC-035	CARBON-NEUTRAL 2,3-BUTANEDIOL BIOPRODUCTION FROM LIGNOCELLULOSIC BIOREFINERY: AN APPROACH TOWARDS FOOD PLUS FUEL NEXUS **Shazia Rehman (The Hong Kong Polytechnic University, China)**
VPC-036	KNOWING THE 'ENVIRONMENTAL' SKELETON OF THE FISHING SECTOR THROUGH THE VALORIZATION OF THE TUNA HEADS, SPINES AND REMAINS **I. Ruiz-Salmón (Universidad de Cantabria, Spain)**
VPC-037	SCIENTOMETRIC ANALYSIS OF MICROWAVE PYROLYSIS IN BIOCHAR PRODUCTION AND ITS APPLICATION **Mari Selvam S (National Institute of Technology Rourkela, India)**
VPC-038	VALORISATION OF KITCHEN WASTE TO BIOCHAR FOR CARBON SEQUESTRATION **Sri Shalini Sathyanarayanan (Anna University, India)**
VPC-039	FABRICATION OF THERMOSTABLE MESOPOROUS BIOCHAR-BASED NANOCOMPOSITE FROM FRESHWATER ALGAL MATS FOR TOXIC DYE REMOVAL **Wasim Akram Shaikh (Birla Institute of Technology, India)**

POSTER SESSION (VIRTUAL)

VPC-040	GREEN ENERGY PROFDUCTION THROUGH THE SEWAGE SUDGE GASIFICATION: PROCESS SIMLATION AND ECONOMIC EVALUATION **Tao SHI (The Hong Kong Polytechnic University, China)**
VPC-041	HOT MICROBES AT WORK! ORGANIC WASTE-TO-HYDROGEN 'CONVERSION USING A HIGH-TEMPERATURE MICROORGANISM **Harita Sistu (University of Massachusetts, USA)**
VPC-042	WASTE PET BOTTLES DERIVED MIL-125 (Ti) AS AN ELECTRODE FOR SUPERCAPACITOR APPLICATIONS **Shashank Sundriyal (National Physical Laboratory (CSIR-NPL), India)**
VPC-043	BIOCHAR FOR ENVIRONMENTAL REMEDIATION AND CARBON NEUTRAL **Jingchun Tang (Nankai University, China)**
VPC-044	ENHANCED GREEN HYDROGEN PRODUCTION DURING PYROLYSIS OF WASTE BIOMASS USING BALL-MILLED, CHAR SUPPORTED IRON CATALYST **Richard Thomson (The University of Adelaide, Australia)**
VPC-045	FLAME-CURTAIN PYROLYSIS AS A LOW-COST AND SUSTAINABLE METHOD FOR THE PRODUCTION OF BIOCHAR FOR ADVANCED APPLICATIONS **Toshiki Tsubota (Kyushu Institute of Technology, Japan)**
VPC-046	THE ORGANIC WASTE MANAGEMENT TRANSITION TO CIRCULAR ECONOMY **Federico Varalta (Aalto University, Finland**
VPC-047	CARBON DEFECTS IN BIOCHAR FACILITATED NITROGEN DOPING: THE DEGRADATION MECHANISM OF CIPROFLOXACIN IN THE PRESENCE OF PEROXYSULFATE **Yangfan Yuan (Yangzhou University, China)**
VPC-048	COPPER PHYTOEXTRACTION AND BIOMASS UTILIZATION AS ESSENTIAL TRACE ELEMENT FEED SUPPLEMENTS FOR LIVESTOCK **Xiaolin Wang (Ghent University, Belgium)**
VPC-049	NONEGLIGIBLE ROLE OF CRYSTALLNITY ON FE-BIOCHAR'S REDOX REDUCTIVE AMORPHOUS FERROUS MINERAL VERSUS OXIDATIVE FUNCTIONALITY WITH GRAPHITIC CARBON **Zibo Xu (The Hong Kong Polytechnic University, China)**
VPC-050	MICROBIAL SYNTHESIS OF POLY (3- HYDROXYBUTYRATE-CO-3-HYDROXYVALERATE) FROM FORMATE **Jihee Yoon (Korea University, Korea)**
VPC-051	STARFISH: WASTE FROM THE SEA THAT IS DIFFICULT TO DISPOSE CONVERTED INTO A BIO-BASED PCM **Beom Yeol Yun (Yonsei University, Korea)**
VPC-052	TRANSFORMATION AND RECOVERY OF P FROM SEWAGE SLUDGE DURING ANAEROBIC FERMENTATION AND HYDROTHERMAL PROCESSES **Shicheng Zhang (Fudan University, Shanghai Institute of Pollution Control and Ecological Security, China)**

VPC-053	TRUST IN GOVERNMENTAL POLICIES FACILITATING SUSTAINABLE ECOSYSTEMS FOR TACKLING COMPLEX SOCIETAL CHALLENGES **Katharina Fellnhofer (ETH Zurich, Switzerland; Harvard University, USA)**
VPC-054	PLASTIC WASTE MANAGEMENT BY EPR TOWARDS A CIRCULAR ECONOMY IN SOUTH KOREA **Yong-Chul Jang (Chungnam National University, Korea)**
VPC-055	RECYCLING AND MATERIAL FLOW OF POLYETHYLENE TEREPHTHALATE (PET) BOTTLES TOWARDS A CIRCULAR ECONOMY IN SOUTH KOREA **Byounghwan Kim (Chungnam National University, Korea)**
VPC-056	CURRENT STATUS AND MANAGEMENT OF EXCAVATED MATERIALS FROM LANDFILL MINING OPERATIONS IN KOREA **Kyuyeon Kim (National Institute of Environmental Research, Korea)**
VPC-057	MULTIPHASE CFD AND SPECIES MODEL FOR IN-SITU FAST PYROLYSIS OF SPENT COFFEE WASTE: EXPERIMENTAL VALIDATION AND ANALYSIS **Mukesh Upadhyay (Ulsan National Institute of Science and Technology, Korea)**

nature conferences

Waste Management and Valorisation for a Sustainable Future

Abstracts | Session I: Sustainable waste management

Keynote Lecture

DILEMMAS IN WASTE MANAGEMENT AND RESOURCE REUSE

Marian Chertow[1], Reid Lifset[1]
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Waste and materials management are topics of increasing fascination in many countries. Beneath this interest, however, lie lingering questions that have been overlooked or unanswered. Such questions become dilemmas in waste management when heuristics, practices, and policies do not keep up with changes in the economy and society and the trades-offs that are often entailed. Five such dilemmas make up the core of this presentation.

1) The Persistence of Waste. Despite decades of efforts and ongoing advances in data and technology, waste generation continues to increase in quantity and complexity. Non-standard waste accounting systems contribute to this dilemma.
2) Upstream and Downstream. Avoidance of combustion and landfilling is viewed as the central rationale for recycling and reuse, while more substantial benefits arise from the displacement of primary production.
3) Back to the Future. The venerable science of thermodynamics tells us that once discards are mixed together the purity of material diminishes greatly limiting resource recovery.
4) Communication and Confusion. Many consumers feel mystified about what to buy and how best to reuse and recycle. Government studies from Oregon, USA, find that in many cases “recyclable” and even “biodegradable” or “compostable” packaging, have higher environmental impacts than comparable packages being landfilled or burned.
5) Fungibility. If we abandon policies that are ineffective or overly expensive, what happens to the freed-up resources? Are they used to support next generation policies?

Most recently, the largest challenges to waste management programs overall have been external forces from the Chinese ban on import of recyclables in 2018 and its aftermath, to weather disturbances, and to disruptions in municipal and commercial waste involving frontline workers exposed to the coronavirus. Such unpredictability often leads to risk avoidance when dilemmas need to be faced.

Invited Lecture

BENEFICIAL USES OF WASTE MATERIALS IN THE BUILT ENVIRONMENT

Elsa Olivetti
Massachusetts Institute of Technology, USA

Use of supplementary materials and more efficient use of materials has bene highlighted as critical strategic ways to reduce emissions in cement. However, providing a sufficient supply of Supplementary cementitious materials to the cement industry is a challenge as materials traditionally used including fly ash and blast furnace slag, are well used making their supply competitive potentially adding environmentally-burdensome transportation and supply chain complexity. The range of potential SCMs has been broadened by the research community to meet this growing demand, encompassing calcined clays, biomass ashes, steel slags, non-ferrous slags, and bauxite residues. This presentation will focus on experimental and computational methods to broaden the use of these materials focused on biomass ashes and metallurgical wastes.

MOVING TOWARDS CIRCULAR MATERIALS MANAGEMENT IN COASTAL CITIES

Jenna R. Jambeck, Taylor Maddalene, Kathryn Youngblood, Jennifer Mathis, Amy L. Brooks
Circularity Informatics Lab, University of Georgia, Athens, GA, USA

How does the circular economy translate into communities that are at the front lines of waste management. UGA developed the Circularity Assessment Protocol (CAP) to be able to measure circularity in a complex system, like a city. CAP developed in 2018, is a standardized assessment protocol used to collect community-level data to inform decision-makers. The CAP characterizes seven community components: 1) Inputs – What products are sold in the community and where do they originate; 2) Community - What conversations are happening and what are the stakeholders’ attitudes and perceptions? 3) Product design - What materials, formats, and innovations are found in products, particularly packaging? 4) Use – What are the community trends around the use and reuse of product types? 5) Collection – How much and what types of waste are generated? How much is collected and what infrastructure exists? 6) End-of-cycle – How is the waste disposed? What is the fate of waste once it is properly discarded? How is it treated? 7) Leakage - What waste ends up in the environment? How and why is it getting there? Various influencing factors drive this system including governance, economics, policy, and legislation (e.g., bans, taxes). Furthermore, multiple stakeholders exist at every level of the CAP influencing the complex system, and these include the public, government, industry, NGOs, consumers, and academia. As of early 2021, CAP has been conducted in 26 cities in ten countries. The CAP can help to provide guidance on the most effective strategies for a community to improve circularity by delivering key metrics and system characteristics and directing potential actions to improve areas that most need it, for example, along the entire value chain of plastic. Addressing multiple intervention points can reduce quantities of plastic entering the environment, aquatic systems and, subsequently, our ocean. CAP results from Vietnam, Philippines, Malaysia, Panama, and the USA show a range of average litter densities from 0.75 – 3.79 items/m^2 with similarities across Southeast Asia, but not the highest concentrations found (average 1.83 items/m^2). The informal sector was a significant factor in waste management in all cities except those in the US. Convenience products were primarily sold in multilayer film packaging, which was also one of the most common materials found leaking into the environment. Community perceptions varied even within cities illustrated by quotes.

Oral Presentation

RE-THINKING ELECTROCHEMICAL SYSTEMS FOR WATER TREATMENT: REDUCTIVE SYSTEMS, INEXPENSIVE MATERIALS, AND HIGH CONCENTRATION TARGETS

William A. Mitch
Stanford University, USA

Given the high energy demands associated with pumping water to and from centralized water and wastewater treatment systems, decentralized treatment systems will play a significant role in efforts to reduce the energy intensity of water treatment. Electrochemical systems are attractive for decentralized applications (e.g., in the basements of apartment buildings), because they can be operated remotely, their modular nature reduces their footprint, and they can generate chemical reagents on-site. Yet current research on environmental applications of electrochemistry has focused on electrochemical oxidation of low concentrations of contaminants. These systems have rarely moved beyond laboratory-scale, because they feature expensive electrode materials (e.g., diamond). They also are inefficient because high-concentration matrix components (e.g., chloride) outcompete contaminants for reaction at electrode surfaces. This presentation discusses a more promising approach focusing on reductive electrochemical systems that use inexpensive electrode materials and that target constituents that either occur at high concentrations or that are pre-concentrated. Applications include water softening, dechlorination of wastewater effluents, advanced oxidation processes for potable reuse and reduction of halogenated organic contaminants.

GLOBAL SUSTAINABLE WASTE MANAGEMENT

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A Sustainable Waste Management is urgently required to fulfil the UN's Sustainable Development Goals. Within this context, the sustainable use of resources such as rare earth elements, mining, sources and production, electronic products, e-waste is of fundamental importance. Thinking and acting in live cycles is urgently required. The environmental standards, health and working conditions in developing countries is often extremely poor. The export of environmental problems from highly developed to low developed countries is against sustainability and should be therefore minimize or eliminated. Also, pollution with emerging contaminants such as PFAS, PAHs, plastics, mercury, arsenic, antimony, thallium is a global issue. This presentation will provide an overview about the status of contamination, mobilization, transfer, bioaccumulation, human health risk assessment and remediation. Also, lessons from the past and future perspectives will be worked out critically discussed.

CREATING NEW VALUE OF IRON SLAG AS SOIL AMENDMENT TO MITIGATE METHANE EMISSION AND IMPROVE RICE CROPPING ENVIRONMENTS

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Korea and Japan have recycled most (>98%) of blast furnace slag (BFS), a by-product of iron and steelmaking process, for beneficial purposes and exploited an average of 2-4% of BFS for agriculture. In rice paddy, BFS has been utilized as a soil amendment to improve rice productivity and quality over 50 years. BFS has high contents of active iron (Fe) and manganese (Mn) that act as electron acceptor was newly known to suppress methane (CH_4) emission in flooded rice paddy, but the effect of its long-term application on rice cropping environment has been debated. In the international investigation data, BFS fertilization significantly decreased seasonal CH_4 fluxes with the relation of $Y=0.8X^2-11.7X+100.5$ ($R^2=0.983$***, X and Y indicate BFS application level (Mg ha^{-1}) and seasonal CH_4 flux index (%), respectively). Long-term BFS fertilization significantly improved rice productivity and soil quality. Periodic BFS fertilization (1.5 Mg ha^{-1} $year^{-1}$) meaningfully increased rice grain productivity by an average of 14% over the control for the last 28 years. Its fertilization clearly improved apparent rice quality without chemical quality changes. Consecutive BFS fertilization was effective to improve soil physical and chemical properties. However, long-term BFS fertilizer addition did not increase heavy metal concentration in soil. In conclusion, BFS could be an excellent amendment to mitigate CH_4 emission in rice paddy, and to improve soil properties and rice productivity and quality without hazardous material accumulation.

Keywords : blast furnace slag, silicate fertilizer, methane, soil quality, rice quality

FEASIBILITY DEMONSTRATION OF DECENTRALIZED WASTE PLASTIC PYROLYSIS AND BIOMASS HEATING COGENERATION PROCESS

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The global recycling industry practically collapsed when the Chinese policymakers drastically reduced the import of secondary materials in 2017. It is predicted that, if the current trend of secondary plastics generation remains unchanged, 111 million metric tons of plastic waste will be displaced between 2017 and 2030. Thermal pyrolysis of plastics stands as a superior waste reduction method compared to landfill disposal and direct incineration predominately since it can create valuable by-products in the process (fuels and chemicals). Although this approach has been in development by many researchers, specifically on centralized industrial scale processes, feasible economics are still a significant challenge. This is predominately due to large energy input for the process (1.3-1.8 MJ/kg, which reduces the output of liquid combustible products) combined with the necessity of energetically taxing feedstock supply chain. In this work we address these challenges with a demonstration (for the first time) of a modular, pilot-scale cogeneration process which integrates automated biomass (woodchip) boiler (100 kW) with a semi-batch plastic pyrolysis reactor (42 L). Based on the operating results of this system (0.7-85 L of pyrolysis oil per kg of plastics and up to 60 kg of plastics per day) we propose a novel business model for decentralized pyrolysis oil production through seasonal heating. Through techno economical assessment and environmental-energy analysis, encompassing both the cogeneration process as well as the feedstock supply chain our expected results will quantify the improvement of economic and environmental parameters compared to conventional large-scale plastic pyrolysis processes. This in turn will provide a feasible business model for economically self-sustainable waste plastics sink without the need for governmental incentives.

Keywords : Waste-to-energy, cogeneration, waste plastics, pilot-scale, decentralized pyrolysis

RECENT ADVANCES IN PLASTIC WASTE RECYCLING AND VALORISATION: CASE STUDIES FROM ASIA

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As an indispensable material in our daily lives, plastic leads to severe pollution which cannot be easily treated. To alleviate the problem, efforts should be devoted to investigate the key functional enzymes within the biodegradation processes for each type of plastic. Such investigations can lead to the identification of recycling or valorization pathways for various types of plastic wastes. In addition, research must be conducted at a large scale to facilitate the implementation of such approaches in industrial applications.

This talk will focus on the recent progress in the recycling and valorisation of plastic waste via the chemical and biological approaches using mixed plastic wastes as the feedstock, which are feasible solutions for tackling the plastic waste dilemma. From an application perspective, relevant case studies from Asia will be presented.

We will showcase our recently funded Collaborative Research Fund (CRF) project titled 'Reducing Transmission of Novel Coronavirus and Other Infectious Diseases Using Food Waste-derived Medical Textiles via Electrospinning for Healthcare Apparel and Personal Protective Equipment'. We aim to use food waste as the feedstock to produce bioplastics. These bioplastics will be fabricated, via electrospinning into medical textile materials that can be used in various applications.

SMALL(ER) PLASTICS, BIG(GER) PROBLEMS? FATE, TRANSPORT AND IMPLICATIONS OF NANO- AND MICROPLASTICS IN THE ENVIRONMENT

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Numerous studies have made the ubiquitous presence of plastic in the environment undeniable, and thus it no longer comes as a surprise when scientists measure the accumulation of macroplastic litter and microplastic fragments in both urban and remote sites. Ultimately, the different physical and chemical characteristics of the different size classes of plastic pollution (macroplastic, microplastic and nanoplastic) will result in divergent fate and hazards. Quantitative data are still limited due to analytical difficulties to detect nanoplastics in complex matrices, and thus mechanistic studies to understand the fate, transport and biological interactions of these materials are limited. While progress is still ongoing to develop protocols to measure particulate plastic in field studies, researchers who study these processes in bench top or pilot scale studies can take advantage of an entirely different approach. In the last years, we have synthesized a variety of particulate plastics with an embedded inorganic fingerprint which can be used as a proxy to detect plastic by common analytical techniques for trace metals analysis. In practice, this affords for quicker and more accurate sampling and subsequently allows us to investigate the basic processes and pathways which control particulate plastic fate and impacts. To highlight the utility of this approach, we have used these materials in a number of different test systems including, 1) mass balance and flux of plastic through pilot-scale wastewater and drinking water treatment plants, 2) application of sewage sludge in agriculture and plastic mobility through porous media and 3) the interaction and uptake of nanoplastics with plants and organism. As environmental nanoscientists, we try to place nanoplastic in the context of global plastic pollution by assessing its source and risk, but also by assessing commonalities nanoplastics may share with other nano-sized objects in environmental systems, such as engineered nanomaterials and natural colloids. The presence of plastic in the environment has sparked considerable discussion amongst scientists, regulators and the general public as to how industrialization and consumerism is shaping our world. Restrictions on the intentional use of primary microplastics are under discussion globally, despite uncertain microplastic hazards and prioritization amongst options for action. Regulations should have a precise focus and must be enforceable by measurements. Policy must carefully evaluate under which contexts microplastic use may be warranted and where incentives to replace certain microplastics can stimulate innovation of new, more competitive and environmentally conscious materials. Collectively, our research aims to understand the implications of (nano- and micro) plastics in the environment and provide information to make more sound and sustainable choices in relation to plastic use and waste management.

ALIGNING RECYCLING AND MANUFACTURING: SMART MICROFACTORIESTM CREATING SUSTAINABLE MATERIALS AND PRODUCTS FROM PLASTIC WASTE

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Ever increasing generation of plastic waste and associated challenges

Plastics have abundant usage in construction, electronics, automotive, health, packaging, coatings, textiles etc for their intrinsic properties; this list is ever increasing. It is unimaginable to think a single day of life that isn't impacted of plastics; many of those are short life span plastic items. The low value short life span plastics take up a massive share of global landfill waste, because of their inability to achieve technically and commercially viable recycling solutions. The rapid expansion of usage and throw-away mentality associated with these plastic products, major challenges are faced in our current systems for solid waste management, with adverse impacts on our natural environments.

There could be long-term consequences of incorporating low quality plastic into engineering applications. For example, when materials like waste plastics are used in roads-based construction for recycling purpose, they could still release micro/nano plastics easily, which will eventually end up in our environment as pollutants [1]. In India, the major cities are blanketed by thick smog due to the extremely high chloride levels, which are now scientifically linked to the burning of plastic waste from the households and low quality consumer products [2]. These effects force us to rethink whether this type of recycling is really good for our environment, so consideration must be given to degradation and harm caused to our environment in the long-term in the name of recycling. We need to consider the quality of plastics used in the product, so that they can be recycled for products where they will not cause long-term harm to our environment. We should challenge the traditional norms of what might have been considered as good recycling, due to short-term interests, without giving due consideration to the long-term consequences of performance of products in-service.

Low quality, short life, span plastic items enter the waste stream immediately after use. A massive challenge is associated with the management of this large increase in quantities of plastic waste, especially in areas of rapid economic and population growth. Our consumption has outpaced society's capacity to effectively deal with the consequences of a throw-away mentality. The consequences include overflowing landfills, waste stockpile fires and the devastating effects of pollution of our waterways and atmosphere. The action of the environment and UV rays degrades the plastics to micro

and nano levels, and ocean and the water body transport these micro nano plastics all over the world. It is now estimated that 51 trillion microplastic fragments can be found on the surface of the oceans of the world [3]; microplastics eventually becomes nano plastics and enter into the food chain.

Holistic responsibility to reduce environmental impact of waste plastics pollution

Plastic waste remains poorly managed, with as much as 12,000 million tonnes projected to have accumulated in landfills or the natural environment by 2050 [4]. Although conventional recycling processes and technologies was initially promoted as the solution to rising amounts of plastic waste, its failure over the past decades has exposed the severity and scale of the plastic waste management crisis. Some widely used recycling technology is effective only when the quality of the waste plastic is good. For example, conventional injection moulding is extensively utilised for plastic products because it can handle wide range of polymers, can also produce a broad range of product sizes (small to large) and shapes. It is a precise and speedy process. However, the quality of the injection-moulded product predominantly depends on input material's property [5]. In light of this, consideration of quality of plastic products for reusing, recycling and remanufacturing is urgent, keeping in mind technical, economic and environmental sustainability [6].

Shaping materials' circularity with MICROfactories™

Sustainable materials technologies could convert problematic waste plastics into products or input for another manufacturing process, such as transforming plastic toys, e-waste plastic into filaments for 3D printing [7, 8]. This approach of sustainable materials research creates win-win outcomes for Engineering, Environment and Economics and goes beyond conventional recycling and supply chains.

When the quality of the waste plastics are good, it can be transformed into useful materials –such as in the form of plastic filaments for 3D printing [7, 9], or can be used as a raw materials for the injection moulding [5] which are fit for producing a wide range of new plastic product. They therefore create opportunities to close the loop between waste and manufacturing to achieve circular solutions. These opportunities point to the need to go further than conventional recycling processes and recover valuable feedstock from waste.

Nevertheless, a challenge to be addressed is how best to establish decentralised, small-scale systems for plastic waste, which can enable the local businesses to use waste plastic instead of virgin plastic. Large-scale, industrial processing operations depend on extensive collection and transport operations to deliver waste to recycling centres. Providing smaller operators with technologies to process most of their regionally available waste would reduce transport need and use of raw materials – as well as producing value-added, recycled and reformed materials and products.

MicrofactoriesTM brings expertise to focus on local waste management solutions for problematic plastic and other waste materials and enhancing a better understanding of environmental and social impacts. Embedded in circular economy principles, this goes beyond materials recycling to product reforming and remanufacturing.

The future of manufacturing lies in innovations such as SMaRT's MICROfactorieTM technologies [10] which are designed to enable communities to produce many of the materials and products they need by using resources largely derived from waste. This is a win-win situation for society, economy and environment. MICROfactoriesTM could be established in cities as well as small towns, rural and remote areas to reduce their reliance on centralised recycling industries. Decentralised MICROfactoriesTM could transform waste into value-added materials and contribute to global supply chains as well as meeting local manufacturing needs, by aligning recycling and manufacturing to create sustainable materials and products from plastic wastes.

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Oral Presentation

THE PROMINENT BENEFIT OF FURANOATES AS A SUBSTITUENT FOR BIODEGRADABLE TEREPHTHALATES

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The consistent accumulation of plastic waste emphasizes the standstill state of our countermeasure on the environment. The used plastic from one continent is found on beaches of others has already provided the need for the biodegradable substitution. But, as we did not recognize the impact on the environment from the invention of polymeric material, developing biodegradable single-use products should also take into consideration. The majority of biodegradable plastics use petroleum-based monomer that cannot guarantee eco-friendliness after biodegradation. Just like dumping plastic waste on a landfill, petroleum monomer accumulation is an unprecedented matter. Hence, finding a suitable biomass-derived substitute is one of the major components in developing biodegradable plastics. Terephthalic acid (TPA), in specific, is an economical, rigid, and highly versatile monomer that is challenging to replace. Fortunately, furan-2,5-dicarboxylic acid (FDCA) has the potential to be a successful replacement. It is a rigid biomass-derived monomer that has a similar steric conformation to terephthalic acid. But the reason for FDCA to draw such attention is its stereochemical characteristics. Its unique structure induces a significant effect on the crystallization process, degradation, chemical resistance, gas permeability, etc. Herein, we present a direct comparative study on copolyesters, derived from TPA and FDCA. As a counterpart, FDCA proves to show compatible mechanical, along with remarkable elastic behavior. Also, the structure and related ester group showed high enzymatic specificity, leading to rapid and superior biodegradability. Through understanding monomeric characteristics that result in synthesized polymer, biomass substitutes such as FDCA can be suggested to be a solution for developing sustainable and biodegradable polymer.

BIO-BASED MACRO- AND MICROPLASTICS DESIGNED FOR SPECIFIC INDUSTRIAL APPLICATIONS

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More than 300 million tons of (macro-) plastics is produced annually around the world. The large amount of accumulated non-degradable plastics causes the wide-scale destruction of ecosystems because the recycling rate of such plastics is low (<9%). In countries with limited land space, landfill facilities are being saturated. For example, in Seoul, South Korea, it has been projected that landfills will become saturated within the next five years.
Additionally, as microplastics have been found in drinking water, coastal water, and rivers, their adverse effects on the human body is considerably concerning. Microplastic pollution is irreversible because microplastics are generally non-degradable, and there is no practical way to collect microplastics from water. Commercial petrochemical plastics vary in type (e.g., HDPE, LDPE, PP, PS, PET, Nylon, PVC, PEEK, and PC) and size (from nanometers to meters). Each type serves different purposes, e.g., for the production of bags, toys, bottles, electronic devices, fibers, and microbeads for cosmetics and daily-care products, according to the physical features and prices of the products. However, research on new sustainable materials is typically biased on the synthesis of new bio-based polymers itself regardless of their applications, although the various petrochemical plastics were made to do individual applications. The synthesis of new bio-based polymers without any definite applications is likely unfeasible considering the wide diversity and broad-scale applications of plastics.

In this study, we design and develop bio-based macro- and microplastics for specific industrial applications: 1) tough and tear-resistant biodegradable plastics for single-use bags, 2) bio-based recyclable high-performance thermoplastics for electronic and medical devices to replace unrecyclable thermosets, 3) biodegradable high-performance filters for face masks, and 4) biodegradable microplastics for personal-care products and rinse-off cosmetics.

FAST MICROPLASTICS (0.3-5 mm) IDENTIFICATION AS POTENTIAL OPTION FOR MONITORING STUDIES

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The mismanaged waste and high consumption of plastics led to a huge and worrying plastic pollution worldwide by large plastics and microplastics. The impacts include hazardous to both terrestrial and aquatic life, as well as an economic loss. To measure the effectiveness of public politics regarding the actions of combating plastic pollution, there is a need to monitor the environment and the creation of indicators, for example, the temporal abundance of microplastics in a specific area of interest. However, the accurate quantification to establish the pollution scenario and monitoring is difficult because of the size and widespread occurrence. An analytical microplastic identification method that can assist the development of pollution indicators is presented[1]. It is applicable for a wide range of microplastics (> 300 µm) size, but especially fast and easy for large microplastics (1 – 5 mm). Hundreds of particles can be measured simultaneously in less than one minute. It is based on a chemical scanning of the environment collected material placed on a tray that moves while irradiated by near-infrared radiation. The technique is called line-scan near-infrared hyperspectral imaging (HSI-NIR). The time analysis depends on the scanning area regardless of the number of particles, then it is possible to measure as many particles fit simultaneously in the scanning area, from 45-75 cm² in this work. To automatically identify the microplastics, a classification chemometric model (machine learning) was developed to convert the spectroscopic data into a chemical imaging which shows in false colors the identity of the polymers polyethylene (PE), polypropylene (PP), polyamide-6 (PA), polyethylene terephthalate (PET), polystyrene (PS). The main limitations include: the intrinsic deficiency in predicting black or very dark particles; the size detection limit (in this work, applicable for MP > 300 µm); organic matter attached to the microplastic surface will decrease the efficiency of the model prediction for biofouled particles. This method delivers higher characterization throughput without subjectivity for large microplastics. The speed of analysis is feasible for monitoring demands.

[1]Vidal, C. Pasquini C. Environmental Pollution, 285 (2021) 117251

Oral Presentation

SUSTAINABLE SUPER ENGINEERING PLASTICS FROM BIOMASS-DERIVED ISOSORBIDE AGAINST BISPHENOL-A BASED PLASTICS FOR OVERCOMING VARIOUS PROPERTIES

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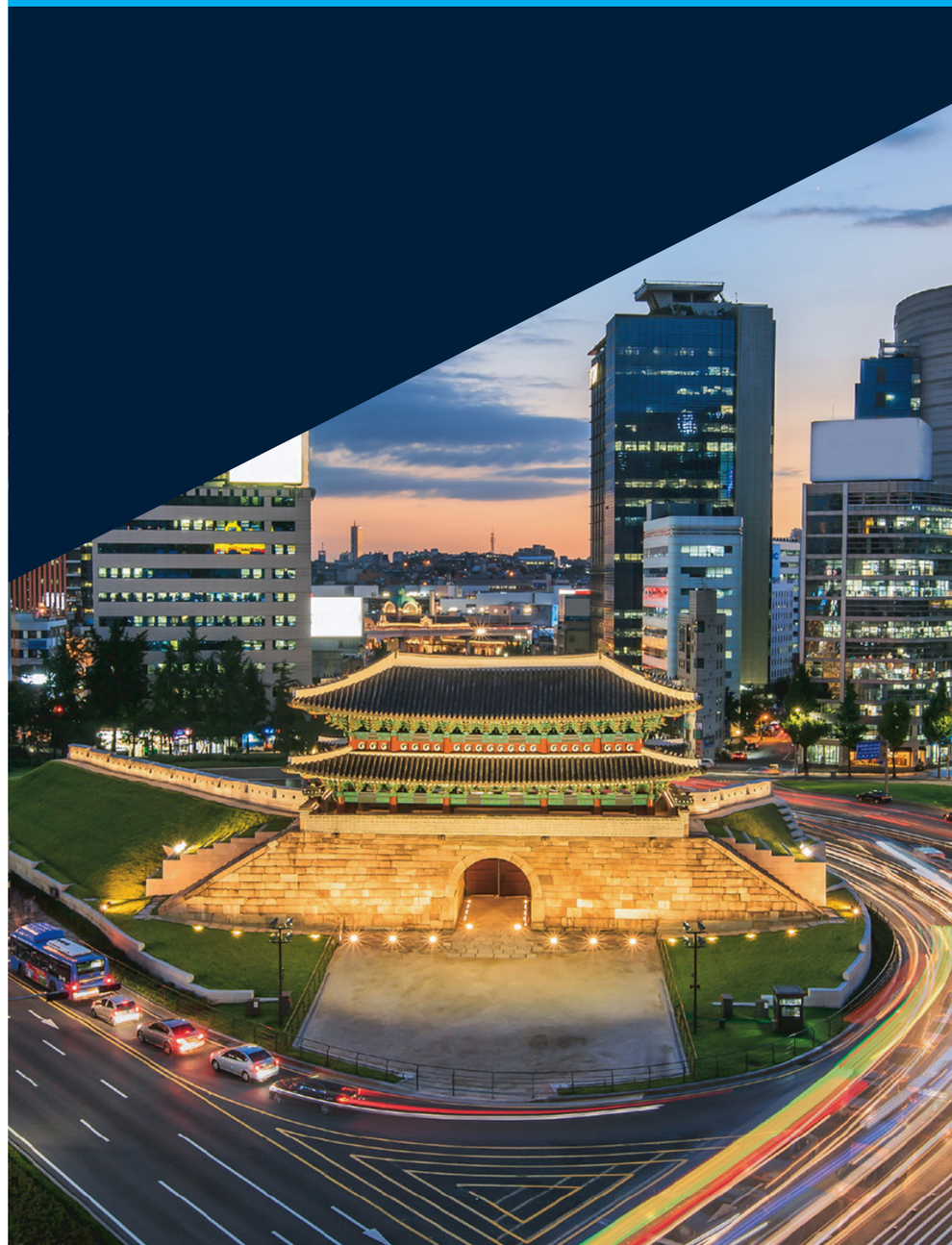
There is a need for Sustainable Super Engineering Plastics (SEP) that utilize bio-derived circulating monomers for environmental and health issues. However, previously reported bio-derived thermosets or thermoplastics offer little to no thermal/mechanical properties, scalability, and recyclability consistent with petrochemical SEPs. Typically, petroleum-based plastics have been produced and consumed over the past decades and can be found anywhere to benefit. However, these petroleum-based plastics have the disadvantage that they must be present when using the endocrine disruptor bisphenol A (BPA). In this respect, interest in bioplastics as an alternative to BPA-based plastics by utilizing biomass resources is increasing recently. The renewable monomeric isosorbide (ISB) is one of the candidates for exchanging BPA-based synthetic polymers produced from fossil resources. In addition, this bio-based monomer has thermally stable polymer stiffness and excellent mechanical properties not found in conventional synthetic biopolymers. Here, we present previously unreported molecular weight ISB-based PAE via solution polymerization using phase transfer catalysts. The novel bio-based polymers with high Tg showed outstanding thermal and mechanical properties that surpass commercial SEPs. The successful transition to ISB also demonstrated a possibility of recycling through melt or solvent processing.

Abstracts | Session III: Electronic waste and circular economy



Invited Lecture

SUSTAINABLE MANAGEMENT OF AN EVOLVING E-WASTE STREAM

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Technological innovation has transformed the role of electronics in education, work, and society. However, rapid adoption and discards of consumer electronics has also led to new concerns about resource consumption and waste management. Past research to address such sustainability issues has been constrained by data that do not capture recent trends in product evolution and consumer adoption, thereby limiting the ability to create proactive solutions. This research presents a dynamic analysis of electronic waste (e-waste) in the United States using material flow analysis and detailed product sales and material composition data.
Findings show that the total mass of the consumer e-waste stream in the U.S. is currently declining, primarily because consumers transitioned away from heavy, legacy products like cathode ray tube TVs and towards new lightweight devices, like flat panel TVs. The observed trends also highlight shifts in the material profile of the e-waste stream. Products being purchased and discarded currently have declining concentrations of hazardous materials such as lead and mercury, but greater amounts of scarce and critical materials, including cobalt, indium, and rare earth elements. Yet modern product designs are increasingly complex, limiting the potential for resource recovery. These results underscore the importance of shifting policy, design, and recycling systems to keep up with evolving e-waste challenges.

SUSTAINABLE MATERIAL SOLUTIONS THAT SCALE TOWARD ZERO E-WASTE

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The World Health Organization recently revealed that more than 18 million children and 12.9 million women currently labor under unhealthy conditions to extract minute quantities of precious and semi-precious materials from the ~54 million tonnes of e-waste discarded annually. This, and the well-documented environmental pollution impacts, is an unstainable price for the world to pay for digital prosperity. The global consensus to solve the e-waste problem depends in part on the establishment of evidence-based targets across various segments of the electronic product lifecycle. Achievement of "zero e-waste" is an idealistic goal that may not be reachable in the near future, but it is approachable with the realistic deployment of accessible technological and policy innovations. Current technical solutions are limited by continuous innovation and not easily scalable, including robotic dismantling and resource recovery. Current policy solutions are limited in scope and do not adequately address inequity issues in the distribution of benefits and risks. The global dimension of the e-waste problem transcends local solutions, and the materials life cycle approach has been researched extensively. Solutions that scale to manage electronic waste is explored in the context of the adoption of green chemistry framework at the level of product conceptualization, design, and manufacturing. In this presentation, I will characterize knowledge gaps and policy differences that are important for mapping the boundaries of major circular economy sectors with emphasis on materials selection pertaining to the electronics industry. I will discuss new ideas such as blockchain digital ledgers for circular mining, resource recovery, and tracking electronic product materials and e-waste from cradle to cradle in an envisioned circular economy. Green materials innovation and supply chain monitoring are scalable if challenges are characterized, and opportunities and best practices are disseminated, including case studies from major electronics manufacturers.

GLOBAL ENERGY TRANSITIONS AND INNOVATION MECHANISMS FOR A SUSTAINABLE ECONOMY

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This presentation will examine the global energy transitions required to meet climate change mitigation targets. I will discuss the changes in technologies and infrastructures that are required to support this transition and will describe promising mechanisms for achieving rapid progress. These insights draw on research examining past rates of progress in clean energy technologies and the underlying mechanisms behind these trends, and on research estimating quantitative targets for future technological progress. I will conclude with several thoughts on prospects for making the clean energy transition more sustainable along multiple dimensions.

FULLY BIODEGRADABLE ELECTRONICS FOR ACHIEVING ZERO-WASTE

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The use of electronic items is constantly growing, and the replacement cycle is shortening with the rapid advancement in electronic device technology. This results in a large amount of electronic waste generated worldwide. Furthermore, the rapidly developing information and communication technology is expanding beyond personal electronics to wearables, bioelectronics, and disposable electronics, which presents several concerns regarding the e-waste issue in the successive generations. Recycling to extract raw materials is inefficient and difficult in some cases of patch-type devices or skin electronics where small amounts of various other materials are implemented as thin films to maximize the flexibility and attachability to skin or tissues. Transient electronics is a newly emerging field designed to manufacture electronic devices using materials that are biocompatible and biodegradable, which can be easily disposed after the device lifecycle ends. In this study, we introduce transient electronics that can be easily removed from aqueous solutions using nano-thin film materials with hybrid use of organic/inorganic materials. Biodegradable kinetics and biocompatibility of prospective biodegradable semiconductor material groups, such as Si nanomembrane, dielectric materials, and metal materials are discussed. Flexible and patch-type electronic devices formed by photopatterned circuits on biodegradable polymers offer comparable performance to that of conventional Si counterparts. The applicability of the current transient electronic device technology is presented through an environment-controlled biodegradable biomedical application including temporary monitoring of intracranial pressure sensor to wireless regenerative peripheral nerve stimulator.

SUSTAINABLE POLICY FRAMEWORK OF EMERGING E-WASTES IN KOREA DURING THE TRANSITION TO THE FOURTH INDUSTRIAL REVOLUTION

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Despite the fact that an increasing number of countries are adopting statutory regulations to address e-waste issue with ESM, the existing management and treatment practices for e-waste are still highly inadequate; for e.g., 80% of the global e-waste is disposed indiscriminately. Additionally, international laws for the disposal of new types of e-wastes, such as end-of-life solar panels, are yet to be established. Here, we aimed to provide a comprehensive overview of the current status of e-waste management in South Korea and to suggest an approach for the management of emerging e-wastes such as solar panels and electrical vehicle batteries, which could assist in the establishment of international legal standards. The Korean government has imposed restrictions on the use of hazardous substances in Electrical and Electronic Equipment (EEE) through the Eco-Assurance System of EEE and Vehicles (EcoAS system) since 2008 and minimized the environmental load through the life cycle management of products and automobiles. The EcoAS system currently manages 49 EEEs and aims for a recycling rate of 7.56 kg/capita. In addition, guidelines for restrictions on the use of ten types of hazardous substances, such as phthalate esters, have been prepared and used for the management process.The “Future e-waste recycling system construction plan” has been established for the development of a safe system for the public collection of the wastes and their recycling, in which professional recycling organizations are fostered through pilot projects. First, by establishing the e-waste resource collection center base, the wastes can be safely collected and stored until the recycling system is activated in the private sector. Second, through amendments of relevant laws, recycling methods and standards can be established for waste solar panels and electric vehicle batteries. The rate of collection and recycling of the e-waste is expected to increase as a result of amendments to existing laws and management through an established system. However, the chances of additional environmental pollution during recycling and methods to reduce this pollution should be investigated. Furthermore, the management of the emerging e-waste (e.g. semiconductor, AI waste, waste batteries of hybrid vehicles) calls for efforts to revise relevant laws and adopt institutionalization for each country as well as guidelines for establishing a systematic consensus for global waste management practices.

IMPEDANCE BASED PROGNOSTICS AS AN EFFICIENT WAY FOR SORTING AND ECHELON UTILIZATION OF SPENT LITHIUM BATTERIES

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Rapid growth in electric vehicles as a green mobility alternative has given rise to the question of environmentally safe and economical disposal of the spent lithium-ion batteries (LIBs). To this end, second life use or echelon utilization of these spent batteries is a viable approach. However, challenges pertaining to sorting and regrouping of these spent batteries rapidly, efficiently and accurately on a large scale need to be addressed. Estimation of remaining life is a straight forward method to find the residual value of the spent batteries. The increasing availability of battery cycle data has enabled data driven prognostics and machine learning approaches to effectively predict remaining useful life of LIBs. However, the nonlinear nature of capacity degradation in LIBs and the irreversible changes that occur in the batteries internal structure due to thousands of cycles of charge and discharge during first life make the prediction of remaining life challenging. Identifying key parameters that reflect the state of battery plays an important role in modelling these data driven approaches. Increase in impedance due to loss of lithium inventory by SEI layer formations can be correlated to capacity fade. Thermal profile of a battery reflects the internal chemical condition and ageing of the battery and change in voltage can be related to capacity degradation. In this paper, an Artificial Neural Network (ANN) model is trained to correlate between impedance, temperature, voltage and capacity data. The trained ANN model effectively estimates the state, remaining life and internal resistance enabling rapid and accurate sorting of spent batteries.

Keywords: Echelon utilization; Spent lithium-ion batteries; Impedance; Artificial Neural Network; Remaining Useful Life

EFFECT OF RICE HUSK BIOCHAR ON LEAD DYNAMICS AND BACTERIAL PHYLOTYPE COMPOSITION IN SOLAR CELL WASTE-CONTAMINATED SOIL

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The release of toxic elements from solar cells can result in a potential risk to the surrounding ecosystems through contamination of soil. Hence, this study aimed to determine the effect of biochar on the Pb dynamics and bacterial phylotype composition in solar cell waste-contaminated soil. Silty loam soil was spiked with 300 mg/kg of Pb^{2+} using solar cell powder (SC) or perovskite solution (PL) and incubated at 25 °C. Rice husk biochar produced at 550 °C (RH550) or 700 °C (RH700) was added (5% w/w) to the spiked/nonspiked soil after 30 days and incubated for another 30 days with four replications. Soil samples were collected before and 30 days after biochar addition and the soil chemical properties and microbial community composition were analyzed. At the end of the incubation period, SC application had significantly increased the soil pH (10.13 ± 0.01) compared to the soil before the treatment (8.25 ± 0.01). No change was detected in soil pH under both PL and biochar treatments. The Pb^{2+} content in PL treatment was approximately five times higher than that of SC treatment, indicating that the amount of Pb^{2+} added was immediately immobilized owing to the high pH of SC-treated soil. RH550 and RH700 significantly ($p < 0.05$) reduced the Pb^{2+} content in PL-treated soil, accounting for 11.9% and 15.3% of Pb^{2+} immobilization, respectively. Application of biochar resulted in an increase in bacterial diversity and evenness in both SC- and PL-treated soil, suggesting that rice husk biochar could be used to improve the soil quality in solar cell waste-contaminated soil. Our study also demonstrated the requirement of long-term studies on the environmental impacts of metal halide-based perovskite solar cells to achieve sustainability.

This work was supported by the Cooperative Research Program for Agriculture Science and Technology Development (Effects of plastic mulch wastes on crop productivity and agroenvironment, Project No. PJ01475801), Rural Development Administration, and Republic of Korea and the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2021R1A2C2011734).

Invited Lecture

CIRCULAR ECONOMY IN URBAN FOOD SYSTEMS TOWARD NET-ZERO CARBON CITIES: CASE STUDIES FROM USA & INDIA

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Resource circularity and carbon valorization, particularly at the Food-Energy-Water nexus, are key pathways to achieve a net-zero carbon emissions future. Transforming urban infrastructure and food provisioning systems – encompassing food, energy, water, waste, mobility, buildings and green infrastructure – will be particularly important. Urban areas will house >66% of the world population and urban transboundary (local-to-global) consumption-production systems focused on food systems will play a key role in resource circularity toward net-zero goals. This paper contextualizes circular economy and resource circularity potential with a focus on the food system and the food-energy-water-wastewater-waste (FEWW) nexus across four cities in the US and India, estimating material and energy flow analysis. The cities include Minneapolis, MN; New York City; Delhi, India; and Pondicherry, India.
In the context of key urban food systems levers for resource circularity, we first compare and contrast three key levers: food waste, diet changes, and urban agriculture interventions in the context of city-wide carbon emissions reduction toward the goal of net-zero emissions. Specifically, we quantify the first order impact of resource circularity at the Food-Energy-Water nexus in contributing to net-zero emissions cities using current technologies for resource circularity and found across all four cities. Second, we present a framework and preliminary results exploring emerging technologies for resource circularity at the intersection of waste valorization and urban agriculture. Linkages between resource circularity and circular economy goals are explored, in the context of advancing wellbeing for all within planetary boundaries.

CIRCULAR ECONOMY DRIVEN SUSTAINABLE COMPOSITES

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The development of biocomposites where both the polymer matrix and reinforcements can be engineered from renewable, recycled, and waste resources as well as their hybrids supports the circular economy model. As we transition towards a waste-free world, the valorization of biomass wastes, agro-food residues, industrial coproducts, plastic wastes for composites uses is the wave of the future. The sustainable composites in this presentation is grouped into two broad categories – biodegradable composites as alternatives to current single-use plastic packaging, and durable materials for lightweight, odor-free, 'green' automotive parts, eco-friendly building structures and affordable consumer products. Bioplastics are costly due in part to a much smaller production scale compared to that of petro-based plastics. The combination of biomass wastes with bioplastics can create innovative compostable alternatives to single-use plastics. While natural fibre composites face major challenges such as undesirable odor and aesthetics as well as supply chain issues, the pyrolysis of biomass from waste resources creates biocarbon that has been successfully used in automotive parts. Biocarbon provides multiple advantages over glass fibres, mineral fillers because it is sustainable, odor-free, thermally stable, and it provides the black color used in around 70% of interior car parts and much more consistent properties than lingo-cellulosic fibres. This presentation will cover the latest innovations on waste valorization in green manufacturing and how these are integrated with a sustainable bioeconomy approach and benefit from University-Industry-Government collaborations.

A SUSTAINABLE CARBON-NEUTRAL FUTURE AIDED BY WASTE MANAGEMENT AND AI

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Facing the pressing environmental and climate change challenges, novel approaches are needed for sustainable development towards a carbon-neutral or net-zero future. Advances in artificial intelligence (AI), especially machine learning (ML), provide enormous smart tools for processing complex data and information generated from experimental and computational research, as well as industrial applications. The potential contribution of ML combined with big data to environmental especially waste management is worth of investigation. Our recent works focus on AI applications in carbon reduction. Data-driven models based on ML techniques are developed for state-of-the-art technologies, and multi-objective optimization is conducted to aid waste to energy and materials. Furthermore, life cycle assessment is applied to compare and optimize multiple scenarios such as centralized and decentralized waste treatment systems. Finally, optimal design of negative emission waste-to-energy systems with biochar production is presented. To conclude, contributions of "Waste Reducing, Recycling and Recovery" to a carbon-neutral future globally are envisioned.

Invited Lecture

WASTE TO RESOURCE TOWARDS ENVIRONMENTAL SUSTAINABILITY IN MEGACITIES

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Facing the pressing environmental and climate change challenges, novel approaches are needed for sustainable development towards a carbon-neutral or net-zero future. Advances in artificial intelligence (AI), especially machine learning (ML), provide enormous smart tools for processing complex data and information generated from experimental and computational research, as well as industrial applications. The potential contribution of ML combined with big data to environmental especially waste management is worth of investigation. Our recent works focus on AI applications in carbon reduction. Data-driven models based on ML techniques are developed for state-of-the-art technologies, and multi-objective optimization is conducted to aid waste to energy and materials. Furthermore, life cycle assessment is applied to compare and optimize multiple scenarios such as centralized and decentralized waste treatment systems. Finally, optimal design of negative emission waste-to-energy systems with biochar production is presented. To conclude, contributions of "Waste Reducing, Recycling and Recovery" to a carbon-neutral future globally are envisioned.

Oral Presentation

STATE-OF-THE-ARTS TECHNOLOGY FOR FOOD WASTE VALORIZATION

Sang-Hyoun Kim[1], Tirath Raj[1], Chandrasekhar Kuppam[1], Roent Dune A. Cayetano[1], Ju-Hyeong Jung[1], Young-Bo Sim[1], Jungsu Park[1], Gi-Beom Kim[1]

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The necessity to carry out a proper management of food waste (FW) is underlined by the amount of resources needed for food production, processing, and transport. Organic material, however, contains various secondary raw materials. Although the characteristics of FW are various depending on the food culture and waste collection method of a country, generally it has high organic and water contents. Organic matters in FW have generally minimal toxicity and can be converted into biofuels, chemicals, and materials under integrated biotechnological processes. Therefore, FW can be considered as inexpensive feedstock for biological transformation. Anaerobic digestion is a representative established recycling technology for FW. However, anaerobic digestion of FW often faces challenges including inhibition by high concentration of ammonia, volatile fatty acids, salinity and/or lipids as well as inadequate digester hydrodynamics due to high viscosity and particular matters. Furthermore, the low energy productivity and price limit the utilization of biogas. Recently, FW biorefineries have gained momentum for the production of value-added products such as hydrogen, biofuels, platform chemicals, biopolymers, biobased proteins and enzymes, fertilizers along with biogas.

This talk will focus on the state-of-the-art technology for FW valorization that would encourage FW for biogas and other value-added products, while reducing the environmental burden and provide a sustainable green solution to modern society. It will also introduce the status and prospects of FW digestion in Korea, where most of FW is separately collected and recycled.

SUSTAINABLE URBAN FOOD SYSTEMS WITH OPTIMUM REDUCTION AND RECYCLING OF FOOD WASTE : A FORESIGHT 2035 STUDY TO BRING OUT THE RESEARCH PRIORITIES

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[1]Montpellier SupAgro, Montpellier, France; [2]Institut national de recherche pour l'agriculture, l'alimentation et l'environnement, Paris France

Almost all urban areas experience high levels of food waste. Wastes at household, food service, wholesale and retail level constitute 70% of total food losses in EU. In practice, urban bio-waste remains marginally recycled and returned to farm soil and therefore, does not contribute to closing bio-geo-chemical cycles and to supporting sustainable food production. A foresight approach was used to i) identify high potential socio-technological innovations in food waste prevention and valorization and ii) extract research and innovation questions contributing to fostering and accompanying cities' breakthrough strategies towards sustainable food systems, specific to different urban settings worldwide. The exploration of three "food systems scenarios" in the context of "three urban scenarios" allows to highlight requirements and questions for the research which were grouped into five broad categories related to issues or types of impacts expected: i) society, ii) industries, iii) health and the environment, iv) technological processes, looping cycles and associated business models and finally v) the information and communications technologies. High potential key measures and generic questions and perspectives for research on the link between cities and Zero waste sustainable food systems are discussed.

nature conferences

Waste Management and Valorisation for a Sustainable Future

Abstracts | Session V: Biomass valorisation: waste to resources

INNOVATIVE APPROACHES TO TURN AGRICULTURAL WASTE INTO ECOLOGICAL AND ECONOMIC ASSETS - THE NOAW PROJECT

Nathalie Gontard[1], Morten Birkved[2], Mauro Majone[3], David Bolzonella[4], Annamaria Celli[5], Hélène Angellier-Coussy[1], Guang-Way Jang[6], Anne Verniquet[7], Jan Broeze[8], Burkhard Schaer[9]

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Agricultural waste is a huge pool of untapped biomass resources that may even represent economic and environmental burdens. Driven by a near zero-waste goal and supported by 32 transdisciplinary academic and private partners from Europe and China, the NoAW project was devoted to generate innovative eco-efficient approaches to convert the growing amount of human-produced agricultural waste into eco-efficient bioenergy and bio-based products with direct benefits for the environment, economy and consumer. Supported by a large international stakeholders platform, agro-waste management strategies were both driven and evaluated by life cycle analysis coupled to territorial metabolism and multi-criteria decision analysis. The resulting NoAW solution is a robust toolbox of imbricated technologies able to convert agricultural residues from livestock farming, fruits, vegetables, cereal and wine sectors into high added-value bioproducts. To enhance anaerobic digestion, a wet explosion process (AD booster pre-treatment) was developed to degrade the recalcitrant ligno-cellulosic residues into accessible substrate in subsequent processes. Then, a 2-step anaerobic digestion process has been developed to produce biogas (H_2, CH_4, CO_2) as well as volatile fatty acids (VFAs) and nutrient rich digestate. The biogas has been upgraded by microbial electrosynthesis into biomethane and biohythane. The volatile fatty acids were used to produce polyhydroxy-alkanoates (PHA) to partially substitute oil-based plastics. The final packaging materials were formulated with lignocellulosic fillers and antioxidants from winery waste. The developed cascading biorefinery enables to convert unused residues instead of virgin oil or crop materials and favoring decentralized production facilities, for new income and employment opportunities in rural areas. NoAW experimental platforms increase biogas production and decrease PHA cost offering a larger PHA market, with significant economic gain compared to biogas.

UNRAVEL MECHANISMS BETWEEN THE CARBON AND METAL SPECIES TOWARDS BIOGRAPHENIC-LIKE MATERIALS

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Agricultural waste is a huge pool of untapped biomass resources that may even represent economic and environmental burdens. Driven by a near zero-waste goal and supported by 32 transdisciplinary academic and private partners from Europe and China, the NoAW project was devoted to generate innovative eco-efficient approaches to convert the growing amount of human-produced agricultural waste into eco-efficient bioenergy and bio-based products with direct benefits for the environment, economy and consumer. Supported by a large international stakeholders platform, agro-waste management strategies were both driven and evaluated by life cycle analysis coupled to territorial metabolism and multi-criteria decision analysis. The resulting NoAW solution is a robust toolbox of imbricated technologies able to convert agricultural residues from livestock farming, fruits, vegetables, cereal and wine sectors into high added-value bioproducts. To enhance anaerobic digestion, a wet explosion process (AD booster pre-treatment) was developed to degrade the recalcitrant ligno-cellulosic residues into accessible substrate in subsequent processes. Then, a 2-step anaerobic digestion process has been developed to produce biogas (H_2, CH_4, CO_2) as well as volatile fatty acids (VFAs) and nutrient rich digestate. The biogas has been upgraded by microbial electrosynthesis into biomethane and biohythane. The volatile fatty acids were used to produce polyhydroxy-alkanoates (PHA) to partially substitute oil-based plastics. The final packaging materials were formulated with lignocellulosic fillers and antioxidants from winery waste. The developed cascading biorefinery enables to convert unused residues instead of virgin oil or crop materials and favoring decentralized production facilities, for new income and employment opportunities in rural areas. NoAW experimental platforms increase biogas production and decrease PHA cost offering a larger PHA market, with significant economic gain compared to biogas.

Invited Lecture

THE ROLE OF LCA IN SUSTAINABLE WASTE MANAGEMENT

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Life-cycle-assessment (LCA) has been used in waste management for the last two decades and hundreds of journal papers have been published on this topic. The use of LCA in waste management has provided a much improved holistic view of waste management including waste flows and potential environmental impacts. Although much general knowledge has been obtained from LCA studies, there is still a need to use LCA models in integrated waste management. This presentation describes and discusses six areas where LCA is expected to play a role in waste management in the future: 1) Understanding an existing waste management system, 2) Improving existing waste management systems, 3) Comparing alternative technologies/ technology performance, 4) Technology development/ prospective technologies, 5) Policy development/strategic development, and 6) Reporting. Illustrative examples are provided for each application area.Note that accepted abstracts will be printed in black and white and will appear in the program book distributed at the conference. Please turn Track Changes OFF before you save your abstract. Remember to edit thoroughly your author names, affiliations, and text before submission.

Oral Presentation

ENVIRONMENT VS HEALTH: THE CRUEL CHOICE IN THE MIDST OF THE PANDEMIC

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Plastic products have played significant roles in protecting people during the pandemic. At the same time, the widespread use of plastic products, including single-use containers and personal protection equipment (PPE) created a disruption in the supply chain and waste disposal system. This generated an enormous amount of plastic waste from both healthcare and household units, and will continue to do so for the foreseeable future. The use of single-use PPE is inevitable to protect human health, but at the same time, is resulting in concerning issue of plastic pollution. Here, we demonstrate production of sustainable PPE from waste-derived substrate to protect both human health and environment. Single-use masks were fabricated using biodegradable polymers to minimize negative environmental impacts resulting from the mask waste. The biodegradable polymer was selected based on the “true” biodegradation level quantitively measured using laboratory-scale biodegradation test device. We also show that these polymers can be synthesized from waste-derived substrates and can be readily recycled without deterioration in polymer quality.

HYBRID BASED COMPOSITE PHASE CHANGE MATERIALS-INTEGRATED LATENT HEAT STORAGE SYSTEM FOR SUSTAINABLE FUTURE

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Latent heat thermal energy storage based on phase change materials (PCMs) plays a central role in the development of state-of-the-art renewable energy technologies. It has been employed in various areas, such as solar-thermal energy storage and conversion and biomedical fields. However, their seepage above the melting point of PCMs, low heat transfer property, and deficiency in responding to multiphase energy sources restrict large-scale employment. In this study, we explore hybrid nanomaterials-supported n-alkane for large latent heat storage systems. Two different hybrid materials obtained from the integration of multiwalled carbon nanotubes (CNTs) with biochar and exfoliated graphene nanoplatelets (xGnP) were used as n-alkane support. The materials revealed distinctive attributes and the synergistic effects of each supporting component for the well-designed composite PCMs demonstrated high physical and thermochemical responses. Biochar/CNT-supported alkane achieved high latent heat storage (127 kJ/kg) without leakage flow above the melting point of pure PCM. similarly, n-pentadecane supported by xGnP/CNT exhibited high latent heat storage 150.9 kJ/kg, which is 36% higher than xGnP/n-pentadecane, owing to the large specific surface area and suitable pore size distributions. Further, the synergy of the supporting materials experienced low electrical resistivity and high thermal conductivity, which are promising in low-temperature thermoregulation applications (e.g. waste heat recovery system, and building).

Keywords : Hybrid materials, biochar, phase change materials, renewable energy storage, heat transfer

Acknowledgement This work was supported by Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government (MOTIE) (20202020800030, Development of Smart Hybrid Envelope Systems for Zero Energy Buildings through Holistic Performance Test and Evaluation Methods and Fields Verifications).

FOOD WASTE BIOCHAR AS A RENEWABLE FUEL: A CASE STUDY OF KOREA

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Food waste is becoming a concern for global environmental health due to the increasing amount. Approximately 97% of food waste is recycled by composting, animal feeding, and generation of biogas in Korea. However, current recycling methods have face challenges such as poor quality, low efficiency, and generation of food waste leachate. In this study, we proposed an alternative treatment approach for food waste to ensure future sustainability. Food waste was converted into solid fuel, food waste biochar, by pyrolysis and demineralization. Various pyrolysis temperatures (450 and 500 ℃), retention time (10-30 min), demineralization methods were applied to optimize the production process of food waste biochar. Food waste biochar meets the fuel qualification of calorific value, chlorine content, ash content, and heavy metal content. Especially, food waste biochar pyrolyzed at 500 ℃ for 20 min and demineralized with citric acid 3% showed promising specifications. Calorific values of all food waste biochar are over 5,000 kcal/kg, which is comparable to that of coal. Furthermore, chlorine concentrations lower than 0.5% were achieved by demineralization. These results constitute clear evidence that food waste can be adopted as a solid fuel for co-firing with coal in a thermoelectric power plant. Based on the results, we can provide a sustainable methodology for handling food waste.

Acknowledgments: This research was funded by the Korea Institute of Civil Engineering and Building Technology (KICT), grant number 20210105-001.

DEVELOPEMENT OF HIGH-SELECTIVITY CAPROATE PRODUCTION AND RESIDUAL CARBON SOURCE RECOVERY PLATFORM

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Production of n-caproate from various organic waste is getting more attention as a promising sustainable waste treatment technology. n-Caproate production from organic waste can be carried out through anaerobic open culture fermentation. In particular, chain elongation based on reverse-β-oxidation is a key fermentation pathway in n-caproate producing reactor system. The chain of the carboxylates can be extended by the reducing power and carbon chain which can be supplied from electron donor such as lactate and ethanol. Therefore, internal production of electron donating chemical from organic waste is important for effective and sustainable conversion of organic waste to n-caproate. For this, two phase system was suggested which consists of lactate fermentation step and chain elongation step. Among these two steps, chain elongation step was rate limiting step. However, developing n-caproate producing reactor system showing stable and high n-caproate productivity was hindered by complexity of gene and metabolite functions in the bioreactor. To overcome this difficulty, we adopted "Design-Build-Test-Learn approach" and developed fast and reliable microbiome shaping technology which ensures to achieve n-caproate producing culture. Finally, we realized that fostering reduced condition was advantageous for production of n-caproate which is the most reduced fermentation product identified in this system. Thus, we developed continuous bioreactor system based on this key knowledge. Anaerobic membrane bioreactor (AnMBR) system was built to increase the n-caproate productivity through cell retention. However, during long-term operating period of n-caproate producing AnMBR, various microbial competitions occurred and n-caproate specificity was markedly lowered. Thus, we developed bioreactor operating technology to guarantee the long-term stability of the n-caproate microbiome. The developed reactor system successfully produced n-caproate with high product specificity, but two-types of residual carbon (i.e., bicarbonate, short-chain carboxylates) was continuously generated. As a following experiments, we cultivated Spirulina platensis to recover the residual carbon and develop complete waste carbon recovery platform.

Keynote Lecture

OVERSHOT AND OVERWHELMED: GLOBAL WASTE MANAGEMENT POLICY SYSTEM: HOW TO ADDRESS GLOBAL WASTE VALORISATION CHALLAGES IN THE COVID19 ERA?

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Centre of Resilience and Sustainable Development (CRSD), Department of Land Economy,
University of Cambridge, UK

The world is at an unprecedented timeline crossroads regarding waste management, governance and valorisation. Solid waste management has become a universal issue and affects every single person living on planet Earth. Whether individuals are managing their own waste, or the governments are providing waste management services to their citizens, there is an awakening awareness that the momentum of the increased unmanaged waste is going to have a snowball effect. At least 33% of this waste is being mismanaged globally through open dumping or burning, according to the World Bank – 'What A Waste 2.0' report, and 90% of the mismanagement happens in the waste importing countries that are typically low-income countries and home of western waste. According to the 2020 US Census Bureau, 78% of those exports were sent to countries such as China, India, Malaysia, and Indonesia, where lacking the infrastructure and regulation to effectively and sustainably sort, process, and recycle plastic waste into new materials. It is the poor and most vulnerable who are disproportionately affected. In the COVID-19 era, it has escalated the complexities of solid waste management and threatened to induce another environmental crisis.

With that context in mind, in this presentation, we will review the main impacts due to mismanaged global waste trade system, impacts of poor waste management and geopolitical failure in waste governance system on people, planet and profit. This paper will explore a novel action-research approach to improve decision making and funding attractiveness for global waste governance and valorisation solutions.

Invited Lecture

CIRCULAR BIO-NUTRIENT ECONOMY: SUSTAINABILITY AT THE NEXUS OF FERTILIZER-FOOD-FECES

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Most nutrients in the global economy are flowing through food to excreta. For more than a third of countries globally, more nitrogen, phosphorus or potassium is flushed down the toilet than added with fertilizers to crops in order to produce the food that creates the excreta that are rarely used as fertilizers. While animal manures have been better integrated in a circular economy, they are poorly utilized and in many countries pose a waste management issue. The challenges to produce market-ready fertilizers from excreta include facilitating collection, the need for technology advances (especially to remove nutrients from liquids such as urine), overcoming challenges of distribution and transport, accessing markets, retooling a fertilizer industry from mining to recycling, and changing consumer aversion to utilize fertilizers made from excreta. Intriguing new technology avenues have recently emerged for nutrient recovery from liquid wastes that not only include more well-known precipitation reactions but also liquid-phase adsorption or dry-phase gas adsorption. Life-cycle optimization shows trade-offs between greenhouse gas footprint, carbon dioxide removal, and revenue that require careful policy intervention. Recycling excreta likely is one of the most wicked sustainability challenges, as it connects disparate societal actors that are affected by it and profit from food production, consumption, and sanitation,- requiring policy guidance to re-distribute rewards and responsibilities.

RESEARCH ON RESOURCE CIRCULATION POLICIES IN THE POST-COVID-19 ERA

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This study examines the changes in consumption pattern, such as online shopping and delivery food, caused by COVID-19 and the consequent changes in the use of couriers and recyclable waste generation in South Korea. Then, analyzing South Korea's current governmental measures for reducing waste and promoting recycling, this study suggests how South Korea could enhance resource circulation more efficiently in the post-COVID-19 era. Since the emergence of COVID-19, there has been an overall decrease in personal consumption expenditure and retail sales in South Korea, yet online shopping transactions have increased year-on-year. Moreover, the consumption of food services has continued to show an increasing trend, which grew even more significantly with the strengthening of social distancing measures. Meanwhile, domestic courier services, i.e., the delivery of parcels and packages, have increased 20.9% year-on-year, which is twice the growth rate of the previous year. Prior to the COVID-19 pandemic, apart from synthetic resins, the amount of recyclable wastes, such as paper and plastics, did not show a significant increase. However, after the outbreak of COVID-19, the amount of waste paper increased by 29.4%, waste plastics by 15.6%, and waste vinyls by 11.1% year-on-year. By examining the impact of the pandemic on existing resource circulation policies and their effectiveness, this research reveals that to increase the effectiveness of resource circulation policies in the post-COVID-19 era, top priority should be given to policies that regulate the use of packaging waste, which has rapidly increased due to the pandemic, and promote recycling. Also, for the mid-to-long term, regardless of the pandemic, policies that should be pursued sustainably were those that promote the use of recycled raw materials and the conversion to eco-friendly materials.

PROSPECT OF SOUTH KOREA'S NEW PLASTIC WASTE MANAGEMENT POLICY AFTER THE COVID-19

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Plastic, which is light, hard, and not easily change its characteristic while also being moldable into any shape, has permeated every aspect of our lives and provided infinite convenience, to the extent of being called the miracle material of the 20th century. Nevertheless, because the indiscriminate use and mismanagement of plastic has resulted in environmental accumulation of plastic wastes, it is now being referred to as the main culprit of environmental pollution such as marine plastic litter and microplastics.
In April 2018, the incident of plastic waste collection refusal in the metropolitan area of South Korea gave rise to concerns regarding the collection and recycling of plastic wastes. In May 2018, the "Comprehensive Plan for Recycling Waste Management" was devised to provide improve measures for each stage of recycling plastic wastes. Accordingly, policies regulating the use of disposable products in restaurants and coffee shops were fully implemented from August 2018. In December 2018, in response to China's ban on imports of solid waste, including plastics, as well as the challenge of national waste such as the increase in wastes abandoned in the environment without proper treatment on plastic waste treatment facilities, the "Master Plan for Resource Circulation (2018 to 2027)" was prepared; however, the enforcement of related policies was temporarily suspended because of the COVID-19 pandemic. In addition, as the amount of plastic waste such as disposable products and packaging materials has been increased considerably owing to increase in food take-outs and deliveries as well as the use of personal protective equipment, the problem of plastic waste has aggravated. In December 2020, given the urgent need to formulate measures to reduce the amount of plastic waste generation during the COVID-19 pandemic, South Korea announced the "De-plastic Measures" to reduce the source of plastic production and consumption while expanding the recycling rate of plastic wastes, which is intended to be implemented as a mid- to long-term plan for conversion into a de-plastic society.
This study aims to introduce the main contents of South Korea's De-plastic Measures from the time of the COVID-19 outbreak to the aftermath of the pandemic, and to present the challenges of the current plastic waste management system as well as the future direction through the material flow analysis of plastic wastes.

AN IMPROVED RESOURCE CIRCULATION STRATEGY FOR EFFECTIVE WASTE MANAGEMENT TOWARD A CIRCULAR ECONOMY IN SOUTH KOREA

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With rapid industrial development, the consumption of resources continues to increase, thereby leading to the generation of a substantial quantity of waste, which poses a threat to the environment and human life. While governments across the world have implemented multiple policies to reduce waste, a definitive solution for coping with the considerable increase in global annual production and consumption is yet to be provided. Under these circumstances, inadequate responses to the increasing proportion of elderly and single-person households, changes in consumption patterns, alterations in resource circulation conditions resulting from industrial changes, and urbanization-induced changes are considered major contributors to the difficulties in waste management. To solve this issue, a circular economy (CE) may serve as a important concept. It encourages the saving of natural resources, identification of sustainable resources, and reducing of waste. Because CE aims to protect the environment from waste pollution, promote industrial growth and innovation, and improve human life, with an overall transformation of existing processes, starting with product designing to manufacture, use, discharge, and recycling processes. In this regard, the Resource Circulation Act (RCA) has been enforced in South Korea, which encompasses the concept of CE and the resource circulation strategy for overall waste management. The Resource Circulation Master Plan for comprehensive waste management has also been implemented based on this. In this study, we introduce the RCA and Resource Circulation Master Plan in the form of a case study in South Korea. First, the background, scope, and details of the new act and plan are outlined, and the ripple effect and limitations reported post-implementation are discussed. In addition, future countermeasures for overcoming these limitations are proposed. The new waste management policy described in this paper focuses only on reports from South Korea. Therefore, related policies may be promoted differently depending on the waste management systems and waste characteristics of different countries, and the potential application of the contents of this study can be further investigated. If the results obtained from this study are directly applicable to the management policies of other countries, this case study may serve as a basic outline for the development of new waste management systems or improving the design of existing waste management systems.

Oral Presentation

THE ANTHROPOCENE WORLDVIEW SCALE: CONCEPTUALIZATION AND DEVELOPMENT

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The Anthropocene means the epoch that humans have reshaped the earth. The emergence of new geological epoch requires a different way of thinking about the earth. Despite the growing body of literature on the Anthropocene, there is a lack of research on the measurement of attitudes towards the Anthropocene. The purpose of this research is to conceptualize and develop a new scale called “the Anthropocene Worldview Scale” to measure the endorsement of worldview of the Anthropocene. Accordingly, this presentation aims to introduce the conceptualization and development process of this new scale. The composite measure intends to reveal the theoretical variable—the endorsement of worldview of the Anthropocene—not readily observable by direct means. The scale has been developed based on the theoretical concepts on the Anthropocene as well as the empirical evidence from the relevant scales such as the New Ecological Paradigm scale. A total of fifteen items have been developed and included in the scale to tap characteristic features of the Anthropocene: (a) earth system, (b) planetary boundary, (c) the Great Acceleration, (d) the Six Extinction, and (e) the Anthropos. Each item is presented as a declarative sentence related to the Anthropocene with response options that indicate varying degrees of agreement based on a 5-point Likert scale. The total sum is 75 points, and a higher score indicates more accepting attitudes towards shift in thinking related to the Anthropocene. We expect this new scale would expand the discussion on the Anthropocene by inviting quantitative researchers in social sciences. Also, it would contribute to the field by promoting the macroscopic discourse on the Anthropocene at an individual level in terms of behavioral sciences.

The Anthropocene Worldview Scale: Conceptualization and Development

Abstracts | Poster Session

IN-PERSON POSTER PRESENTATION

POSTER SESSION 'A' | October 26, 2021

PA-001

ECONOMIC AND ECOLOGICAL EVALUATION OF PROCESSING SCHEMES FOR THE ENZYMATIC RECYCLING OF PLASTIC WASTE

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Austrian Centre of Industrial Biotechnology, Austria

Global plastic waste production is estimated to be 27.1 million tons per year[1]. About two thirds of plastic waste are landfilled or incinerated and only 31.1% is recycled (Figure 1). Plastic waste is linked to 6.7 million tons of CO_2 emission per year while the economic impact of plastic waste management accounts for over 19.3 billion Euros per year[2]. Enzymatic plastic depolymerization (Figure 2) has emerged in recent years as a new promising technology to target the plastic waste fractions (e.g. PET trays) which are currently not recycled. Despite the discovery of several plastic-degrading enzymes[3] and the proof of concept at a pilot scale of the process[4], multiple challenges are found ahead to make the enzymatic recycling of plastic a commercially competitive technology. One of the main obstacles is the scalability of the process and the costs associated with it. In order to deal with a significant percentage of the European plastic waste volume, an enormous quantity of enzymes will need to be produced. As new and more efficient enzymes are isolated and engineered to increase activity and stability, the enzymatic activity will increase hence lowering the enzyme dosage per unit of plastic. Other strategies to scale up effectively are the adoption of continuous in-situ enzyme production and the optimization of the depolymerization process. Enzyme recovery can also help to reduce the costs of the overall recycling process. In order to assess the readiness of this new technology and the feasibility at industrial scale, a techno-economic analysis (TEA) of both the recycling schemes and the relative enzyme production will be performed. The TEA is meant to estimate the overall costs and profitability of a large-scale recycling plant as well as the main environmental metrics (i.e. water, energy consumption, CO_2 eq. emission). These output numbers will then be compared with the status quo of the plastic recycling industry in order to understand the advantages and disadvantages of the proposed solution. Multiple scenarios and process improvements will be evaluated with the aim of designing the best possible processing schemes and relative setup. A fundamental parameter that will be calculated is the "green premium" which is defined as the additional cost of choosing a clean technology over one that emits a greater amount of greenhouse gases (Gates, 2020). The lower the green premium, the more likely is that a green technology will replace traditional carbon emitting ones, therefore it represents a key number to define the readiness of the solution under examination.

The doctoral research is part of the EU funded ENZYCLE project (H2020-BBI-JTI-2019) involving 13 industrial and academic stakeholders. More info at www.enzycle.eu

PA-002

FABRICATION OF BIODEGRADABLE POLYCAPROLACTONE (PCL) OIL ADSORBENT REMOTELY CONTROLLED VIA EXTERNAL MAGNETIC FIELD

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Adsorbents are used effectively for oil spill removal due to their high adsorption capacity. However, they cause secondary pollution by landfill or incineration after use. In addition, workers are at risk of exposure to hazardous substances. In this research, magnetic nanoparticles embedded biodegradable polycaprolactone ultrathin fibers (PCL/MNP) were prepared via facile one-step electrospinning method as sorbent materials. Due to the porous structure of electrospun mat, hydrophobicity of PCL and magnetism of Fe_3O_4 magnetic nanoparticles, the prepared adsorbent exhibited excellent oil removal capacity (arabian light crude oil, 45.7 g/g), high water contact angle (WCA, 146.5°) and remote controllability (magnetic saturation, 7.7 emu/g). In addition, the adsorbent could also easily recover light oils on water surface and dramatically reduced secondary pollution through of biodegradation in 2~4 weeks. With these aspects, our work provides a sustainable strategy for the oil spill removal process and insight for design eco-friendly adsorbent.

PA-003

SIMULTANEOUS TREATMENT OF NITROGEN AND PHOSPHORUS FROM SYNTHETIC WASTEWATER BY SYNERGISTIC INTERGRATION OF MEMBRANE CONTACTOR AND HYDROXYAPATITE CRYSTALLIZATION

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Development of sustainable nitrogen (N) and phosphorus (P) treatment technologies can prevent eutrophication and substitute for commercial fertilizers. Although adsorption, precipitation, and membrane-based N or P recovery technologies have been widely studied for decades, synergistic integration of N and P recovery technologies has rarely been successfully demonstrated. In this study, we developed a novel process wherein calcium-based phosphate precipitation and membrane contactor-based ammonia recovery are synergistically combined. Addition of calcium hydroxide ($Ca(OH)_2$) to synthetic wastewater enabled orthophosphate to be recovered as hydroxyapatite ($Ca_5(PO4)_3(OH)$), a biocompatible fertilizer, and at the same time created alkaline pH condition that is favorable for ammonia recovery via membrane contactor. We comprehensively evaluated both the technical and economic feasibility of this combined process by investigating the effect of chemical dose ($Ca(OH)_2$), stirring speed, initial N and P concentrations, pH, and temperature on the hydroxyapatite crystallization and ammonia recovery. It is demonstrated that N and P in wastewater can simultaneously be recovered with notable efficiency and cost-effectiveness when membrane-based and precipitation-based processes are combined through use of $Ca(OH)_2$ as a multi-functional chemical.

PA-004

KINETIC STUDY OF MUNICIPAL WASTE PLASTIC PYROLYSIS USING A DISTRIBUTED ACTIVATION ENERGY MODEL

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The global plastic production has been steadily increased for more than 50 years, and recently about 8% of crude oil is consumed for the production of plastic. The importance of efficient and eco-friendly plastic treatment method has been emphasized in order to handle increasing plastic waste. Pyrolysis is one of chemical recycling technologies, which thermally decompose plastics under an inert atmosphere. Production of fuel and/or chemicals from plastics via pyrolysis could address the challenges of waste plastic management and global energy demand. A better understanding of the intrinsic kinetics of plastic decomposition reactions improves fundamental knowledge of chemistry of plastic pyrolysis. A well-established model with more accurate kinetic parameters allows systematic process design and optimization. Our research group developed a new type of continuous two-stage pyrolysis process, consisting of an activator and a fluidized bed reactor. The activator plays its own role in the two-stage pyrolysis, elevating vibrational energy state of feed material before the main pyrolysis in the fluidized bed reactor. To confirm this phenomenon, we performed a kinetic study to obtain kinetic parameters for the decomposition of municipal waste plastic (MWP) before and after activation process. Thermogravimetric analysis (TGA) was performed to measure the degree of decomposition of municipal waste plastic according to temperature. The TGA experiments were conducted in two modes. In the first mode (without activation), the MWP sample was linearly heated to 900 °C. In the second mode (with activation), the sample similarly heated to 900 °C but it was additionally held at 300 °C for 10 min to simulate the atmosphere of the activator. The kinetic parameters of MWP degradation were obtained from TGA using a distributed activation energy model (DAEM). The DAEM assumes that decomposition of material involves several independent, parallel, first-order reactions, each of which has its own activation energy. In the kinetic study using the DAEM, the activation energy in the decomposition of activated MWP was lower than that of unactivated one.

PA-005

EFFECT OF BIOCHAR ON ENVIRONMENTAL CHANGE IN SMALL-SCALE BURIAL WITH CHICKEN CARCASS

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In recent years, animal carcasses are increasing due to infectious diseases in domestic animals, heat waves, and road kills. There are methods such as burial, composting and incineration for treating livestock, but in South Korea burial is the most common method in domestic environment conditions. However, three years after the burial period, the animal carcass becomes undegradable and pathogenic microorganisms as well as eco-environmental changes arise. Therefore, it needed to research to solve the dilemma of this burial method. This study was performed to investigate the characteristics of leaching water and greenhouse gas emissions obtained in small-scale burial and to evaluate the effect of biochar application on the biodegradation of chicken carcasses. The nitrogen and phosphorus of leaching water in burial treatments with biochar application were lower than that of control treatment. The result of greenhouse gas emission showed that the relative flux of nitrous oxide in biochar treatment was lower than those in other treatments. Overall, this study demonstrated that the proper biochar application reduced pollutants production in burial site and could contribute to minimize environmental change in burial condition.

PA-006

MICROWAVE-ULTRASOUND ASSISTED LEACHING OF NI, CO AND CD FROM WASTED NI-CD BATTERY VIA GLYCINE IN SUBCRITICAL WATER

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Due to their severe environmental pollution and to minimize the loss of valuable metals, recycling of spent Ni-Cd batteries has received a lot of attention in the recent year. Despite several studies, recycling of hazardous metals from the spent Ni-Cd batteries using an ecologically acceptable and cost-effective technique still remains a challenge. The goal of this research is to recover/leach heavy metals from the spent Ni-Cd battery powder using subcritical water over glycine as an ecofriendly leaching agent in microwave-ultrasound reactor. On the recovery efficiencies of Ni, Cd, and Co, the effects of different variables such as time, temperature and Ni-Cd battery powder: glycine mass ratio were also examined. To predict the chemical compounds before and after the recycling experiment, the solid residues obtained after metal extraction were analyzed by XRD, XPS, FT-IR, FESEM, and EDS element mapping. In the meantime, the metal content of the leachate was determined using ICP-OES analysis. Under the optimized conditions of 40 °C, 120 min and Ni-Cd battery powder: glycine mass ratio of 1:2, more than 77% of Ni, 81% of Cd, and 96% of Co were satisfactorily leached from the spent Ni-Cd battery powder. The findings show that the proposed approach could be a cost-effective, environmentally friendly, and long-term solution for recovering valuable and hazardous metals from the spent Ni-Cd batteries.

PA-007

UPCYCLING WASTE-PET INTO METAL-ORGANIC FRAMEWORKS FOR INACTIVATION OF HARMFUL ALGAL BLOOMS

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Metal-organic frameworks (MOFs) are crystalline nanoporous materials consisting of metal ions and organic ligand linkers. Their high specific surface area, adjustable pore structure, and controlled release of metal ions make MOFs a prospective antibacterial agent. In this study, waste polyethylene terephthalate (PET) was upcycled into an antibacterial MOFs as a sustainable way of adding higher value to waste plastics. Harmful algal bloom (HAB) is an enduring environmental problem worldwide, which needs an effective and economical removal strategy. Value-added MOFs will be a solution for inhibiting cyanobacteria blooms and simultaneously reducing the environmental impacts of PET waste. Therefore, this study aims to investigate the growth inhibition of cyanobacteria (Microcystis aeruginosa) by waste PET-derived MOFs.

PA-008

HIGHLY EFFICIENT AND RECYCLABLE POLYOLEFIN-BASED MAGNETIC SORBENT FOR OILS AND ORGANIC SOLVENTS SPILL CLEANUP

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Polyolefins are potentially applicable for oil sorbent which are only comprised of hydrocarbons. Based on swelling phenomena, polyolefin-based oil absorbent (PA) can selectively absorb oil in aqueous media as well as float on the water. Nevertheless, collecting PA in marine is remained issue, which can cause another unintentional marine pollution. Herein, we develop a kind of polyolefin-based magnetic sorbent (PMA) hybridized with magnetic nanoparticle (MNP), to facilitate the collection process. The MNP is uniformly dispersed in PMA due to the hydrophobic functionalization of MNP. This enables the convenient collection of isolated sorbents even when they were placed in the marine system and show a desirable oil recovery performance up to about 37 times for organic solvents. Moreover, oil-soaked PMA can be fully converted into refined oil via a pyrolysis process. After pyrolysis, the thermally undecomposed compounds, which comprise of carbon residue and magnetic nanoparticle, can be also separated by a magnet. The as-prepared PMA possesses good oil recovery performance, fast magnetic response, and efficient oil recycling, thus representing an environmentally promising method for oil spill cleanup.

PA-009

FACILE MODIFICATION OF PHYSICO-CHEMICALLY ROBUST AND SUPER-HYDROPHOBIC FeOOH-PVDF MEMBRANE FOR STABLE AND ANTI-WETTING MEMBRANE CONTACTOR SYSTEM

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Valuable gaseous compounds such as NH_3, CH_4, H_2 and volatile fatty acids in waste streams can be effectively harvested by membrane contactor system using microporous hydrophobic membrane. However, widespread implementation of membrane contactor-based resource recovery is still hindered by membrane wetting which lowers selectivity and decreases mass transfer rate during contactor operation. Herein, we present facile and reliable preparation of FeOOH nanoparticle and fluoro-silane modified PVDF membrane with wetting resistance and physico-chemical durability. Re-entrant FeOOH nano-structure was firmly coated on the substrate membrane by one pot hydrothermal synthesis accompanied by n-butanol immersion without arduous substrate pretreatment. The modified membrane was systematically characterized by SEM-EDS, FTIR, XRD and capillary flow porometer. Anti-wetting performance and physico-chemical durability were evaluated by contact angle, liquid entry pressure and tensile strength measurements. The modified membrane was super-hydrophobic with contact angle of greater than 145 °, while excellent chemical resistance and mechanical strength of 5.86 MPa was exhibited. The modified membrane achieved NH3 recovery flux of 1016 mg NH_3/m^2-h without wetting occurrence from feed solution containing 5000 mg/l of sodium dodecyl sulfate (SDS) surfactant. The same surfactant solution readily caused severe wetting of pristine PVDF membrane. This study demonstrates facile and scalable method for preparing robust and super-hydrophobic microporous membrane, thereby widening the potential of membrane contactor-based valuable gaseous compounds recovery from various waste streams.

PA-010

EVALUATION OF PROPERTIES FOR HIGH-STRENGTH CONCRETE USING COMPOSITE SLAG FINE AGGREGATE

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The demand for sand as a fine aggregate for domestic construction in 2021 is estimated to be 116,588 thousand m3. Of these, natural aggregates such as river sand and sea sand account for 49.9%, and recycled aggregates such as slag aggregates account for 50.1%. Currently, in terms of resource conservation and environmental protection, the demand for recycled aggregate is continuously increasing as the natural aggregate collection of river sand and sea sand is decreasing. Composite slag fine aggregate is an aggregate in which slag and ferronickel, which are by-products remaining after removing metals from the steel manufacturing process, are mixed in a 1:1 ratio. In the construction industry, many studies have been conducted on recycling of slag generated in large quantities in the steel industry, and efforts are being made to reduce environmental damage and industrial waste by replacing natural aggregates in fine slag aggregates.
Therefore, this study evaluated the mechanical properties of 60 MPa class high-strength concrete by adjusting the crushed fine aggregate replacement rate(0, 25, 50, 75, 100% volume replacement) for composite slag fine aggregate among slag aggregates that are expected to increase in use in the future. As for the evaluation method, the slump flow and air volume were evaluated for the non-solidified characteristics, and the elastic modulus of the compressive strength was measured for the curing characteristics at 7, 28, and 56 days of age.
As a result of the evaluation, the granularity and standard particle size curve, which are the quality standards for fine aggregate, were satisfied when the replacement rate of the composite slag fine aggregate among the crushed fine aggregate consumption was 50% or more. In terms of flow characteristics, compressive strength, and modulus of 60MPa class high-strength concrete, it is judged that 30~60% of the composite slag fine aggregate replacement rate is appropriate, and 40~50% of the level is judged as the optimal mixing rate. Based on the experimental results, the composite slag fine aggregate is judged to be an aggregate usable even in the high-strength concrete area.

PA-011

SOLAR-DRIVEN ELECTROCHEMICAL ADVANCED OXIDATION PROCESS USING CuO-CuFeO2 PHOTOCATHODE WITH PROTECTIVE TiO2 OVERLAYER

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In this work, we designed new durable solar-driven electrochemical advanced oxidation process (SEAOP) system which can transform O_2 to •OH at the photocathode under 1-sun irradiation condition. The generation of •OH from the in-situ formed H_2O_2 enabled the degradation of persistent organic pollutants. The photoelectrochemical properties were improved by the heterojunction of CuO and $CuFeO_2$ to make CuO-$CuFeO_2$. However, H_2O_2 was consumed by the reaction between H_2O_2 and Cu(I), resulting in low •OH conversion efficiency. Also, the stability of CuO-$CuFeO_2$ photocathode was low and morphology of the electrode was broken after few hours of experiment. TiO_2 layer made up for the disadvantages of the CuO-$CuFeO_2$ photocathode. First, the stability of the CuO-$CuFeO_2$ photocathode is enhanced by coating a thin TiO_2 layer for the purpose of protect the CuO-$CuFeO_2$ layer. In addition, the heterojunction between CuO-$CuFeO_2$ and TiO_2 enhanced the •OH generation efficiency dramatically and improved the charge separation. Second, H_2O_2 to •OH conversion efficiency increased by blocked the reaction between Cu(I) and H_2O_2. As a result, O_2 converted to •OH successfully in this SEAOP system without the need of costly chemicals or secondary treatment. The proposed SEAOP was used for the degradation of 4-chlorophenol and the pseudo-first order kinetic rate constant using CuO-$CuFeO_2$/TiO_2 (0.911 h^{-1}) was higher than the system using CuO-$CuFeO_2$ (0.334 h^{-1}). This study demonstrated a new method that generate •OH from the in-situ formed H_2O_2 without using any chemical reagents, which can be used sustainable and environmentally friendly wastewater treatment.

PA-012

PREDICTION OF SOIL HEAVY METAL IMMOBILIZATION BY BIOCHAR USING MACHINE LEARNING

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The application of biochar to contaminated soils is a promising strategy for both green remediation and sustainable waste management. The remediation of heavy metal (HM)-contaminated soil using biochar is primarily dependent on the soil, biochar, and HM properties. Determining the optimum conditions for HM immobilization in biochar-amended soils is site-specific; thus, it varies between studies. As such, a generalized approach, capable of predicting HM immobilization efficiency in biochar-amended soils, is needed. This study employ machine learning (ML) approaches to systematically map HM immobilization efficiency in biochar-amended soils. We find that the nitrogen content in the biochar (0.3%–25.9% N range) and the biochar application rate (0.5%–10% range) were two of the most significant features for HM immobilization. Causal analytics show that the important empirical categories, for HM immobilization efficiency, in the order of importance were: biochar properties > experimental conditions > soil properties > HM properties. This study presents new insights into the effects of biochar characteristics and soil properties on HM immobilization. The approach used can help determine optimum conditions for enhanced HM immobilization in biochar-amended soils. This work was supported by the Cooperative Research Program for Agriculture Science and Technology Development (Effects of plastic mulch wastes on crop productivity and agroenvironment, Project No. PJ01475801), Rural Development Administration, Republic of Korea and the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2021R1A2C2011734).

IN-PERSON POSTER PRESENTATION

PA-013

SEAWATER BATTERY DESALINATION WITH A REVERSE OSMOSIS MEMBRANE FOR SIMULTANEOUS BRINE TREATMENT AND ENERGY STORAGE

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Inevitably produced brine water has been an avoidable issue in the seawater desalination technology, especially in reverse osmosis (RO) process, as it is conventionally disposed to the ocean. Addressing this challenge, a seawater battery-desalination (SWB-D) system has been applied to reduce the concentration of RO brine as well as to store an electrical energy by harvesting sodium ions from the brine. The SWB equipped with anion exchange membrane (AEM) can lower the RO brine concentration to seawater levels, but the use of AEM for brine treatment is costly and the slow kinetics of salt transport required a long operation time. Herein, we present a concept proof for the use of RO membrane as an alternative of AEM in the SWB desalination system. Using RO membrane is feasible application because of its comparatively low cost and unexpected support for salt removal by diffusion across the RO membrane. The results showed that SWB-D-RO reduced the charging time by 36.8% (up to ~40.5% salt removal) compared with SWB-D-AEM owing to the ion diffusion through the RO membrane. In addition, SWB-D-RO stored ~52.6 kWh m^{-3} of energy (assuming 80% energy recovery) while lowering the RO brine concentration to seawater levels (from 1.2 to ~0.6 M). Hence, the SWB with RO membrane system can achieve an a much faster and efficient brine treatment compared to the previous SWB system with AEM.

PA-014

PYROLYSIS OF MIXED PLASTIC CONTAINING PVC TO PRODUCE CHLORINE-DEFICIENT OIL

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Concerns on waste plastic have been steadily increased, and many researchers have endeavored to explore the appropriate plastic recycling method. Nowadays, chemical recycling technologies, which are represented by pyrolysis and gasification, emerged as promising methods for waste plastic treatment because they exploit circular economy and because the complex pre-sorting processes are not necessary. Among them, pyrolysis can convert waste plastic into a variety of valuable chemicals, such as ethylene, propylene, gasoline range aliphatic hydrocarbons, or aromatic hydrocarbons, which can be obtained by controlling reaction conditions. However, pyrolysis of waste plastic is hard to succeed without solving problems related to chlorine. Chlorinated compounds in pyrolysis are mainly originated from PVC (polyvinyl chloride) and salts used as plastic stabilizers and they can form dioxins when they are exposed to heat.

This study aims to produce a chlorine-deficient oil from pyrolysis of mixed plastic containing PVC. To figure out the chlorine release behavior, TG-FTIR study was at first conducted. When evolved gas compositions were examined, it was found that releasing temperature of HCl was lower than that of hydrocarbon vapors. This finding was applied in a discontinuous two-step pyrolysis concept, which consisted of sequential treatment of mixed plastic in an auger reactor and a batch pyrolyzer. The auger thermal pretreatment in this work was conducted to release HCl in advance of main pyrolysis. The thermally pretreated residue was then inputted to the batch pyrolyzer to investigate whether the thermal pretreatment was effective to produce a chlorine-deficient oil from the batch pyrolyzer. After the discontinuous two-step pyrolysis, a continuous two-stage pyrolysis of mixed plastic was conducted using a two-stage pyrolysis process consisting of auger and fluidized bed reactors connected in series. In the two-stage pyrolysis, a chlorine-deficient oil was obtained from the fluidized bed reactor through continuous removal of HCl from the auger reactor.

PA-015

A FACILE METHOD OF OIL SPILL REMOVE WITH RECYCLING DISCARDED MASK

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As coronavirus disease 19 (COVID-19) spreads around the world, wearing a mask has become mandatory. However, billions of used masks are infected with the virus, and most must be discarded. Face masks are made of non-woven polypropylene (PP). Non-woven PP has low surface energy and shows adsorption capacity in organic solutions. In this study, the roughness of the mask surface was increased by using heated solvents (heptane, hexane and decane) to recycling the disposal mask as an oil adsorbent. Recrystallization by swelling of the surface of the mask is to contribute to the formation of sub-micron projections to increase the surface roughness and lead to a dramatic superhydrophobic behavior. The treated mask shows up to 21 times the adsorption performance of Arabian light crude oil. Also, adsorption of organic solvent from the water surface or underwater and separation oil/water mixture is effective. The conversion of the waste mask to the adsorbent through a simple method could be an environmentally benign way to remove discarded masks.

PA-016

OXYGEN VACANCY MODIFICATION OF COMMERCIAL ZNO TO ENHANCE THE PHOTOCATALYTIC ACTIVITY for MICROPOLLUTANT DEGRADATION IN WATER

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In recent years, photocatalysis has gained great interest as a green technology in the area of water and wastewater treatment. To this aim, semiconductors are the most commonly used materials as photocatalysts. Zinc oxide is a popular metal oxide for photocatalytic degradation of organic compounds in water, due to its optical and electronic properties, non-toxicity, low cost comparing to other metal oxides, and its ability to complete mineralization of pollutants. However, the use of ZnO has also limitations such as improper bandgap for activation by visible light, high rate of recombination of electron-hole pairs, and photo-corrosion.

In this research, by introducing surface oxygen vacancies in the ZnO catalyst, the aforementioned limitations have been reduced, and its effect on the photocatalytic degradation of thiabendazole (typical fungicide) and methylene blue has been investigated under simulated solar light. To characterize the surface oxygen reduction of the ZnO, temperature programmed reduction of commercial ZnO was performed by an Autochem II Micromeritics instrument with a 10% H_2/Ar gas (60 mL/min), ramp rate 10 K/min, and final temperature of 1000°C. Through Gaussian peak fitting to have an accurate temperature of each reduction peak, results reveal that surface oxygen reduction occurs until 500°C. At temperatures higher than 650°C, the bulk oxygen reacts with the hydrogen, which results in a considerable mass loss and corresponding photocatalytic efficiency. Optimization is done by reducing commercial ZnO at different reduction times and temperatures below 650°C in a systematic approach.

During the presentation, focus will be put on (i) the dark adsorption and photocatalytic degradation of thiabendazole using ZnO, reduced at different conditions; (ii) the characterization of the reduced ZnO samples by different techniques like XRD, XPS, SEM and Tauc plot; and (iii) the effect of pH on both the adsorption and photocatalytic degradation of thiabendazole and methylene blue by commercial and oxygen vacancy mediated ZnO.

PA-017

PROMOTING SELECTIVE NITROGEN REDUCTION WITH A FE-CONFINED MOS_2 CATALYST INSPIRED BY NITROGENASE

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Electrochemical reactions involving multiple steps, such as nitrogen reduction reaction (NRR), often suffer from low catalytic efficiency due to competition with other simple reactions. Hence, developing an electrocatalyst that can promote the selective activation of such a multistep reaction is vital. Here, we propose a highly selective electrocatalyst for NRR comprising molybdenum disulfide (MoS_2) with the iron (Fe) confined in van der Waals (vdW) gaps, which is inspired by Nitrogenase capable of nitrogen fixation in atmospheric conditions. This bio-inspired structure is achieved by sequential intercalation of lithium and Fe ions followed by Fe reduction in vdW-layered MoS_2, whose design is confirmed by structural analyses. We found that the metallic Fe-confined MoS_2 structure offers a favorable active site for boosting selective NRR. As a result, the Faradic efficiency and yield rate of the ammonia production are obtained as high as 30.2 % and 1.2 $\mu mol \cdot cm^{-2} \cdot h^{-1}$, respectively. Such improved catalytic performances can be attributed to the change of the d-band center of MoS_2 by Fe intercalation, strengthening the binding strength of nitrogen and lowering the potential barrier of NRR. Our demonstration offers new insight into designing novel catalysts to enhance selectivity and activity in complex catalytic reactions.

PA-018

NEURON-INPIRED ENERGY CONVERSION USING SALINITY GRADIENT ENERGY

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A neuron is an electrically excitable cell that communicates with other cells via synapses. These electrical signals are mostly generated by ion movement, referred to the cellular transport, across a cell membrane with exceptional characteristics: high ion selectivity and fast ion diffusion kinetics. In this research, we will present the implementation of this foregoing concept of neuron-inspired ion transport, using inorganic materials as a fast ion-diffusion channel with high selectivity, to build the electrostatic potential difference between reservoirs. All the chemical energy of chemical compounds can be converted into electrical energy without paying "Second law tax", and therefore is comparable to the power generated by human neurons. This work represents a step toward a promising but simple passive power generation design for practical energy harvesting apparatus.

PA-019

A NOVEL METHOD TO DETECT AND QUANTIFY MICROPLASTICS IN WATER

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Research on microplastics was first initiated in marine environments; however, in recent times, the presence of microplastics in tap water, bottled water, surface water, groundwater, and sewage has been investigated actively. Orb Media has investigated the microplastic content in tap water and bottled water in various countries worldwide, and found that most of survey samples were contaminated with microplastics. Although there are concerns about the harmful effects of microplastics on humans, there are no sufficient data to support these claims. The World Health Organization is yet to comment conclusively on the risks of microplastics to humans, and has stated the need for continuous investigation and research for obtaining additional data. Moreover, the methods of microplastic analysis in water currently in use are diverse and non-standardized, and it is difficult to verify the data obtained from these studies. Therefore, it is difficult to compare the results of different studies or elucidate the true scenario of microplastic distribution in the environment. To obtain the data necessary for decision-making in this area of research, such as for the establishment of microplastic management practices and policies, it is necessary to first design reliable analytical methods. The International Organization for Standardization has recently initiated a discussion to establish a standardized analytical method for microplastics. The analysis of microplastics has evolved gradually, starting with visual and microscopic observation. Fourier transform infrared spectroscopy (FT-IR) combined with microscopy and Raman spectroscopy (RS) are primarily used as instrument-based analytical methods for qualitative and quantitative analysis. We developed a pyrolysis-GC/MS method that can help overcome the size limitations of FT-IR and RS and can be used to analyze additives present in microplastics. Filtration, solvent extraction, pulverization, centrifugation, and evaporative concentration were used as the sample treatment methods, and the accuracy and precision of each method were checked and optimized. As a result of method validation for the analysis method including sample treatment combining filtration and solvent extraction, the recovery rates of PS and PMMA standard materials were 77.8 ± 5.9 % and 75.5 ± 1.6 %, and the precisions were 7.5% and 2.1%, respectively. We believe this method can be developed as one of the standard methods for microplastic analysis in water.

PA-020

MICRODISK LASER INDEX SENSOR WITH META-HOLE PATTERNS

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Recently, microplastics accumulated in the body of marine organisms are detected along the food chain, and microplastics smaller than 1 μm, which cannot be filtered out by the filtration filter in the water purification, can accumulate in the human body because they can enter drinking water. These methods of detecting microplastics include FT-IR or fluorescence analysis, which have the disadvantage of being complex in the measurement system. It makes hard to measure microplastics in the field. Thus, we paid attention to the difference in refractive index between microplastics and seawater. While the refractive index of standard sea water (SSW) S=35‰, @27°C) is n_SSW = 1.3981, the refractive index of microplastics is higher than the average of 1.51 (PVC: 1.526, PE: 1.519 PVA: 1.4630, PET 1.54 @ 2000 nm). In other words, it can be expected that the higher the number of microplastics in seawater, the higher the refractive index of the standard seawater. Since it is possible to measure the presence and density of microplastics by measuring the difference in refractive index, we intend to develop a refractive index sensor that can measure the difference in the fine refractive index. There are various ways to measure the refractive index of liquids, among which microcavity with the Whispering Gallery mode, can trap light inside the cavity for a long time, thereby increasing the interaction between light and matter. Most microcavity sensor is used passive type, in that case is required complex optical system to couple light. However, the active cavity type has the advantage of being able to use a relatively simplified optical system and, also signal from active type accuracy and resolution are better than passive type, it is possible to detect changes more sensitively in external refractive index. In this study, we demonstrate a micro-laser sensor that is sensitive to external refractive index changes by introducing meta nano-holes into an InGaAsP microdisk laser. The meta holes increase the area of interaction between the microdisk laser mode and the external materials. Based on the simulation, we designed a meta-hole patterned in a square lattice arrangement and then fabricated the InGaAsP microdisk laser. When the meta-hole patterned microdisk laser was used as an index sensor in liquid environment (Methanol, Ethanol, IPA), the wavelength-shift for a refractive index difference of 0.04619 was measured to be 2.7nm (=58.45 nm/RIU), which shows 1.58 times higher sensitivity than the wavelength-shift of 1.7nm (=36.8 nm/RIU) of the non-patterned microdisk laser.

PA-021

MXENE($Ti_3C_2T_X$) SURFACE PLASMON RESONANCE SENSOR IN THE SHORT-WAVE INFRARED WAVELENGTH

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Surface plasmon resonance (SPR) is a phenomenon in which light is aggregated and propagated below the diffraction limit from the surface of a metal/dielectric. Optical sensors have been developed to maximize the interaction between light and material by utilizing this. Currently, the strongly integrated light propagates up to ~mm and is very sensitive to the index change of the external dielectric. SPR is specialized in the detection of optical properties of physical/chemical/biological materials that are widely spread spatially. Despite these advantages, they are rarely used in silicon-based micro bio/chemical chip devices, which have been actively developed recently. Instead, devices with good optical sensitivity, such as photonic crystal resonators and local surface plasmon resonance metal nano antennas, but with a micro/nano level whose spatial measurement area is much smaller than SPR are used. The reason is that silicon chip sensors use near-infrared light, whereas in metals such as gold and silver, SPR occurs only in visible light. However, it has been recently known that MXene ($Ti_3C_2T_x$) operates as a metal in the infrared region, and at the same time, the surface plasma frequency (SPF) at the air/MXene($Ti_3C_2T_x$) interface exists in the infrared region. In other words, if MXene($Ti_3C_2T_x$) is bonded to silicon, it means that it is possible to develop SPR sensors in the infrared region. It was confirmed through simulation that an MXene($Ti_3C_2T_x$) Si-based surface plasmon resonance index sensor operating at a wavelength of 1550 nm could be implemented. We propose a SPR index sensor based on a MXene ($Ti_3C_2T_x$) film operating in the SWIR regime. We theoretically found that the sensitivity was optimized to 0.00482 nm^{-1}/RIU when the thickness of MXene ($Ti_3C_2T_x$) film on a silicon substrate was 70 nm.
In conclusion, it was confirmed through simulation that an MXene($Ti_3C_2T_x$) -Si-based surface plasmon resonance index sensor operating at a wavelength of 1550 nm could be implemented. Through this study, it is expected that the development of SPR sensors with higher efficiency and practicality in the infrared region will be possible if combined with a silicon nano lattice structure and a silicon waveguide structure.

PA-022

RELEASE OF MICROPLASTICS TO WATER AND WASTEWATER FROM DAILY PRODUCTS: QALITATIVE AND QUANTATIVE ANALYSIS USING MICRO-FTIR

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Microplastics (MPs) that are fragments ranging from 5 mm to 1 μm, exist abundantly in wastewaters, raw waters, treated drinking waters (bottled water) and they may be released from daily products. The quantitative/qualitative analysis was conducted by microscope equipped Fourier-transformed infrared spectroscopy. First, eye-glass lens polishing process was revealed to be a MPs source to wastewater treatment plants: One liter of the wastewater contained 1380 – 62,539 g MPs and 0.0136-0.0324 mg NPs (< 1.2 μm), corresponding that 57 g of NPs are generated every day in South Korea and passing through wastewater treatment plants. Wet wipes that are being frequently used in daily life, generate significant amount of MPs fibers, but its disposal to water and environments are not regulated as a separate collection. An experimental study revealed that the highest number (1966 p/sheet) of MPs fibers were released when the wet wipes in wet state were immerged in water, corresponding that wet wipe were directly disposed to water. This quantitative/qualitative study warns the possibility of MPs release from daily products to water environment, and the potential associated risks.

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PA-023

A COMPARATIVE STUDY ON AGGREGATION BEHAVIOR OF POLYSTYRENE AND POLYMETHYL METHACRYLATE NANOPLASTICS IN AQUEOUS ENVIRONMENT

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Microplastics (MPs) are widely used in a variety of fields due to their unique properties. MPs are normally defined in size less than 5 mm, but plastics with sub-micron size are found in environments. These nanoplastics (NPs) can have potential to negatively affect human beings because of their high level of exposure to fresh water environment. The extent of NPs' dispersion is influenced by surrounding environment, and it is associated with the physico-chemical properties of NPs. Therefore, this work aims to investigate the dispersion and attachment of NPs to sediment under different solution chemistry in fresh water environment. Two types of NPs were selected: polystyrene (PS) and poly(methyl methacrylate) (PMMA). Quartz was used as sediment, and the average size of the sediment was about 400 μm. The primary and secondary size of NPs were determined with TEM, FE-SEM, and DLS method. The dispersion of both NPs were examined with the change of size over time; the results showed that both NPs are very stable under all solution chemistry conditions tested. The interaction energy between NPs was analyzed with classic and extended DLVO (XDLVO) theories. For PS, the dispersion in NaCl was explained by classic DLVO; however, in $CaCl_2$ the dispersion behavior was not explained by any DLVO. For PMMA, their dispersion behavior was not explained with the any DLVO. Batch attachment tests showed that the amount of NPs attached to sediments increased with increasing ionic strength while the amount was always less than 30%. The attachment behavior for the sediment-NPs (PS and PMMA) was not fully explained with classic DLVO while the XDLVO well described the behavior. From all the test results, we concluded that the NPs are expected to distribute more in bulk water than the surface of sediments and the NPs are stable in fresh water environment.

PA-024

MICROPLASTICS CONTAMINATION IN BIOWASTE COMPOSTS – A CRITICAL ANALYSIS ON POSSIBLE PATHWAYS AND ILL-EFFECTS

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Microplastics are reportedly increasing in the aquatic and terrestrial environment because of their manifold enlargement of utility and persistent nature. Due to various pathways, the plastics dumped in the environment, slowly degrade and form microplastics of <5.0 mm size. Also, the use of pharmaceutical and personal care products add a significant quantity of microplastics, thus leading to the existence of microplastics in water and soil. Even, the agricultural soils are prone to the contamination of microplastics through the application of composts derived from biowastes, especially rural and urban organic solid wastes which are utilized for compost and vermicompost production as a mean of sustainable waste management option. This, in turn makes the presence of microplastics in agronomic soils and products. Considering the deleterious effects of microplastics, there is an emergent requirement for tracing the routes and existence of microplastics in organic compost materials as well as agricultural soil so as to prevent the contamination of microplastics and their accumulation through food chain. The development of analyses protocols for the extraction, identification and quantification of microplastics is biowaste derived composts is helpful for precautious compost utility and for setting compost limits for agricultural use. However, the information on the source and chemical nature of microplastics in various composts, their evaluation and extraction methods are required to be updated. Thus, the present article has been focused on the kind of microplastics present in composts, dispersal and bioaccumulation mechanisms, and their ill-effects on soil dwelling and other organisms in the food chain.

Keywords : Organic compost, Microplastics, Soil contamination, Sustainable environment, Biotransformation.

Acknowledgements

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PA-025

PRECISE CONTROL OVER THE SILICA SHELL THICKNESS AND FINDING THE OPTIMAL THICKNESS FOR THE PEAK HEAT DIFFUSION PROPERTY OF AUNR@SiO_2

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The silica coated gold nanorods (AuNRs) showed significantly enhanced photothermal effect and photoacoustic (PA) signal intensity, which is beneficial for various applications in material science. However, the thickness of silica shell for the optimum enhancement is not fully understood and even controversial depends on the physical state of silica shell. This is because of the lack of systematic investigation between the nanoscale silica shell thickness and the photothermal effect. In this article, we are providing the robust synthetic method to control over the thickness of silica shell in nanoscale and the silica shell thickness and physical state dependent heat diffusion property. The selected base and solvent system enabled to produce silica-coated AuNRs (AuNR@SiO_2) with silica shell thicknesses of 5, 10, 15, 20, 25, 30, 35, and 40 nm. AuNRs with 20 nm silica shell showed the highest photothermal effect which is 1.45 times higher photothermal efficiency than that of AuNRs without silica shell. The low density of silica shell on AuNRs showed a low photothermal effect and photostability. We found the disruption of cetyltrimethyl ammonium bromide (CTAB) layers is responsible for the low photostability of AuNRs. The simulation study for the heat diffusion property showed the facilitated heat diffusion in the presence of silica shell. In cell-based study, AuNRs with a 20 - 25 nm silica shell showed the most sensitive photothermal effect for cell death. The understanding in this study will be useful for the future design of nanomaterials in various field of applications with light.

Keywords : Gold nanorods silica shell, heat diffusion, thickness

PB-001

A GREEN PROCESS FOR RECOVERY OF HIGH PURITY RARE EARTH ELEMENT FROM NDFEB WASTE MAGNET OR SCRAP

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With the markedly increasing use of NdFeB magnet and discharge of EOL product, recycling becomes crucial in both environment and supply. Many researchers have studied their recycling based on hydrometallurgy, which gives rise to the high purity of the Rare Earth Element(REE) compound. However, the leaching of iron consumes significant acid chemicals and release iron-containing waste liquor. It acts as an obstacle to the commercialization of the hydrometallurgical recycling process. Selective leaching of REEs over iron from waste magnet or scrap has been developed using caustic digestion and thermal oxidation methods. The caustic digestion decomposes Nd-Fe-B alloy to REEs hydroxide and iron oxide separately as follows;

$$3Nd + 3H_2O \rightarrow Nd(OH)_3 + 3/2H_2$$
$$3Fe + 4H_2O \rightarrow Fe_3O_4 + 2H_2$$

The oxidation of caustic digested powders at ca. 350℃ yields mixtures of REEs oxide and ferric oxide, where the latter is highly resistant to acid. Therefore, REEs much selectively dissolves upon the leaching of resultant powders. The obtained leach liquor contains a deficient level of iron below 100ppm; therefore, it is applied directly for the solvent extraction of REEs. It simplifies the separation and purification process much. The more important thing is that caustic soda is not theoretically consumed during caustic digestion and is fully reused because it does not participate and only catalyzes the reaction. In summary, the developed process does not require chemicals and high temperatures and does not exhaust greenhouse gases.

More details will be discussed in the presentation.

PB-002

ALL SOLUTION-PROCESSED VAN DER WAALS THIN-FILM ELECTRONICS WITH HIGH PERFORMANCE AND LOW-POWER OPERATION

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Solution-processable van der Waals (vdW) materials, which have an atomic layered crystal structure, are promising building blocks for large-scale, high-performance electronics owing to high material quality and stability in addition to low-temperature processability. In particular, vdW-assembled thin films of transition metal dichalcogenides (TMDCs) in solution have recently shown great potential for using a high-mobility channel. However, utterly solution-processed vdW electronics have not yet been reported due to the lack of appropriate dielectric materials and fabrication processes. Here we report all solution-processed vdW thin-film transistors (TFTs), consisting of the TMDCs as a channel and the perovskite oxides as a high-k gate dielectric. The colloidal inks of each constituent layer were prepared by chemical or electrochemical exfoliation, followed by the sequential assembly into the semiconductor/dielectric heterostructure for constructing TFTs, all of which were performed at low temperatures under 300 ℃. The fabricated MoS2 TFTs with the Dion-Jacobson-phase perovskite dielectric exhibited excellent device characteristics, including the mobility > 30 $cm^2/V{\cdot}s$ and ON/OFF ratio >106. Furthermore, the use of high-k dielectric permits the operating voltage as low as ~1 V, enabling low power consumption. Our demonstration on the low-temperature fabrication of high-performance TFTs opens a new route for cost-effective, scalable electronics capable of hetero-integration.

PB-003

RECYCLING STRATEGIES FOR THE HYDROMETALLURGICAL TREATMENT OF RARE EARTH PERMANENT MAGNETS IN NON-AQUEOUS MEDIA

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Rare earth permanent magnets have been widely used from small electronics to wind turbines because of their high magnetism. Recently, as many countries have declared to fight global warming to achieve carbon-neutral till 2050, the usage of the rare earth permanent magnets is being expanded to the field of electric vehicles which can replace internal combustion engine vehicles. Because electric vehicles need traction motors consisted of rare earth permanent magnets, it is expected that the number of waste magnets will be exponentially increased in the next 5-10 years. To prevent any environmental pollution caused by waste generation and secure critical metals from the magnets, i.e. rare earth elements, recycling strategies to environmentally-friendly treat the magnets are required. Until now, many hydrometallurgical magnet recycling technologies in aqueous media have been developed, but they generally consume a lot of resources, such as water and chemicals, to recover rare earth elements from the waste magnets. So, in this presentation, the authors will introduce hydrometallurgical rare earth permanent magnet recycling technologies that utilized non-aqueous media. As the non-aqueous media, deep eutectic solution (DES) has shown good ability as a lixiviant of rare earth elements contained in the magnets. Comprehensively, among lots of DES, the mixture of ionic liquid and organic acid (e.g. maleic acid, lactic acid, acetic acid, etc.) showed high leaching efficiency of rare earth elements and high separation factor from other impurities like iron. So, compared with the aqueous hydrometallurgical recycling process of the magnets, the purification process was rarely required to separate rare earth elements from other impurities. Additionally, the non-aqueous solution can be recirculated several times in the process without lowering its ability as a lixiviant. Thus, it can be noted that the hydrometallurgical recycling process of the rare earth permanent magnets can go greener utilizing non-aqueous media.

PB-004

SELF-ASSEMBLED NANOPARTICLES FOR COLORIZATION AND COOLING

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Recently, dealing with climate change such as global warming, which is getting serious, world scientists are looking for an eco-friendly way to restore this situation. Radiative cooling is one of the care solutions, which can cool objects without energy consumption. For the best cooling efficiency, the cooler should be designed that can absorb as little sunlight as possible while maximizing the intrinsic radiation ability. Since this technology can be applied to most things that require cooling, such as electronic devices, vehicles, and buildings, additional functions are needed as well as cooling. Cooler, with the functions such as colors and large areas, can be used in a wider field. To mount these features, we made a radiative cooler through the self-assembly of silica colloids. Since the silica particles contain many siloxane groups that emit electromagnetic waves in the 8 to 13 um range, which can penetrate the atmosphere, it can act as an eco-friendly cooler. In addition, when the silica particles self-assemble into a face-centered-cubic structure, only a selected electromagnetic wave can be reflected by Bragg scattering which means a color function can be added. The silica particles, which is closed-packed in the air, were able to express all three colors: red, green, and blue. Also, it can cool the silicon substrate by up to 13.5`C even under an average of 900 W/m^2 of sunlight. Although these colorful radiative coolers have an excellent cooling effect, their stability against external impacts is vulnerable, so they can be easily damaged. To beyound this fragile limit and broaden the radiation range, silica particles are dispersed in Trimethylolpropane ethoxylate triacrylate(ETPTA) for non-closed packing. The Silica/ETPTA photonic crystal is very rigid, so it can withstand external shocks excellently. Moreover, it has higher radiation efficiency compared to simply using silica particles, because it contains a number of bonding groups that have exceptional heat radiation in the infrared region. The colors of the cooler can be controlled by adjusting the diameter of the particles and the distance between the particles. It cool the silicon substrate by up to 6`C under an average of 700 W/m^2. All these colorful radiative coolers made by the solution-based process can be applied to any surface, and have the advantage of being mass-produced and applicable to large scale.

PB-005

SEPARATION OF SILICON PV MODULE USING DELAMINATION

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As the depletion of fossil fuel, environmental protection and global warming become important issues, the solar energy has been attracted attention as an alternative energy. In addition, as the amount of PV (photovoltaic) modules installed increases, the number of end-of-life modules will gradually increase. Many countries are interested in how to recycle PV modules. In general, three methods (mechanical, chemical, thermal) are used to separate glass and solar cells to recycle PV modules. In the initial research, the purpose was to recover the components (glass, solar cells) of the module, but now it is being studied with the purpose of recovering the components without damage. In this study, a structure of a module with a sacrificial layer applied between glass and encapsulant was proposed. This sacrificial layer is removed through an electrochemical reaction. A module-like structure was fabricated, and it was confirmed that the glass was completely separated from the EVA by the removal of the sacrificial layer.

PB-006

A COMPARATIVE STUDY ON RECYCLING OF WASTE LITHIUM-ION BATTERIES CHLORINATED POLYMERS IN SUBCRITICAL WATER

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Recently, many studies have investigated the recycling of lithium (Li), nickel (Ni), cobalt (Co), and manganese (Mn) from waste lithium-ion batteries (LIBs). However, the leaching and efficient separation of the valuable metals from NCM active cathode material through an environmentally friendly and economic process is still challenging. Herein this research, we present a novel and energy an efficient route through which to leach valuable metals, for example, lithium (Li), nickel (Ni), cobalt (Co), and manganese (Mn) from the NCM cathode material of the waste LIBs using water-containing waste chlorinated polyvinyl chloride (CPVC) or polyvinyl chloride (PVC) in a batch reactor. Parameters such as temperature, time, liquid-solid, and mass ratios on the extraction efficiencies of Li, Ni, Co, and Mn were carefully examined. The results show that CPVC performed better than PVC for the extraction of valuable metals from NCM material, and this was attributed to its high Cl contents. The maximum extraction efficiencies of Li, Ni, Co, and Mn (99.15%, 98.10%, 99.30%, and 100%, respectively) were achieved under optimized reaction conditions: a temperature of 290 °C, the reaction time of 1 h, a liquid-solid ratio of 60:1 mL/g, and solid to solid mass ratio of 1:3. The apparent activation energies (Ea) for Li, Ni, Co, and Mn were computed to be (24.42, 28.85, 29.67, and 28.79) kJ/mol. The results obtained in this work indicated that it may contribute to efforts aiming to reduce industrial chemical consumption and increase sustainability in waste management techniques.

PB-007

CO_2-ASSISTED CARBOTHERMIC REDUCTION PROCESS OF $LI[NI_{0.8}CO_{0.1}MN_{0.1}]O_2$ AS AN ECO-FRIENDLY AND EFFICIENT PRETREATMENT FOR RECYCLING SPENT LITHIUM-ION BATTERIES

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Due to the ever-growing concerns about global warming induced by greenhouse gas (GHG) emissions impacting environment and eventually human health, many researchers have made efforts to mitigate the GHG. With the rapid growth of electric vehicle market in the world, meanwhile, the development of a sustainable and eco-friendly recycling strategy for increasing spent lithium-ion batteries (LIBs) is highly desired. In this work, a carbothermic reduction (CTR) process as a thermal pretreatment strategy of spent LIBs is investigated firstly utilizing carbon dioxide (CO_2) to promote a circular economy while reducing GHG. Based on Boudouard reaction ($CO_2 + C \leftrightarrow 2CO$), the conversion property of CO2 into a high value-added syngas (CO) and reduction behavior of cathode materials are systematically compared under N2 and CO_2 environments at various experimental conditions such as treatment temperatures and isothermal gasfication time using commercial graphite and co-precipitated $Li[Ni_{0.8}Co_{0.1}Mn_{0.1}]O_2$ (NCM811) as a carbon source and a cathode material, respectively. Subsequent acidic leaching efficiencies for valuable metals including Li, Ni, and Co were higher in the case of CO_2-assisted process in a 2 M H_2SO_4 solution at 40℃, which could be predicted by thermodynamic calculations. The feasibility of a preemptive Li recovery strategy under the CO_2 condition was also assessed by a facile water leaching process, while the degree of carbon removal during the CTR process was highly active in the CO_2 condition for a prolonged gasfication time. Optimization of the CO_2-assisted CTR process will effectively contribute to the GHG mitigation and the recovery of valuable metals.

Keywords : LIB recycling, GHG mitigation, Carbothermic redution, Carbon dioxide, Syngas, Leaching efficiency

PB-008

THE EFFECTS ON GREENHOUSES GAS OFFSETTING THROUGH REFRIGERANTS RECOVERY FROM THE WEEE

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Since 2008, Republic of Korea has operated an Extended Producer Responsibility (EPR) regulation for collecting and recycling the Waste of Electrical and Electronic Equipment (WEEE) with a regulation, calling Act on Resource Circulation. In 2014, 23 more electronic products were added to the EPR framework to achieve the increasing-targeted recycling quantity. Thus, the total of 50 electronic products in 2020 were divided into five groups.The biggest driver of global warming has been reported to be GHG emissions. There are four main types of GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (F-gases). CFCs (chlorofluorocarbons), HCFCs (hydrochlorofluorocarbons), and HFCs are major refrigerants used in domestic and commercial refrigeration and air conditioning. Especially, those refrigerants were injected and implemented refrigeration or air-conditioning system in several electronic products such as refrigerators, vending machines, air-conditioners, water purifiers, dehumidifiers. Statistics from Environment of Ministry detail the annual quantities of collected and recycled WEEE. In 2016, a total of 258,102 tonnes of electronic waste were recycled from the formal sector. Continuously, 281,610 tonnes (2017), 309,459 tonnes (2018), and 328,114 tonnes (2019) of WEEE were formally recycled in South Korea, respectively. In terms of recovery of refrigerant, In 2016, approximately a total of 68.371 kg of refrigerants were recovered in formal sector. Also, a total of 74,692 kg of refrigerants were recovered in 2017. In 2018, about 76,731 kg of refrigerants were recovered. Finally, a total of 87,191 kg of refrigerants were recovered from the WEEE in 2019. The total refrigerant recovered over four (ranging from 2016 to 2019) years amounts to 306,985 kg (approximately 307 tons).Through the refrigerant recovery work, the potential GHG offsetting effects achieved. The four-year (2016-2019) total was a reduction of 1,172,476 tonnes of CO_2 eq. the amount of GHGs emitted from WEEE recycling processes (including transportation) during the four years under examination was approximately 228,600 tonnes CO_2 eq, and the potential reduction in GHGs through refrigerant recovery was about 1,172,476,151 tonnes CO2 eq. Summing these estimates eventually leads to a total offset effect of 943,876 tonnes CO_2 eq.

PB-009

TOWARDS SUSTAINABLE ORGANIC ELECTRONICS

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A paradigm shift in resource exploitation and e-waste management is needed to promote sustainability in electronics. Reusing and recycling electronic devices is not only environmentally desirable but also economically viable and increasingly socially acceptable. A promising route to alleviate the environmental footprint of electronics is based on the use of abundant materials, novel production schemes involving non-toxic materials (through green chemistry processes), and eco-design of devices that includes environmentally acceptable end-of-life scenarios. The present contribution will discuss the integration of biosourced electro- and photo-active organic electronic materials, such as melanin, indigo, tannin and lignin derivatives (some of these readily available from biomass feedstock) into electronic and energy storage devices. Biosourced organic electronic materials can be biodegradable. As such, they offer the opportunity for an environmentally benign device end-of-life scenario (as opposed to the present accumulation of e-waste). Being solution processable (e.g. printable), organic electronic devices feature lower embodied energy (energy spent in the production phase and stored in the inner constituents), and possibly lower cost, than their inorganic counterparts, processed through high-vacuum and high temperature techniques. Furthermore, the use of conductive inks based on carbon nanotubes (CNTs), graphene or conducting polymers for the devices' electrodes would permit to avoid the use of expensive and toxic metals and enable the devices' safe disposal. The contribution will highlight the case of the biopigment eumelanin (Sepia melanin), studied for applications in electrochemical energy storage (supercapacitors and batteries operating in aqueous electrolytes) and printed electronics (transistors) as well as its biodegradability in industrial compost conditions (following the standard ASTM5338).

PB-010

VERIFICATION OF MOLD TREATMENT EFFECT IN HYDROPONICS DRAINAGE OF MICROBUBBLE OXIDATION SYSTEM USING FUSARIUM OXYSPORUM F. SP. LYCOPERSICI

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Recently, as the hydroponics of facility horticulture increase, the use of agricultural water also increases, which leads to a increase in the amount of drainage, and there is a growing concern that the environmental load may increase. Therefore, this study investigated whether pathogens such as fungi that may be included in the drainage can be safely treated by using the microbubble oxidation system to reuse the drainage. Microbubble oxidation system was operated while supplying air at a flow rate of 2L/min. An artificial drainage was prepared by mixed the drainage generated in the tomato cultivation greenhouse and culture medium of Fusarium oxysporum f. sp. lycopersici isolated from the tomato. The reaction time of the microbubble oxidation system was a total of 6 hours, and the reduction of Fusarium mold was investigated using the drainage sampled every hour. In order to determine the degree of Fusarium fungal death, the number of colonies formed by culturing Fusarium using Komada selective medium was compared over time. The Fusarium was reduced to about 94.1% after 3 hours, and all of them were killed when treated for more than 4 hours. As a result of the tomato cultivation verification experiment by inoculating the drainage before(0hr) and after(6hr) the treatment, the tomato wilt was expressed in the group inoculated with the untreated drainage(0hr). But the tomato wilt was not expressed in the inoculated group after treatment for 6 hours. The tomato plant length was found to be 152% larger at 21.7±4.9 cm and 32.9±5.8 cm as a result of comparing 0 and 6 hours of treatment. Tomato biomass was also found to be 2.3 times heavier. Therefore, this study confirmed that it was possible to effectively treat the fungus that causes tomato wilt by applying the microbubble oxidation treatment system. It is judged that it can be used as a reuse method by sterilizing molds in drainage discharged from horticultural facilities.

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PB-011

OPTIMIZATION OF MEDIUM THROUGH APPLICATION OF SUPERNATANT LIQUID FROM SEWAGE IN SYNGAS FERMENTATION PROCESS

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As energy consumption is increasing world widely and global warming is accelerating, environmental issues are increasingly becoming a problem to be solved in the present rather than in the future. Utilization of waste from various industries is a crucial and obligatory option for sustainable environment as well as future. Synthesis gas (syngas) is a mixture type of gas, which contains hydrogen, carbon monoxide and carbon dioxide produced from gasification of carbonaceous feedstocks. It is possible to produce various valuable chemical feedsocks and fuels in an eco-friendly way through the fermentation process by feeding synthesis gas to microbes. However, the nutrients limitations routinely occur in syngas fermentation when required high productivity. In order to solve the limitations of nutrients, an excessive amount of medium can be introduced or an optimization of medium for process should be recommended. In this study, we tested the supernatant liquid from the sewage treatment plant to maximize carbon recycling and minimize waste from syngas fermentation. Eubacterium limosum KIST612 is an acetogen, which is one of most promising strain due to its high strength of syngas utilization as well as products formation. We evaluated essential components of minerals and ions of supernatant liquid during the cell growth by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Ion chromatography (IC) analysis. Finally, the operation of the bioreactor using the supernatant liquid was tested, and the productivity increase was confirmed even in the absence of yeast extract, which is known as “not available” compound in industrial medium. By using the supernatant liquid in syngas fermentation with Eubacterium limosum KIST612, it can be suggested that the operation process simultaneously recycle waste gas and waste sewage is also feasible and efficient in desired bioprocess of syngas fermentation.

PB-012

ANALYSIS OF WASTE HEAT RECOVERED IN LIQUID-COMPOSTING FERMENTATION HEAT OF LIVESTOCK MANURE

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With the scaling up of national livestock farms and advancement of farming technology, the number of livestock has rapidly increased. The amount of waste treated through contract livestock manure treatment facilities in 2019 was 309 hundred tons, from which 91 hundred tons of livestock manure and 108 hundred tons of liquid manure were converted into resources that could be recycled at the farmland. The aeration supplied to fermenters for liquefaction during livestock manure treatment generates heat from fluid friction, and this heat energy is an energy resource of waste heat that can be recovered or used with heat recovery devices etc. The waste heat generated by livestock manure treatment can be described as the heat given off during the treatment process at a public treatment facility, a complex waste treatment facility, or an individual farm. To maximize the recovery of such heat energy as an effective energy in the process or the system and to increase the efficiency of it use, introduction of heat recovery systems, such as heat exchangers, is essential and it is becoming an important aspect in terms of energy conservation. Therefore, in this study, a waste heat recovery system composed of a heat exchanger, heat pump, stratified thermal storage tank, and control unit to recover the waste heat generated in a livestock manure treatment system was developed, and the recovery of waste heat was quantified through on-site application. The heat exchange rate was calculated indirectly by circulating the liquid manure from the fermenter in the heat exchanger, and it was measured to be 76.31 MJ/h. The power usage of the circulation pump measured was 0.8 kWh. The energy generated from the heat pump required to increase the water temperature to 45℃ after heat exchange was 77.37 MJ/h, and the coefficient of performance of the heat pump at this point was 4.27. If the reducible heat energy is recovered and supplied in a customized form to meet the demand, it could be considerably beneficial to the crop livestock farming system and could reduce the environmental load of manure treatment facilities.

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PB-013

FUNGI AND BACTERIA TARGET SPECIES IDENTIFICATION FOR DRAINAGE WASTEWATER REUSE IN A HYDROPONICS HORTICULTURE FACILITY, SOUTH KOREA

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The greenhouse horticulture industry is rapidly growing in South Korea. Greenhouse horticulture utilizes many automation technologies, among which hydroponic cultivation systems are increasingly employed. Hydroponic systems are an easy and efficient way to provide nutrients directly to plants. However, hydroponic solutions typically supply 20%–30% more nutrients than required by the plant, resulting in nutrient-rich drainage wastewater. Drainage water containing high concentrations of nitrogen and phosphorus must be recycled to prevent negative environmental impacts. Drainage water may also contain harmful fungi and bacteria, which must be removed via sterilization. We analyzed fungi and bacteria in 36 drainage wastewater samples from hydroponically cultivated tomato (12), paprika (12), and strawberry (12) plants to determine the scope of sterilization. In the paprika samples, we detected 16 species of fungi belonging to 7 genera and 7 families, with a concentration sum of 160, and 2 species of bacteria in 2 genera and 2 families, with a concentration sum of 38. In tomato, we detected 9 fungus species in 6 genera and 6 families, with a concentration sum of 36, and 5 species of bacteria in 3 genera and 3 families, with a concentration sum of 36. In strawberry, we detected 16 fungus species in 8 genera and 8 families, with a concentration sum of 203, and 5 bacterial species in 2 genera and 2 families, with a concentration sum of 76. The concentrations of fungi and bacteria were highest in strawberry wastewater samples, followed by paprika, and lowest in tomato. The majority of fungi detected were Fusarium, Phytophthora, and Pythium, and bacterial species were mainly Agrobacterium and Pseudomonas. Water containing these species must be sterilized to facilitate the safe reuse of drainage wastewater. This research will contribute to water pollution prevention, water conservation, and sustainable agriculture.

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PB-014

AN AI LIFE CYCLE ASSESSMENT TOWARD A SUSTAINABLE FOOD SUPPLY CHAIN

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Optimization of resource allocation in agri-food sector, in order to find the most appropriate mix of inputs, could contribute to mitigation of environmental impacts, reduction of agricultural and food wastes, and moving toward a more circular food supply chain. Life cycle assessment (LCA) has been coupled with several artificial intelligent-based optimization techniques in order to optimize food systems in terms of environmental impacts. One important step in an optimization problem of a food system is to determine the bounds for the optimization variable. This study developed an optimization bound determination scheme through application of Delphi methodology. A hybrid LCA + multilayer perception artificial neural network + Delphi methodology + genetic algorithm was applied to optimize a food production system. Five functional units were considered for this study: one ton of produced pomegranate, one hectare, daily energy intake, vitamin C, and dietary fibre for 1 person. The results indicated that a remarkable amount of environmental impacts could be mitigated using this approach in a case study of pomegranate production.

Keywords : Artificial intelligence, Environmental impacts, Food system, Sustainable food

PB-015

IMPROVING THE ECOLOGICAL UTILIZATION OF EARTHWORMS AND EARTHWORM FECES IN ORGANIC FARMING

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Earthworms have become a growing part of the livestock industry since they were first classified as livestock in 2004. Earhworms are used in organic resource recycling facilities along with Dongaedungae. Earthworm feces are a by-product of this process. Raw materials available for compost are fed to worm, such as stem worms and red worms. After worms consume and digest the raw materials, their feces consist of organic materials that can be used as fertilizer. Such sustainable reuse of organic materials is in line with the principles of organic resource circulation. However, when producing and using worm feces relevant legal regulations and food guidelines must be observed to meet acceptable standards. In this study, we examined the ecological utilization of worm feces compared with other fertilizers. Soil trimester was improved by treatment with earthworm feces (worm feces 61.5%, Mixed Expeller Cake fertilizer 73.1%, fertilizer 66.0%, and untreated 72.6%). Volume density was also improved in the earthworm feces treatment (worm feces 1.04 g/cm3, Mixed Expeller Cake fertilizer soil 1.16 g/cm3, fertilizer 1.08 g/cm3, untreated 1.25 g/cm3). Hardness was improved to less than 2 MPa, even at a depth of 30 cm or less. Compared to the typical practice of cabbage and tomato farming, the amount of growth did not increase significantly in the earthworm feces treatment. The quantity was lowest at 7,096 g/plot, compared with oil foil at 7,992 g/plot, fertilizer at 7,455 g/plot, and untreated at 7,511 g/plot, but the availability was recognized. It is believed that combined agriculture of organic rice and freshwater fish production, which has recently been highlighted, is ideal for purifying water quality, supplying nutrients, and improving physical soil properties.

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PB-016

OPTICAL FOURIER VOLUME FOR SOLAR CONCENTRATOR

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Over the decades, the cost of energy produced by solar cells is expected to decrease to 0.24 $/W. This has resulted in a significant increase in the amount of solar energy produced, but it is far less than the world's required electrical energy demand. Although cost savings have been made at various process stages to create a solar module with high power conversion efficiency at a low cost, additional methods for improving power conversion efficiency are needed.
In this regard, we fabricated an Optical Fourier Volume by holographic lithography as solar concentrator for improving energy conversion yield per cost.
Through holographic lithography mixing with two coherent beams, interference patterns with intensity sinusoidally changed can be recorded in thick photopolymer films. The interference pattern is recorded in the photopolymer without etch out process (i.e. photolithography), and achieved volumetric 1D grating is corresponding to the Fourier optics.
By modulating a grating vector of interference pattern in Optical Fourier Volume, a light can be controlled spatially to guide external light into solar modules for improving power conversion efficiency.
In this presentation, I'll talk about an Optical Fourier Volume using an epoxy-based photopolymer. This is cheaper than other materials used in producing the solar concentrator, and can be mass-produced in large areas, contributing to the increase in energy generation yield per cost.

PC-001

SCENARIO ANALYSIS FOR UTILIZATION OF LANDFILL GAS IN PRODUCTION OF HYDROGEN AND ELECTRICITY IN ECONOMIC and ENVIRONEMTNAL ASPECTS

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According to increased global demands for novel hydrogen (H_2) production system, research for utilization of landfill gas (LFG) consisting of green-house gas (GHGs) of methane (CH_4) and carbon dioxide (CO_2) has been actively conducted to escape conventional energy paradigm using fossil-fuel, which is main source of CO_2. This study presents several production scenarios of H_2 and electricity with detailed processes of CO_2 capture using to classify LFGs as high-grade (HG), medium-grade (MG), and low grade (LG) according to its compositions of CH_4 and CO_2 and H_2 production ways of its dry reforming and steam reforming. For each scenario, levelized cost of H_2 (LCOH) and electricity (LCOE) are estimated using itemized cost estimation, and net present values are obtained by profitability analysis using cash-flow diagram (CFD) under different selling prices and additional scenarios for utilization of captured CO_2 to valuable products of methanol (MeOH), dimethyl-ether (DME), and formic acid (FA). In addition, environmental impacts of each scenario in terms of CO_2 emission are quantified based on estimated amount of energy consumption. This study with detailed process simulation and evaluation for various LFG utilization scenarios in economic and environmental aspects will provide technical, economic, and environmental guideline for commercialization of this premature technology.

Keywords : Waste-to-energy, Utilization of landfill gas, Process simulation, Economic analysis, Environmental assessment, Feasibility study

PC-002

GREEN HYDROGEN FROM AIR GASIFICATION OF WOOD BIOMASS USING A TWO-STAGE FLUIDIZED GASIFIER

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Even though the demand of fossil fuel has steadily decreased, it is still dominant energy source around the world. During using fossil fuels, CO_2 emission is inevitable, which significantly affects global warming. Replacing fossil fuels, the use of biomass has been recommended from society due to its carbon-neutral property. Biomass can be utilized through thermochemical and biochemical conversion. Thermochemical conversion process involves combustion, gasification and pyrolysis and is a faster process than biochemical conversion one. Recently, gasification which converts biomass to a gas consisting mainly of hydrogen, small hydrocarbons and carbon monoxide under the lack of oxygen attracts attention, especially due to the possibility of production of green hydrogen. In the production of green hydrogen via biomass gasification, tar generated during gasification should be minimized. Tar can cause blocking and fouling problems, which make a smooth gasification operation difficult. To remove tar efficiently, our research group developed a two-stage gasification process called the University of Seoul two-stage gasification process. The key part of the process is the fluidized bed gasifier and tar-cracking reactor usually filled with tar-cracking additive like activated carbon. In this study, air gasification of wood pellet was conducted to produce green hydrogen. In particular, a gasification experiment was performed at about 600 °C to avoid the defluidization caused by melting of alkali and alkaline earth metals of wood. To quantify our gasifier performance, we evaluated the efficiency of process like carbon conversion efficiency, cold gas efficiency and condensed tar removal efficiency. As a result, we could produce a product gas having a hydrogen content of ?? vol.% with air as the gasifying agent.

PC-003

CARBON DIOXIDE GAS UTILIZATION FOR THE SLAGGING AND FOULING ALLEVIATION OF FOOD WASTE BIOCHAR FUEL

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Food waste has low availability as a fuel due to its high moisture content, but pyrolyzed food waste biochar has high merit as a combustion fuel by energy density improvement. Food waste biochar contained high alkali and alkaline earth metal(AAEM)s content originated in salt and endocarp of plant, which may induce slagging and fouling at the combustion processes and need to be alleviated. In the preliminary study, sufficient chlorine removal through water rinsing of food waste biochar has confirmed, but AAEM removal efficiency was low due to the adsorption of AAEM by CEC of biochar. When carbon dioxide is purged in water, it dissolves and decreases the pH of water. Accordingly, an increase in the H+ ion contet may have and effect of inhibiting AAEM adsorption due to CEC, also it has implications in terms of recycling route development of carbon dioxide emitted from the food waste pyrolysis process. Therefore the purpose of this study was te verify the effect by saturating carbon dioxide gas during the water rinsing process of biochar, which is pyrolyzed food waste at 500°C for 15, 30, 45 minutes and 60 minutes, respectively. The effect of AAEM re-adsorption was noticeably confirmed as the pyrolysis time increased, and the effect of inhibiting AAEM re-adsorption by purging carbon dioxide gas was also proportionally high. This result confirmes the possibility of applying carbon dioxide gas generated from pyrolyzing food waste processes to the quality improvement of biochar, and additional research is required about optimal conditions.

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PC-004

BIOPOLYMER SYNTHRSIS FROM WASTE ACTIVATED SLUDGE VIA ACIDOGENIC FERMENTATION WITH PRETREATMENT

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Polyhydroxybutyrate (PHB) is a natural polyester that may be made utilizing volatile fatty acids (VFAs) as a substrate. VFA generated by continuous anaerobic fermentation of waste activated sludge was fed into bioreactors for PHB synthesis in this work. Series of optimization tests were conducted to increase the biodegradability and hydrolysis of waste activated sludge (WAS). It was found out that 0.05 % concentration of SDBS (sodium dodecylbenzene sulfonate), 70oC (heat treatment) and 2h as pretreatment condition would give the highest solubilization (9 g SCOD/L). Impact of pH (4 – 10) on batch acidogenesis of pretreated WAS was conducted and results indicated that when pH is between 7.5 to 8, the VFA yield was 5.3 - 18.1 % higher compared to VFA produced in other different pH values. Preliminary batch experiments were used as a basis for the subsequent continuous acidogenic fermentation operation at varying hydraulic retention time (HRT) of 4, 5, 7 and 10 d. Highest VFA yield (52%) was achieved at 7d HRT which was explained by the better hydrolytic and acidogenic activity tests, while PHB can be produced at a maximum of 0.42 ± 0.011 g-PHB/g-VFA-added.

Keywords : PHB; Biopolymer; Acidogenesis; Waste activated sludge, VFAs, SDBS

PC-005

CATALYTIC DEPOLYMERIZATION OF KRAFT LIGNIN INTO PHENOLIC MONOMERS OVER Ni-Pd/HZSM-5

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Lignin is one of the most abundant renewable sources of aromatic chemical on the Earth and its depolymerization is of great importance. Although there are several studies on lignin depolymerization into bio-oil in literature, developing an effective lignin depolymerization technique still remain a great challenge. Therefore, in this study, depolymerization of Kraft lignin was investigated using ethanol over the synthesized Ni-Pd/HZSM-5 catalyst in a batch reactor. The influence of different process parameters, such as reaction temperature, time and catalyst amount was also carefully examined. The highest bio-oil yield of 86.5% including 17.03% phenolic monomers and the lowest yield of char (11.6%) were achieved at the optimum conditions of 300 ℃, 4h and 0.5 g of catalyst loading. These results indicate that in ethanol, Ni-Pd/HZSM-5 acted as an effective catalyst for enhancing bio-oil yield and suppressing the char formation. The synthesized catalyst was characterized by BET, N2-adsorption-desorption, XPS and TEM analyses, while the produced bio-oils were analyzed by GC-MS, FT-IR and 2D HSQC NMR analyses. The GC-MS results indicated that the bio-oil obtained at the optimized conditions was consisted of guaiacol, 4-methylguaiacol, 4-ethylguaiacol and homovanillic acid as the major compounds. The depolymerization process and outcomes of this study suggest that this technique could be applied in large scale operation for the production of valuable aromatic compounds from lignin.

PC-006

RECOVERING RAW SULFATED POLYSACCHARIDES FROM WASTE ACTIVATED SLUDGE

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Notably around 50% of urban waste resources end up in wastewater, recycling chemical materials from these resources is vital to alleviate the natural resource scarcity challenges. Many wastewater chemical recovery technologies (e.g., phosphorus, bioplastics, and biofuels) have already been well developed; these successful recovery technologies demonstrate that recovering valuable materials from wastewater is feasible. Sulfated polysaccharides (SPs) are macromolecular polymers formed by introducing sulfate on the carbon chain of polysaccharides, having various functions such as anti-coagulation and anti-oxidation. Therefore, recovering SPs from waste activated sludge (WAS) is fascinating for obtaining raw SP chemicals for industrial/pharmaceutical applications. The objective of this paper was to investigate the optimal design of recovering SPs from WAS, eventually to provide an economic and effective method for maximizing valued chemicals recovered from wastewater.

PC-007

PRODUCTION OF BIOCHAR USING FLEXIBLE COUNTER FLOW MULTI BAFFLE (F-COMB) TECHNOLOGY

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Biochar is a realistic way to mitigate climate change through long-term carbon sequestration and greenhouse gas reduction. In particular, the carbon storage in the form of biochar was recognized as a negative emission technology (NET) by the IPCC and is being actively pursued as a BM of many private companies. Besides, biochar can enhance the crop productivity by improving water holding capacity and nutrient retention of soil. Biochar is generally produced by thermal conversion of waste solid materials such as agricultural crop residues, forest residue, animal manure, and sewage slurry. Flexible Counter flOw Multi-Baffle (F-COMB) technology by KIER provides drying and pyrolysis process that has secured economic feasibility, thanks to its low operational cost and simple structure. It shows highly efficient contact of the solid pieces with hot gas, based on the counter flow mechanism and vortex mixing. The temperature difference stays large along the whole column, resulting in the high thermal efficiency. F-COMB is advantageous in terms of installation economics, thanks to its simple structure and short (4-10 min) residence time. In addition, the internal structure of F-COMB is adjustable depending on the feedstock, simply by controlling the opening, tilting, and spacing inside the column. Pyrolysis of solid wastes has produced biochars successfully using a 0.5 ton/day pilot scale F-COMB. Biochar with >75% carbon content, H/C < 0.6, and O/C < 0.3 was continuously produced at 1-4 min feeding interval in three flexible-baffle operation.

PC-008

DESIGNER BIOCHAR WITH ENHANCED FUNCTIONALITY FOR EFFICIENT REMOVAL OF AQUEOUS ^{137}Cs AND ^{90}Sr

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Radioactive elements can be released into the environment due to the decommissioning of nuclear power plants causing serious health hazards to humans and other organisms. In this research, three gasified biochars (feedstock mixtures of wood, chicken manure, and food waste), and KOH-activated biochar (40% food waste + 60% wood biochar (WFWK)) were used to remove cesium (Cs^+) and strontium (Sr^{2+}) from water. Physicochemical properties of the biochar before and after Cs^+ and Sr^{2+} adsorption were determined using XRD, FTIR, SEM-EDX, XPS, and synchrotron (EXAFS). Among the tested biochar, WFWK exhibited the highest adsorption capacities for non-radioactive Cs^+ (62.7 mg/g) and Sr^{2+} (43.0 mg/g). More than 80% and 47% of the radioactive elements (137Cs and 90Sr) were removed in the presence of competing ions, such as Na^+ and Ca^{2+} (100 mg/L), respectively. The results showed that functional groups of biochar including -OH, $-NH_2$, and -COOH facilitated Cs and Sr adsorption. The Cs K-edge EXAFS spectra revealed that only a single coordination shell was assigned to the Cs-O bonding at 3.11 Å, which corresponded to outer-sphere complex between Cs and biochar. Overall, designer WFWK could be used as an effective adsorbent to treat ^{137}Cs- and 90Sr-contaminated water after a nuclear power plant accident or to treat stored nuclear liquid waste during the operation of nuclear power plants due to the enrichment of functional groups via alkaline chemical activation. This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2021R1A2C2011734), and "Development of Environmental Remediation Technology for Decommissioning site of Nuclear Facilities" Project (No.2017M2A8A5015148).

PC-009

APPLIED MACHINE LEARNING FOR PREDICTION OF CO_2 ADSORPTION ON BIOMASS WASTE-DERIVED POROUS CARBON

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Biomass waste-derived porous carbons (BWDPCs) are a class of complex materials that are widely used in sustainable waste management and 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 make it challenging to understand the underlying mechanism of CO_2 adsorption. Here, we compiled a dataset including 527 data points collected from peer-reviewed publications, and applied machine learning (ML) to systematically map CO_2 adsorption as a function of the textural and compositional properties of BWDPCs and adsorption parameters. Various tree-based models were devised, where the gradient boosting decision trees (GBDT) had the best predictive performance with R^2 of 0.98 and 0.84 on the training and test data, respectively. Further, the BWDPCs in the compiled dataset were classified into regular porous carbons (RPCs) and heteroatom-doped porous carbons (HDPCs), where again the GBDT model had R^2 of 0.99 and 0.98 on the training, and 0.86 and 0.79 on the test data, for the RPCs and HDPCs, respectively. Feature importance revealed the significance of adsorption parameters, textural properties, and compositional properties in the order of precedence for BWDPCs-based CO_2 adsorption, effectively guiding the synthesis of porous carbons for CO_2 adsorption applications. This work was supported by the Cooperative Research Program for Agriculture Science and Technology Development (Effects of plastic mulch wastes on crop productivity and agroenvironment, Project No. PJ01475801), Rural Development Administration, Republic of Korea and the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2021R1A2C2011734).

IN-PERSON POSTER PRESENTATION

PC-010

OCCURRENCE OF AFRICAN SWINE FEVER PANDEMIC ALONG THE KOREAN DEMILITARIZED ZONE AND COUNTERMEASURE ON CARCASS DISPOSAL

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African Swine Fever (ASF) was firstly reported on 16th September, 2019 in the Republic of Korea at a domestic pig farm in Paju City which is located within several kilometers from the demilitarized zone (DMZ). Then, it had spread and occurred at 14 farms of 4 neighboring cities and counties in a month. Slaughtering about 450 thousands domestic pigs in 261 farms of the occurred areas had been immediately performed for biosecurity. However, ASF in a wild boar carcass was discovered in the DMZ on 3rd October, 2019. Since then, it had been occurred and spread gradually from the west to the east along the DMZ, resulting in removal of 113,359 (17,662 from infected areas and 95,697 from non-infected areas) wild boars for a year with firearms and various traps. Because ASF causes high mortality rates up to 100% and its vaccine has not been developed yet, it would be very difficult to deal with and take years or decades to the end of disease after the virus is occurred. The Ministry of Environment, Korea established an ASF standard operating procedure (SOP) on the basis of cases of EU's countermeasures as well as various knowledge and information obtained through international collaboration. In the SOP, carcass disposal including incineration, burial, and rendering must follow the methods based on the Enforcement Decree of the Wildlife Protection and Management Act. As results, the number of ASF occurred cases have been remarkably reduced in the country throughout aggressive and consistent strategies with supports of local governments, and most positive AFS cases have been found within the blocking enclosures which were installed to prevent its proliferation. The findings and results indicated that our countermeasures for ASF diagnostics and quarantine actions have been well achieved to minimize the catastrophes relative to other Asian countries suffered from the ASF pandemic. However, availability of acquisition of on-site manpower is restricted along with a number of difficulties including the management of burial sites from flood, washed out, collapse, etc. Analysis and monitoring of environmental samples (water and soil) on the ASF carcass sites are very important for preventing potential proliferation and finding the source of contamination. Therefore, proper on-site treatment and post-management of carcass disposal are highly required.

nature conferences

Waste Management and Valorisation for a Sustainable Future

VIRTUAL POSTER PRESENTATIONS

POSTER SESSION 'A'

VPA-001

DEVELOPMENT OF CATALYTIC HYDROGEN PRODUCTION TECHNOLOGY USING AMMONIA RECOVERED FROM WASTEWATER

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Recently, ammonia is attracting attention as a hydrogen storage material due to its high hydrogen storage capacity per unit volume. Contrarily, ammonia is considered as a pollutant that needs to be removed in water and wastewater treatment plants. Noting on the fact that both the synthesis of ammonia with high purity and the removal of ammonia from wastewater require highly energy demanded processes, ammonia from wastewater has potential as a useful resource for hydrogen if it can be separated and recovered. While research on recovery technologies of gaseous ammonia from wastewater, such as membrane technologies, are available, only few studies exist for hydrogen production using ammonia recovered from wastewater. Most studies used refined liquid ammonia as a hydrogen source due to its usability. There needs a catalytic technology that can convert low-concentration ammonia to hydrogen in high-yields to utilize ammonia from wastewater. This research aims (1) to confirm the possibility that low-concentration ammonia can be decomposed by conventional Ru- and Ni-based catalyst and (2) to develop a new catalyst that can decompose low-concentration ammonia. We have investigated the influence of the type of catalyst support materials and their pore structure on conversion efficiency of low-concentration ammonia to hydrogen. Ru and Ni catalysts were prepared using ammonia alumina and zeolite Y as the support materials. Preliminarily, we tested Ru-based and Ni-based catalyst supported by Al_2O_3 for decomposition of pure ammonia (99.99%) with inflow rate of 10,000 mL/h·g_{cat}. The hydrogen concentration in outflow was measured to be 58.1 $\%_{v/v}$ (± 9.46) for Ru-based catalyst and 76.3 $\%_{v/v}$ (± 3.72) for Ni-based catalyst at 700 ℃, which is equivalent to 58.1 % (± 12.6) and 101.8 % (± 4.95) in ammonia decomposition efficiency, respectively. To further investigate the catalyst activity, physicochemical properties (e.g., specific surface area, pore structure) of the catalysts were characterized via N_2 physisorption.

VPA-002

INTEGRATION OF CLOSED-LOOP SUPPLY CHAIN MULTIOBJECTIVE OPTIMIZATION AND LIFE CYCLE ASSESSMENT: A CASE STUDY OF LEAD-ACID BATTERIES

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Over the past ten years, the supply chain concept has evolved towards an integrated approach considering simultaneously the upstream and downstream supply chains, leading to the so-called closed-loop supply chain (CLSC) used to improve the use of materials from different manufacturing processes. This work presents a methodological framework that explores the mirror effect between CLSC management concepts and Life Cycle Assessment (LCA). The increased use of lead-acid batteries in motor vehicles, particularly for electric vehicles, will support this analysis. The model formulation is based on a mixed variable linear mathematical programming procedure (MILP) that involves a multi-criteria approach related to cost minimization and environmental impact, considering five echelons (i.e. suppliers, producers, distributors, wholesalers, and retailers) in the forward network and seven echelons (i.e. collection and recycling centers, product disposal, disassembly plant, raw material disposal, third parties and remanufacturing) in the reverse one. The multi-level multi-period strategy involves first identifying and reducing the significant criteria that can be used in the multi-objective (in this case, bi-objective) optimization procedure. The total cost of the supply chain as well as greenhouse gas emissions have emerged as relevant and conflicting criteria to be taken into account in the epsilon-constraint based optimization procedure. The first application of a decision support method (M-TOPSIS) allowed the identification of the relevant candidate supply chain configurations. A life cycle assessment was then carried out on the set of Pareto front-end solutions to conduct a multi-criteria analysis on all the criteria of the selected impact analysis method (Impact 2002+) and the cost criterion. This step made it possible to identify more interesting solutions concerning all the criteria than those identified at the previous level, which justifies the validity of the approach. A sensitivity study showed that for the case study (1) an increase in the percentage of utilization of raw materials recovered from a product to be recycled (2) an increase in the recovery rate, (3) an improvement in the manufacturing/remanufacturing process regarding GHG emissions are particularly significant for improving the performance of all the indicators.

VPA-003

MICROALGAE BASED NUTRIENT RECOVERY FROM SOURCE SEPARATED URINE: PERSPECTIVES TOWARDS LOW CARBON CIRCULAR BIOECONOMY

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One of the possible methods of efficient waste management involves the segregation of waste streams with the possibility of reuse and recycle. The source-separated urine constituting 1% of domestic wastewater having 80% nitrogen and 60% phosphorous load is a valuable waste stream with abundant macronutrients that are often conventionally recovered via physical and chemical processes to be used as fertilizers. The current operational recovery techniques are extremely costly, energy-intensive, and have lesser yields. To tackle the above-mentioned problems, the biological method of microalgal cultivation is regarded as one of the economic and sustainable methods to recover the stored nutrients. Algae assimilate the macronutrients along with the trace metals and toxic micropollutants, generating biomass, biochemically rich in carbohydrates, lipids, and proteins, which could be processed into biofuel and other value-added co-products. The proposed strategy seems to be visibly advantageous but the large-scale real-time application is still lacking due to the absence of proper literature review data to guide the information flow. The present study highlights the use of urine as a potential medium for culturing microalgae with a focus on nutrient recovery, microalgal productivity along with insights into different photobioreactor designs. Factors influencing process efficacy have also been elaborated. The associated challenges and possible solutions for implementing the technology have been discussed. The study could act as the basic state of art information guiding the real-time application of source-separated urine for microalgae cultivation facilitating simultaneous natural waste resource management, bioenergy production, and generation of other profitable by-products with lower carbon footprints.

Keywords : Microalgae; Biomass; Carbon footprints; Urine; Resource recovery; Natural Resource Management

VPA-004

SUSTAINABLE MANAGEMENT OF AGRICULTURAL AND FOOD WASTE IN DELHI NCR REGION OF INDIA USING CIRCULAR ECONOMY FRAMEWORK

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Agriculture and food waste have always been cited as the one of the main challenges for a developing metropolis. Rapid population growth necessitates expanded agricultural production to meet the ever-increasing demand. Every year, India generates about 350 million tonnes of agricultural waste and 68.7 million tonnes of food waste. Environmental pressures caused by these waste generation result in considerable greenhouse gas emissions, leading to global warming and climate change. This study focuses on the National Capital Region (NCR) of India i.e Delhi, which faces major concerns in terms of environmental deterioration caused by high level of pollution due to crop residue burning and food waste generation. Circular Economy (CE) strategies are applied on agricultural sector of the city, targeting minimisation of waste and thereby reducing CO_2 emissions which are caused due to agriculture and food wastage under business-as-usual scenario. The Low Emission Analysis Platform (LEAP) has been used to incorporate CE as a scenario into agriculture and food waste practises of the city and forecast the emission portfolio. By application of CE strategies using the ReSOLVE framework, CO_2 emissions from agricultural and food waste should 7.3% and 17% per year, respectively. When comparing the circular economy scenario to the business-as-usual scenario, the results suggest that for the years 2020 to 2040, a reduction of about 18 kt of CO_2 emissions (32%) and 35 Mt of CO_2 emissions (49%) for agriculture and food waste can be accomplished respectively. The proposed CE strategies not only demonstrates its applicability in a complex city such as Delhi but also should be able to assist decision-makers in making major improvements in the concerned areas for improving the state of environment in the city.

Keywords : Circular economy, Climate change, CO_2 emission, Agriculture waste, Food waste

VPA-005

CATALYTIC PYROLYSIS atalytic Pyrolysis of Municipal Plastic Waste: A REVIEW

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Plastic waste is a global problem that severely threatens the environment if not handled properly. It is widely treated in unsustainable ways such as landfill or incineration that generally do not contribute to the circular economy or to sustainable development principles. Catalytic pyrolysis of plastic waste is considered an alternative solution with the potential of recovering value-added chemicals from plastic waste that is not recyclable. In this review, the main steps required for running an operational pyrolysis plant will be described from a whole system perspective. The types of plastic waste that are suitable for pyrolysis are defined. The recent technical advancement of plastic pyrolysis is described to guide the selection of relevant technologies. The practical applications of products derived from plastic pyrolysis are reviewed. This review will facilitate the development of the capacity to make better decisions upon the design and analysis of plastic pyrolysis processes and systems.

VPA-006

LINKING TOURISM AND SUSTAINABLE WASTE MANAGEMENT: THE CASE STUDY OF THE CAMINO LEBANIEGO IN CANTABRIA (SPAIN)

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The tourism sector requires a standardized framework to define, evaluate and modify strategies, balancing environmental and socio-economic value. Results should provide tools that incorporate both consumers and public managers in the decision-making process. In addition, appropriate management is needed to achieve sustainable development and maintain the integrity of the heritage, ecological integrity, biological diversity and livelihood system. To achieve these results, it is necessary to include Life Cycle Assessment (LCA) methodologies such as the Carbon Footprint (CF) to promote the circular economy in the tourism sector, as well as scientific and methodological innovation and eco-labelling. In this scope and considering that the tourist attraction in the study is the pilgrimage (religious tourism), the main goal is developing a sustainable integrated model by assessing the impact of a hostel on the Camino Lebaniego in the region of Cantabria (Spain). The system boundary does not consider the whole journey, but only the hostel where pilgrims stay overnight and the subsequent waste management. Furthermore, it is considered a "door to grave" study since it is only based on the use of the hostel and the final waste management through the incineration process. According to the functional unit (FU), "1 overnight stay of a pilgrim" has been used for the evaluation, based on the concept of the life cycle of tourist accommodation whose function is the overnight stay of a pilgrim in a hostel with the different services it offers. The CF obtained in the study is 7.73 kg CO_2-eq/pilgrim overnight stay where the management of the municipal solid waste (3.42 kg CO_2-eq/FU) and the electricity consumption (2.67 kg CO_2-eq/FU) produce more than 78% of the total impact. The impacts associated with the generation of organic waste are so high due to the incineration process to which it is exposed. Although the incineration process aims to achieve energy recovery, it is not a sustainable solution for waste treatment due to its harmful consequences on health and the environment. This is also the case for landfilling waste. To avoid these environmental burdens, the 3Rs: reduce, reuse and recycle. In this way, these impacts could be reduced in a large percentage.

VPA-007

EFFICIENT SUSTAINABLE GREEN STRATEGY FOR BIOREFINING OF DISTILLERY WASTE FOR FOOD APPLICATIONS

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Rapid growth of ethanol industry in recent period is witnessing a corpus production of its by-products mainly Distilleries Dried Grain Soluble (DDGS), that is being used as animal feed. Presently the sheer quantity of DDGS globally produced each year far exceeds the requirement of feed. Thus its effective management in an environmentally safe manner is imperative. DDGS is a potential storehouse of a wide variety of antioxidants/ phenolic compounds which, if extracted efficiently, have far reaching applications in industries. Currently employed methods involve solvents which are toxic for human consumption and pose threat to the environment. Hence greener and sustainable alternatives for extraction need to be explored. In this present study, an attempt has been made to evaluate the plausibility of using DDGS as a potential source of antioxidants for applications in food processing. This work has been designed to develop a sustainable separation process to recover natural antioxidants from DDGS using natural deep eutectic solvent (NADES) e.g., choline chloride, L-proline, lactic acid etc. Additionally, a low-cost sustainable extraction technique i.e., ultrasonic assisted extraction (UAE) was employed and compared with stirring and shaking. The effect of different operating parameters (i.e., solvent type, method of extraction and time) on antioxidant extraction efficiency was studied to determine the optimal conditions for recovery of antioxidants. Optimal antioxidant yield was found to be two-fold more than the yield obtained using conventional methods. Toxicity tests of the extract revealed the absence of Naturally Occurring Toxins. Encapsulated extract was successfully used in development of food products. Results obtained indicate that the demonstrated strategy is a sustainable effective approach for utilizing the underexploited resources.

Keywords : Valorisation of DDGS, Green extraction, Deep eutectic solvents, Ultrasonic assisted extraction, Antioxidants, optimization

VPA-008

MINERAL WASTERS TO RESOURCES RECYCLING USING AN ARSENIC BIO-LEACHING SYSTEM

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Arsenic contamination of tailing waster to resources threatens the health of ecosystems, especially crop and streams in surrounding villages over 5,000 abandoned mines in the Republic of Korea. In particular, mine waste continues to damage the ecosystem and surrounding farms as the neglected mine, abandoned arsenic-contaminated used to secure military supplies for Japanese invasion of JESEON during Japanese colonial period. Here we present on the maps the areas with an average tailings waste As-concentration of 3,000 mg/kg ± 2,000 mg/kg. Thus, mine waste purification is urgently needed. Arsenic contamination 3,000 mg/kg for Samkwang mine waste recovery using Xanthomonas sp. strain BGRI EBC SJ18-W4 arsenic resistance system, bio-slope leaching; 2,100 mg/kg, bio-heap leaching; 2,213 mg/kg, bio-in-situ leaching; 2,971 mg/kg confirmed the possibility of arsenic recycling. These results confirmed the possibility of performing arsenic recovery and recycling of mineral wastes. Such recovery and recycling could benefit from development bacteria techniques for arsenic-contaminated Sangdong mine, Myoungbong mine, Dackdong mine, Duckum mine, and Songcheon mine. Arsenic resistance system and biological leaching technology of arsenic-contaminated mine waste supplemented the weakness of physical·chemical characteristics through the possibility of purification and resource recycling. Resource recycling of the critical factors controlling the biogeochemical cycling of arsenic-contaminated mine waste is bio-leaching and geochemical important.

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VPA-009

BIOCHAR AS GREEN AGGREGATE IN CEMENT-BONDED PARTICLEBOARDS

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Biochar is a green material obtained from the thermochemical conversion of waste biomass under an oxygen-limited condition. This study demonstrated an innovative and low-carbon technology by using ordinary Portland cement, magnesium oxysulfate cement and supplementary cement materials (SCMs) to recycling 50-70 wt% waste wood-derived biochar into eco-friendly cement-bonded particleboards. The X-ray diffraction (XRD) and thermogravimetric analyses (TGA) illustrated that the incorporation of biochar promoted the generation of additional cement hydrates owing to moisture regulation effect of biochar and the reacted SiO2 in SCMs reacted with the cement hydration product to generate additional C-S-H and M-S-H via the Pozzolanic-like reaction. The 40PC, 50PC, 30PC-MK and 50MS particleboards successfully fulfilled the flexural strength requirement of the gypsum board (6 MPa) and dimensional stability (<2% swelling after 24-h water immersion). Moreover, thermal conductivity was significantly reduced with the incorporation of porous biochar that can block the heat transfer. Life cycle analysis was also performed for the mixtures that can meet the gypsum board requirements. Results showed that all the mixture are carbon negative except for the 50PC and the 30PC-MK can even absorb 512.8 kg per ton particleboards. Therefore, this study presents an environmentally-friendly technology to upcycle wood waste into value-added carbon-negative product in a sustainable way.

VPA-010

NOVEL PROCESSING AND RECYCLING TECHNIQUES FOR POLYETHYLENE TEREPHTHALATE (PET) BOTTLES

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Polyethylene terephthalate (PET) has been widely used for the fabrication of packaging materials. With rising environmental awareness, the recycling of PET attracts attention. PET bottles are the most recycled, and mechanical recycling is the most commonly used method. However, recycling of colored PET bottles is a problem for mechanical recycling because dyes cannot be easily removed and it will decrease the purity and affect the color of products. Our research groups have developed a promising decolorization process for PET bottles. Through a pretreatment with ethylene glycol decreasing the size of PET, PET bottles are then decolorized by ethylene glycol below the boiling point of ethylene glycol. This technique makes it possible to recycle colored PET bottles by mechanical recycling method. However, the quality of PET, recycled by mechanical recycling method, would be lower and lower because of inevitable breakage of bonds under high operating temperature. Therefore, a more sustainable method is required, that is, chemical recycling method. Chemical recycling method can convert PET into its monomers or other value-added products, and the monomers can be repolymerized into virgin PET.Our research groups have developed an efficient depolymerization process with glycolysis reaction catalyzed by zinc sheet, which is recycled from waste batteries. It not only shows great performance, 92.5% of PET conversion, and 72.8% of BHET yield but also possesses good recyclability of catalyst. With a cheap and easily recycled catalyst from waste batteries, this technique shows a higher possibility to be used in the industry.In conclusion, decolorization can integrate with currently available mechanical recycling to increase the market value of the PET recycling industry. On the other hand, depolymerization can realize a circular economy for PET bottles in the future, and make the world more environmentally friendly.

VPA-011

WASTEWATER TREATMENT THROUGH ISOLATION OF MICROALGAE FROM ALGRICULTURAL, DOMESTIC, AND INDUSTRIAL WATERWASTE STABILIZATION PONDS

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Microalgae are a diverse group of organisms which have the potential to provide a solution for wastewater treatment by removing Nitrogen, Phosphorus and heavy metals. During this study several microalgae species (Chlorella, Synechococcus, Chrococcus, Naviculoid, Anabaena, Oscillatoria, Spirullina and Spirogyra) were identified using morphological characteristics in wastewater stabilization ponds in agricultural, domestic and industrial locations. BG 11 medium (2000 lux light, 28°C, and 100 rpm) was used to isolate Chlorella and Oscillatoria species. N and P removal ability of the isolated species was studied in laboratory cultures through four treatments (T1; N 0 mg/l, P 0 mg/l, T2; N 90 mg/l, P 0 mg/l, T3; N 0 mg/l, P 80 mg/l, T4; N 90 mg/l, P 80 mg/l). Among them, best results were obtained for T2, T3 and T4. In T2 and T4, Highest significant N removal was shown by Chlorella at 2, 7 and 14 days after inoculation. Oscillatoria alone or Chlorella+Oscillatoria mixed culture did not show N removal ability. Significant P removal was shown by Chlorella, Oscillatoria and mixed culture at 2, 7 and 14 days after inoculation. Mixed culture was able to show highest removal at 1 and 2 days after inoculation. In T4, Chlorella and indicated the potential for removal of 49.83% P while Oscillatoria indicated 60.3% P removal within 1 week. Indicating that there was no effect of microalgae in controlling the growth of Fecal Coliform, Coliform counts in wastewater inoculated with Chlorella, Oscillatoria and the mixed culture remained the same even after 1 week of inoculation.

Keywords : Microalgae, Nitrogen, Phosphorus, Waste water treatment.

VPA-012

COMMUNITY DIVERSITY METRICS, INTERACTION AND METABOLIC FUNCTION ANALYSIS OF PIRANA MUNICIPAL SOLID WASTE LANDFILL AT DIFFERENCE LIMEN OF AGE

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The Municipal Solid Waste Landfills utilize for discarding waste include organic waste, paper, cloths, rubber, wood, plastic, leather, and many more that created a unique anthropogenic ecosystem. The Ahmedabad Municipal Corporation approach for mining of 40 years old Pirana dumpsite to overcome the unsegregated legacy waste issue to resolve effectively and efficiently. The aim of this work focuses on the characterization of the bacterial microbiome of municipal solid waste practice in order to change with time of age.
In this study, soil samples were collected from Pirana landfill site in Ahmedabad city Gujarat, India. In total 107 phyla, 84 class, 167 order, 348 families, 1021 genera, and 2137 species were predicted in mined waste. While in fresh sample 111 phyla, 86 class, 155 order, 325 families, 807 genera and 1619 species were recorded. The core 1052 species and 2704 unique species reported in both samples. This indicates the high diversity at species level in community. Similarly, at genus and phylum level diverse community was obtained. The dominant phyla were observed for Proteobacteria, Chloroflexi, Candidatus and Firmicutes in excavated MSW sample whereas, Bacteroidetes, Firmicutes, Candidatus woesebacteria and Candidate division WWF3 in fresh MSW sample. The predictive functional profiling revealed the presence of enzymatic groups and pathways involved in biodegradation of xenobiotics and methane metabolism, biosynthesis of secondary metabolites. Present study indicates the relationship between microbial community structure and rich sources of gene pool change by age gap which revealed wide opportunity for isolation of novel extremophilic and unique microorganisms for environmental, industrial and biotechnological application.

VPA-013

WATER WASHING AS PRE-TREATMENT FOR ENHANCING THE BIOLEACHING OF METALS FROM BOF SLAG

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The Iron and Steel industry is one of the most polluting industry in India, due to production of huge amount of solid waste. Various types of solid waste are generated, however the basic oxygen furnace (BOF) slag is of major concern since, it contains various metals, which restricts its use in industrial applications. Bioleaching is an emerging leaching method which uses microorganisms for the solubilization of metals from the slag. Since, the slag is highly alkaline in nature, it affects the growth of bacteria and thereby also affects their leaching potential. Hence, water washing was used as the pre-treatment method to lower the pH of the slag. Slag (1 g) was added to 100 ml of distilled water, stirred at 120 rpm for 24-48 h. After constant pH was achieved, the solution was filtered and the slag was air dried. Air dried slag was again mixed with the leachate of previous cycle. This process was done until the pH remained constant in consecutive cycles. It was found that five and four water washing cycles was needed under stirring/shaking and static condition, respectively, to decrease the pH from 13.4 to 8.7. This lowering in pH was attributed to precipitation of calcite during water washing which was verified using XRD analysis and alkalinity-hardness data. The pre-washed slag was then used for the bioleaching of metals, using acidophilic bacteria, Acidothiobacillus ferrooxidans. The bioleaching efficiency of Al, Cr, Mg, Mn, Sr, V, Ti and Zn was found to be increased from 10.12% to 53.44%, 0% to 60.63%, 12.45% to 95.55%, 21.5% to 87%, 22.15% to 61.36%, 20.05% to 44.68%, 15.55% to 65.15% and 15.85% to 85.31%, respectively. The possible mechanism includes efficient growth of bacteria as well as change in slag morphology. The time taken for the bioleaching was also decreased from 25 days to 21 days. Maximum leaching for most of the metals was achieved within 12-15 days. The major mechanism of bioleaching using acidophilic culture involved in-situ production of sulfuric acid. The pH drop in pre-treated slag was more as compared to raw slag. In pre-treated slag, the pH dropped to 2-2.5, however in raw slag it dropped up to 3.5 only, which was possibly responsible for the enhanced leaching. The high concentration of sulphates in solution after bioleaching using pre-washed slag also confirmed greater conversion of sulphides into soluble sulphates. Hence, it can be concluded that pre-washing of slag can effectively help in bioleaching of the metals.

VPA-014

NOT WASTE, SAND: ADDRESSING GLOBAL SAND SUSTAINABILITY CRISIS AND CHALLENGES IN MINE WASTE MANAGEMENT

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The use of sand and construction aggregates – the second (after water) most exploited natural resource in the world – has tripled over the last two decades to reach an estimated 50 billion tonnes per year. The demand is growing exponentially around the world, strongly driven by urbanisation and population growth, and in particular infrastructure construction (UNEP, 2019; Bendixen et al, 2019a; Franks, 2020). Sand has been recognised as a strategic resource for sustainable development. Yet, its extraction from rivers and the nearshore environment is already a global environmental and resource problem, which remains largely unaddressed and unresolved in many places around the world (Peduzzi, 2014; Torres et al, 2021; Bendixen et al 2019b). The efforts towards responsible sand sourcing include the use of different alternatives, such as recycled aggregates from construction and demolition waste, by-products from other production and consumption processes (e.g. steel slag, fly ash, bottom ash, and waste foundry sand), and previously undeveloped natural resources such as glacial sand from Greenland (Bendixen et al, 2019b). However, these alternatives cannot substitute a significant share of the global demand (UNEP, 2019). Manufactured sand from crushing suitable rocks is also now becoming popular (Wijepala et al, 2019), however it is represented by additional extraction activities and may cause its own environmental impacts.The recovery and supply of alternative aggregates from the processing of mineral ores, mainly discarded as mine waste at present, could provide a new solution at scale, without causing new but solving existing environmental problems. The reuse of mine residues in different applications has been attracting attention in the academic literature for many years, though mainly at the laboratory scale (Almeida et al, 2020). The examples of commercial uptake still barely exist. Most recent changes in mining, environmental and waste policy mean that large volumes of mine waste, in particular tailings, now need to be treated differently in many places in the world (Franks et al, 2021). The rising value of sand and the costs of storing mining residues may provide new incentives for alternative aggregates with a strong contribution to sustainable development. Alternative sand from mineral ores ('ore-sand') could become a new disruptive innovation aligned with the circular economy.Multiple factors have to be taken into account to estimate the opportunities for alternative sands from mineral ores at the global level. They include, but are not limited to:

- the volume of tailings generation and disposal;
- their physicochemical properties;
- waste management practices and/or tailings (re)use;
- required/possible adjustments in the processing circuits and/or reprocessing options to recover sand;
- geographic location and climate settings;
- regional and national regulatory requirements;
- transportation distances to potential markets; and
- overall relative economic and technical advantages.

Our initial approach is based on the estimation of total mine tailings generation per year, and then comparing it with the estimated annual demand for sand on a geographic basis. To overview the locations and volumes of tailings generation worldwide, we combined information from three – most comprehensive to date – sources: The Global Tailings Portal (GTP) (Franks et al, 2021), the S&P Global Market Intelligence Database (S&P) (S&P, 2021), and the United States Geological Survey (USGS) Mineral Commodity Summaries 2021 (USGS, 2021). By developing a method for merging the information from these databases, we were able to create a global map which has accurate locations of 3654 mine sites, with either direct or indirect estimates of tailings generation volumes. The preliminary results show that, at one extreme, for some

VPA-015

STARFISH DERIVED COLLAGEN PEPTIDE-ENCAPSULLATING ELASTIC NANOLIPOSOMES FOR THE COSMETIC APPLICATION

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Asterias pectinifera, a starfish that has been known to ruin the aquaculture industry owing to its voracious appetite, has recently been identified as an eco-friendly source of non-toxic and highly water-soluble low-molecular weight collagen peptides, which promotes wound healing, bone regeneration, and skin protection. Although they have potential applications in biomedical applications, including pharmaceuticals and cosmetic products, it remains unclear how to improve the in vivo absorption of collagen peptides. Here, we present a novel method to enhance the absorption rate of collagen peptides using a lipid-based nanocarrier. We prepared an elastic nanoliposome by controlling the composition ratio of phospholipids and low-molecular weight collagen peptides. Our results indicate that low-molecular weight collagen peptides extracted from Asterias pectinifera have higher encapsulation efficiency than the collagen peptides extracted from pork and fish, which have traditionally been considered as a conventional source of collagen. Moreover, we demonstrate that the elastic nanoliposome containing the collagen peptide of Asterias pectinifera can reduce MMP-1 expression caused by ultraviolet radiation-induced photoaging. Therefore, the combination of Asterias pectinifera -derived low-molecular-weight collagen peptides and elastic nanoliposomes may be a promising formulation as an eco-friendly source of materials for anti-aging cosmetics.

VPA-016

BREAKDOEN OF CO_2 BY USING ARTIFICALLY DESIGNED CHLOROPHYLL ARTICIALLY DESIGNED CHLOROPHYLL TO MITIGATE GLOBAL ENVIRONMENTAL WASTE

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Due to the rapid development of modern civilization the burning fossil fuel globally increased amount of CO_2 concentration into the atmosphere at alarming which is a complete threat to get a fresh breath for all mammals near future. Recent study revealed that global carbon (CO_2) emissions from fossil fuel use were 9.795 gigatons (Gt) in 2019 or 35.9 Gt CO_2 of carbon dioxide which is alarming the earth for seriously to survive. Simply, the global CO_2 emission accelerating rapidly. Consequently, the accumulation of depleted CO_2 in the atmosphere getting heavier to heavier, which is alarming for all living beings for this planet to survive. Neither can we stop to accelerate to develop our modern civilization, nor we can go back to the jungle live due to overcome the impact of this deadly element of CO_2. To neutralize this deadly effect, an innovative step has been proposed by implementing artificial photosynthesis process to breakdown the CO_2 to convert it into oxygen and glucose in order to mitigate global climate change. Since photosynthesis is a process that convert light energy into chemical energy that can later be released to fuel the organisms' activities. This chemical energy is stored in carbohydrate molecules, such as sugars, which are synthesized from carbon dioxide and water. In most cases, oxygen is also released as a waste product which is largely responsible for producing and maintaining the oxygen content of the Earth's atmosphere, and supplies most of the energy necessary for life on Earth. Therefore, a chemical reaction technology has been proposed to breakdown this CO_2 by implementing artificially designed chlorophyl which is being extracting by using blue green algae (Cyanobacteria) into a bioreactor to convert it into O_2 as the vital element for the living being and glucose as the fertilizer for the agriculture in order to mitigate global environmental vulnerability ultimately.

VPA-017

IMPROVING BIOGAS PRODUCTION FROM SEWAGE SLUDGE THROUGH MAGNETIC BIOCHAR SUPPLEMENTATION

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Magnetic biochar has the potential to be an eco-friendly additive that enhance anaerobic digestion (AD) effectiveness. To better understand its roles in improving AD performance and system stability, magnetic biochar derived from rice husk and sewage sludge granule were introduced into anaerobic digesters at ratios of 0.2, 0.5 and 1.0% w/w. The oxygen and carbon contents in both magnetic biochar were increased by 46.7-74.3% and 52.3-61.1%, respectively after iron-doping modification. Fourier transform infrared spectroscopy (FTIR) and X-ray diffractometer (XRD) studies of the biochars showed that iron oxide can be successfully decorated on the biochar surface through thermochemical modification, and the resulting biochar's features were influenced by the pristine biochar. Meanwhile, methane production increased by 42% for magnetic rice husk biochar (MRH), and 32.7% for magnetic sewage sludge biochar when added to AD at a ratio of 0.5% w/w when compared to a control treatment without biochar addition. In addition, both types of magnetic biochar used in this study facilitated the degradation of acetate and propionate during the AD process. The supplementation of magnetic biochars also improved buffering capacity and increased ammonium tolerance, resulting in advanced process stability for sewage sludge AD under mesophilic conditions. Furthermore, the addition of magnetic biochar enhanced the structural complexity of digestate by increasing its fixed carbon and total ash content, providing improved potential for further soil applications.

VPA-018

BIODEGRADATION OF PLASTICS USING THERMOPHILIC BACTERIA FROM THE AUSTRALIAN GREAT ARTESIAN BASIN TOWARDS SUSTAINABLE PLASTIC WASTE MANAGEMENT

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An overwhelming 37% of global plastic waste is mismanaged; including plastic which is littered, uncollected, openly dumped or handled through uncontrolled landfills. Microbial, biological degradation (biodegradation) is a trending avenue of plastic recycling, however the majority of literature focuses on mesophilic strains which are often slow at biodegradation. To fill this gap, this research studies whether two wild-type thermophilic bacterial strains offer faster and more efficient plastic degradation, studied both at a whole-cell and enzymatic level. Two Anoxybacillus strains were isolated from Australia's Great Artesian Basin, the world's largest non-volcanic geothermal subsurface aquifer. This study identified both strains to be mesophilic thermophiles, thriving at 45˚C-50°C. In a whole-cell approach, cell density was found to be significantly elevated when cultivated in the presence of low-density polyethylene (LDPE) film, when compared to the controls. Despite the hydrophobic nature of LDPE, scanning electron microscopy revealed significant extracellular matrix formation and attachment to the plastic surface by 21 days. Fourier transform infrared spectroscopy also provided supporting evidence of biological residues covering the LDPE from 21 days. Furthermore, GC-FAME demonstrated several break-down products as early as 7 days when compared to the controls. Therefore, the cells were likely using LDPE as the major carbon and energy source. In an enzymatic approach, genome mining of select Anoxybacillus strains, as well as protein modelling, revealed an

esterase enzyme with structural similarity to a polyethylene terephthalate-degrading enzyme (a PETase). Further, in silico modelling revealed that the identified esterase was able to bind to polyethylene terephthalate with hydrogen bonding. Initial tests also demonstrated this enzyme works optimally at the elevated temperature of 45˚C. Continued research will test this enzyme on various plastics including PET. This research works towards an efficient, thermophilic biodegradation strategy to cycle plastic waste products back into the circular economy and steer towards a waste-free world.

VPA-019

MAGNETIC MICROPARTICLE AND RAMAN-BASED ASSAY FOR HIGHLY SENSITIVE VIRUS NUCLEIC ACID TARGET DETECTION WITH ATTOMOLAR SENSITIVITY

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Highly sensitive assay for nucleic acid targets will be of great importance to cope with various diseases especially in recent. In the case of COVID-19, three different nucleic acid targets should be examined to confirm the infection, which indicates the importance of a reproducible and sensitive assay.
In this study, we compare the sensitive nucleic detection method using magnetic microparticles (MMPs) and two different optical signals such as fluorescence and surface-enhanced Raman scattering (SERS). Here we found MMP-based assay with SERS shows higher sensitivity and reproducibility for the nucleic acid targets designed for RNA dependent RNA polymerase gene (RdRp gene), envelope protein gene (E gene), and nucleocapsid protein gene (N gene) in COVID-19. The SERS-based detection with silver nanoparticles (AgNPs) reproducibly exhibited 1.0 fM sensitivity from the Raman analysis, which is 1000 times higher sensitivity compared with fluorescence-based assay. The sensitivity for the target could be further improved up to 10 aM by utilizing anisotropic silver nanostructures (i.e., silver nanostar, silver triangular plate). The MMP and Raman-based assay envision the strong capability of assay for future bioanalytical applications.

VPA-020

ASSESSMENT OF RESOURCE EFFICIENCY TOWARDS A CIRCULAR ECONOMY IN SOUTH KOREA

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In recent years, resource efficiency towards a circular society has been an important agenda around the world to conserve natural resource and respond to climate change. In this study, we examined policy framework of material cycle society over the last 20 years, conducted resource and material flow, and evaluated resource efficiency in South Korea. This study found that the resource productivity in 2018 increased up to 100% when compared with the productivity in 2000. It indicated that the relative decoupling between economic growth and material use over the period was oberved. It was noted that resource circularity has continually increased since 2000. Resource recycling, one of the critical components for resource efficiency, enabled significant savings of raw materials for manufacturing and production in industries. The resource recycling rate increased up to 250% between the period, while the landfilling rate decreased down to 38% in the period. However, the resource productivity (3.0 million USD/1000 ton) in 2016 was relatively low compared with those from the OECD G7 countries (average of 3.6 million USD/1000 ton). Waste minimization and prevention is still a challenging task due to the ever-increasing waste generation over time.

VPA-021

WASTE PET PLASTIC BOTTLE-DERIVED METAL-ORGANIC FRAMEWORKS FOR ARSENATE REMOVAL FROM WATER

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This work is a challenging endeavor to assess the removal of arsenate from aqueous solutions using metal-organic frameworks (MOFs) derived from polyethylene terephthalate (PET) waste bottles. We successfully synthesized three different kinds of MOF materials (Fe-MOF, Zr-MOF, and La-MOF). The as-synthesized MOFs were systematically characterized by various analytical techniques such as PXRD, FTIR, FE-SEM, BET, and XPS. The effect of contact time, initial pH, and competitive co-anions was investigated to determine the optimum adsorption condition. Arsenate adsorption followed Langmuir isotherm model and pseudo-second-order kinetic model. The maximum adsorption capacities of arsenate onto Fe-MOF, Zr-MOF, and La-MOF were 70.02 and 85.72, and 114.23 mg/g, respectively. The adsorption of arsenate on MOF materials was mainly governed by electrostatic, surface complexation, and ligand exchange reactions. The as-synthesized MOF materials showed an excellent adsorption capacity for the elimination of arsenate ions upto five cycles. In addition, the Fe-MOF, Zr-MOF, and La-MOF treated 176.1, 255.5, and 398.1 bed volumes of arsenate contaminated water, respectively, and consistently reduced the arsenate concentration from 500 µg/L to 10 µg/L. This study clearly demonstrated that the as-synthesized MOF materials from waste PET bottles can be an economically promising candidate for the successful elimination of arsenate from aqueous solutions.

VPA-022

A REVIEW ON ALUMINA RECOVERY FROM BAUXITE RESIDUE (RED MUD)

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The demand for aluminum metal has increased with modernization of our society. This resulted in generation of larger amounts of bauxite residue. Bauxite residue typically contains 15-25% of alumina depending on the origin of aluminum ore and process conditions. Along with alumina, iron, titanium and rare earths are also present in the residue in considerable levels. There is still no large scale utilization of the bauxite residue. Direct recovery of iron by reduction smelting process is not economical as the co-existing alumina hinders efficient separation of metal phase from the formed slag. Direct acid leaching of the residue for recovery of titanium and other valuable metals may not be economical as well due to large amounts of acid consumption and the need for more processing steps for solution purification. One of the most promising options is the alumina recovery followed by iron removal via smelting and lastly leaching of the slag for the recovery of titanium and other valuable metals. The main focus of this paper is to give an overview on the processes developed for aluminum recovery from bauxite residues. These process are, namely, a second Bayer process, Pederson process, soda and soda-lime sintering, reduction alkali roasting, smelting and acid leaching, and calcification and carbonation processes. Alumina recovery is enhanced by increasing the temperature and alkali concentration of the Bayer Process. However, handling large amounts of caustic liquid is not easy because of corrosion of the equipment. Alumina recovery in alkali roasting process is sufficiently high but also energy-intensive. By using a reductant in the alkali roasting process, the energy consumption decreases and also iron separates more effectively from the roasted mass. In calcification and carbonation process, the soda level also becomes low after alumina removal and the processed residue can be used in cement production as well.

VPA-023

KEEP MANURE FRESH, GET MORE!

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The increase in the demand for animal products has been driving the significant production of livestock manure (LM). Due to its high nutrients content, LM is a useful substance for crop growth and biogas production, while the serious environmental problems can be caused unless well managed. In most countries, LM mandatorily requires the storage period for 1-6 months before being transferred to the final treatment facility due to the capacity limitations of manure management system. During this period, a huge amount of greenhouse gases (GHGs) and odor are emitted from the consumption of organic nutrients in the LM by the indigenous microbial activity, which would cause reduced biogas generation and crop yields in the further treatment. In this study, first, we collected the data on the amount of GHGs emission depending on various parameters such as type of LM, temperature, storage tank structure, etc. Then, two main storage methods (acidification and cooling-down) were introduced with its advantage/disadvantages, and their effect not only on the reduced GHGs and odor emissions, but also on the increased biogas potential and crop yields were discussed in detail. In addition, economic and environmental assessment was made, whether adopting above storage methods are worthy or not. To our knowledge, this was the first review article addressing the importance of keeping freshness of manure during storage to save planet and gain money.

VPA-024

SUSTAINABLE BIOGEOCHEMICAL BEHAVIOR STUDY USING GEOMICROORGANISMS FROM ARSENIC CONTAMINATED MINE

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Sustainable monitoring and controlling arsenic contamination in geological environment using technologies for prediction and surveillance are within the discipline of environment/disaster prevention. Sustainable monitoring and controlling arsenic contamination use the same technologies as those used for predicting and reducing natural disasters. To treat problems at sites that damage to the ecological system from restored abandoned mines due to floods in the rainy season, existing technologies based on physical-restoration such as covering up seed with soil, containment, ex-situ washing, flushing, permeable reactive barriers, and so on have been used for geological environment physical control. To provide the same function for restoring damage geological environments with sustainable biogeochemical behaviour of arsenic, arsenic resistance system evaluation approach is needed. Pure culture of arsenic-resistant system are Agrobacterium tumefaciens strain EBC-SK1, Ochrobactrum xylanexedens strain EBC-SK2 and 4, Paenibacillus anthropic strain EBC-SK11 and SK12. In particular, sustainable biogeochemical control is needed as a tool for sustainable biogeochemical control functions and includes As-S-S-Cys structures of ArsB-permease, arsenite oxidase, As(III)-SH-binding group, transcription repressor, methyltransferase, organoarsenical permease, and anion stimulated ATPase. Assessment for arsenic resistant system, arsenic behaviour, and sustainable biogeochemical control by exploiting microorganisms can provide researchers with a new understanding of arsenic environmental hazards. Establishing molecular geochemistry analysis of arsenic behavior and prevention methods is contributing to biogeochemical cycling in the arsenic-contaminated mines. The importance of sustainable biogeochemical behaviour is coupling of biotransformation, arsenite oxidase, bio-leaching, and microbial vacuole storage might have profound evolutionary.

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VPA-025

CLOSING THE PHOSPHORUS LOOP THROUGH INTEGRATED STRUVITE CRYSTALLIZATION AND MICROALGAL CULTIVATION

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The alarming depletion of phosphorus (P) resources has triggered a rising need for the recycling and recovery of this non-renewable resource. Retrieval of P from nutrient-rich wastewaters such as urine in the form of struvite can be a sustainable solution for cessation of leak in the P cycle. This approach leads to a win–win strategy for both the environment and ecology and gained spotlight in the recent years due to advantages of slow-release fertilizer, low impurities and presence of all the major essential nutrients required by plants. However, in a real-time scenario only ~90-95% of P can be recovered due to variation in nutrient concentration, process conditions and crystal size. Hence, microalgal cultivation can be integrated along with struvite crystallization to enhance the phosphorus recovery. In this study, the supernatant collected after recovery of struvite was utilized as a nutrient medium for microalgal growth. It was found that almost 85-90% P and ammonium was recovered in the form of struvite crystals, at an alkaline pH, stirring rate of 100 rpm, storage period of 24 days and $MgCl_2.6H_2O$ addition in a 1:1 (Mg^{2+}:PO_4^{3-}) molar ratio. The physicochemical characteristics and nutrient concentrations of phosphate, ammonium, nitrate, calcium, potassium and sodium were estimated to test the suitability for growth of microalgal consortium containing Chlorella sp., Scenedesmus sp., Synechocystis sp., and Spirulina sp. The optimum urine concentration for microalgal cultivation was found to be 6.5%, which infers that the supernatant of struvite-recovered urine can be diluted twice for efficient growth. Agronomic value of struvite and microalgal biomass were tested using cation exchange capacity, nutrition profiling and elemental analysis revealed both the materials are suitable for utilization as fertilizer. The interplay between the resource recovery and wastewater management has made such interdisciplinary concept a prospect of vast importance and further explorations can thrust us ahead towards attaining a circular bioeconomy.

Keywords: Struvite ; Phosphorus loop; Human urine; Microalgae; Fertilizer; Circular bioeconomy

VPA-026

FEASIBILITY OF NON-THERMAL PLASMA GASIFICATION FOR A WASTE-TO-ENERGY POWER PLANT

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The feasibility of non-thermal plasma gasification of municipal solid waste (MSW) was investigated by modeling waste-to-energy power plants, such as an incineration power-plant cycle and integrated plasma gasification combined cycles (IPGCCs) with thermal plasma and non-thermal plasma gasification. Non-thermal plasma gasification is expected to improve the energy efficiency of IPGCC because it consumes less electric power than conventional thermal plasma gasification. Thus, the energy efficiency, sensitivity of energy efficiency, and exergy loss of the modeled cycles were investigated to confirm the feasibility of using non-thermal plasma gasification for IPGCC. The analysis of the energy efficiency of the modeled cycles delineated the operation conditions of non-thermal plasma gasification, in which the process can attain better energy efficiency than when thermal plasma gasification was adapted for IPGCC. The sensitivity analysis of the energy efficiency revealed that cold gas efficiency (CGE), which is the ratio of the heating value of the syngas to the heating value of MSW, is a more important variable than the power consumption of the plasma source for energy efficiency. The exergy analysis revealed that the largest total exergy loss occurred during plasma gasification, regardless of the type of plasma source. The total exergy loss of IPGCC with thermal plasma gasification could be reduced by adapting non-thermal plasma gasification if non-thermal plasma gasification achieves a CGE level similar to that of thermal plasma gasification. Therefore, along with a reduction in the power consumption of a plasma source, non-thermal plasma gasification should attain a similar CGE level of thermal plasma gasification to enhance the performance of IPGCC, and using non-thermal plasma gasification for IPGCC would become feasible.

VPA-027

ARE THEY ON THE SAME PAGE? EXPLORING KOREAN CLOTHING REVERSE LOGISTICS SYSTEM USING NATURAL LANGUAGE PROCESSING AND NETWORK ANALYSIS

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As the fashion industry has overly stimulated consumers to purchase and dispose of clothing products more frequently, clothing waste management is no longer a trivial issue. The purpose of this study is to explore Korean clothing reverse logistics, or the system of managing clothing waste, by analyzing the actual context of stakeholders in each stage of the system. Twelve stakeholders participated in the in-depth interviews. We utilized the transcribed textual data to conduct network analysis, and the similarities to construct networks were measured using GloVe, a co-occurrence-based NLP algorithm. Two networks were created: One showed the relativeness of context between stakeholders in general and another represented the co-occurrence of keywords with modularity clustering. The results are as follows. First, the first network started to divide into two sub-networks at a 93.7% similarity rate: One consisted of all remanufacturing stakeholders, another consisted of stakeholders involved in other stages, and the rest were isolated. The second network was composed of: one stakeholder each from collection stage, reuse stage, remanufacturing stage, and the government. The context of the first network mainly focused on producing products: they collected materials from stocks or donations which is relatively cleaner. On the other hand, the context of the second network concentrated on clothing waste management and its collection operation. Second, the co-occurrence keyword network represented two dense clusters and 19 small clusters. The keywords in the first cluster were related to the collection and reuse stages and the second cluster contained keywords related to sorting, remanufacturing, and recycling. In conclusion, both networks indicate to the particularly weak connection between the collection stage and the remanufacturing stage in clothing reverse logistics in South Korea. Also, it was apparent that, the actual remanufacturing operations of the stakeholders in the same stages of clothing reverse logistics may vary. Only one participant was producing products with genuine “used” clothing and paid more attention to the collection phase. Future studies are recommended to track the possible arrival of used clothes across the countries.

VIRTUAL POSTER PRESENTATIONS

VPA-028

UPCYCLING OF WASTE POLYETHYLENE TEREPHTHALATE PLASTIC BOTTLES INTO POROUS CARBONS FOR CO_2 CAPTURE

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The serious awareness of global warming urges the development of technologies to reduce the emission of greenhouse gases that cause the global warming issues. Therefore, removing greenhouse gases became an important concern for environmental problems and various technologies such as absorption, adsorption, and membrane separation have been considered greenhouse gas capture technologies. Among various greenhouse gas capture technologies, adsorption has advantages of easy regeneration and low energy consumption without producing unfavorable by-products or any polluted sorbent. For adsorption, appropriate adsorbents are most important and porous carbons are attractive because of advantages such as cost-effectiveness, chemical and mechanical stabilities, and tunable pore structures. In this study, waste polyethylene terephthalate (PET) plastic bottles were used to prepare value-added and cost-effective porous carbons. PET plastic bottles were carbonized and activated to develop porous carbons, and their CO_2 (major greenhouse gas) adsorption behaviors were investigated from both equilibrium and kinetic perspectives. Varying the activation temperature had a dramatic effect on the textual properties of the prepared carbons. The CO_2 adsorption on the PET-derived porous carbons was also mainly related to the pore volumes of narrow micropores. The PET-derived porous carbons not only exhibited high CO_2 uptake, but also good selectivity, simple regeneration, excellent cyclic stability, and rapid adsorption-desorption kinetics. The development of porous carbons from waste PET plastic bottles can provide cost-effective and promising CO_2 adsorbents, and can also alleviate environmental issues caused by PET plastic waste.

VPA-029

GREENER CHEMICAL REACTIONS ENABLED BY DOMAIN KNOWLEDGE INTEGRATED MACHING LEARNING

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Greener organic synthesis is one of the crucial building blocks for a sustainable future. It enables clean energy technologies, efficient waste valorization, and many fundamental domains towards climate neutrality. Various machine learning models were built for forward planning synthesis that predicts the products from reactants and reagents. Despite the high accuracy of these methods on available reaction datasets (e.g., USPTO and Reaxys), the limited chemical space that could be explored, as well as the false positive issue, hinder the wide applications of the developed methods. In this study, a framework for predicting the validity of chemical reactions is proposed that possesses knowledge of a larger chemical space and also has the ability to reduce false-positive reactions. Various balanced classification datasets with different focuses can be constructed, by taking advantage of pre-trained models that utilize different domain knowledge (e.g., molecule datasets with larger chemical space and reaction type classification focused datasets) to produce negative reaction entries. A committee of classifiers is constructed by training classifiers on different classification datasets. This developed committee of classifiers can evaluate the validity of a reaction entry generated from the forward reaction prediction models from different perspectives and reduce the false-positive rates, especially in exploration tasks. We expect such a versatile framework could contribute to the green chemistry community by finding more sustainable reaction routines in an extremely low-carbon way (i.e., no need to carry out millions of reactions in the wet lab, but to virtually screen them all in silico) for various applications.

VPA-030

BIO-SOLID FUEL PRODUCTION FROM ORGANIC SOLID WASTE USING FRY-DRYING AND TORREFACTION

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The disposal of organic solid waste (OSW) such as livestock manure, sewage sludge, food waste, and industrial organic waste is a serious concern to society and the environment[1]. With stringent sludge disposal regulations, OSW is reused as a viable resource of energy via thermal technologies[2]. Thermal drying, or the removal of moisture through evaporation, is an important process in the disposal of OSW to recover a carbon-neutral energy and to achieve sustainable development[3].

In this study, a fry-drying and torrefaction (FDT) plant produced 10 t/d bio-solid (BS) from 45 t/d of OSW containing 80 wt% water. The plant included eight areas[3]: 1) OSW-oil mixing, 2) multi-effect evaporation, 3) vapor condensation, 4) water-oil separation, 5) torrefaction and pelletizing of BS, 6) steam boiler combusted by 67% of BS produced in this plant, 7) N_2 generation by pressure swing adsorption (PSA), and 8) waste-water treatment areas. The total capital investment (TCI), total production cost (TPC), return on investment (ROI) and payback period (PBP) were evaluated to identify economic feasibility of the FDT plant. A sensitivity analysis was conducted to determine the major factors influencing ROI. The TCI, TPC, ROI and PBP in a year of 2015 were $3.6 million, $1.3 million/y, 6.0 %/y and 9.8 y, respectively[2].

In Korea in 2019, 3.7 million t/y of OSW were produced and one third were disposed without treatment. When the untreated OSW is converted to BS, 100 MWth can be generated and 0.2 million t-CO_2/y can be reduced replacing fossil fuel with BS produced from the FDT plant.

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VPA-031

DECISION ANALYSIS FRAMEWORK BASED ON GAME THEORY AND MCDM METHOD FOR SLUDGE MANAGEMENT

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Conflicting interests are common in the decision-making process for the sludge management due to different involved stakeholders in the same project. The interactions between different players can influence the outcome of each other as well as their strategy. A decision analysis framework based on game theory and multi-criteria decision making (MCDM) method was developed to solve such kind of decision-making problem and promote the sustainable development of sludge valorization management. A criteria system consisting of four dimensions and eleven criteria was constructed to address the sustainability performance of the investigated strategies. A novel individual and group fuzzy best-worst method (BWM) was applied to obtain the fuzzy weights determined by the stakeholders. A two-player game was proposed as the basis of this framework to find out the most suitable strategy among all the alternatives according to the sustainability index generated from the sustainability assessment results and corresponding weight of each criterion. A step of mutual agreement was utilized to help the stakeholders reach a consensus for their final consistent strategy on sludge management. A case study was conducted which investigated the game between sludge treatment facility (STF) and the government considering four different sludge valorization technologies, including incineration for power generation followed by landfill (S1), incineration for power generation followed by cement production (S2), biogas from sludge digestion for electricity generation by fuel cells (S3) and biogas from sludge digestion for electricity generation by combustion (S4). Results showed that S3 can provide acceptable sustainability index for both players through compromise due to the emphasis on environmental aspect and the impressive performance on this aspect. Sensitivity analysis was also carried out to study the influence of weighting variations on the final strategy selection. The results indicated the feasibility and robustness of the proposed methodology framework for sludge management and similar type of decision-making problems.
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Keywords : Sludge-to-energy technology, Game Theory, Multi-criteria Decision Making, Sustainability Assessment, Fuzzy best-worst method.

VPA-032

AIR STRIPPING SYSTEM USING WATER SPRAY REACTOR FOR AMMONIA REMOVAL AND RECOVERY

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Air stripping technique is one of promising means to remove water pollutants such as ammonia. In this study, we evaluated the performance of water spray reactor to remove ammonia via air stripping process and its recovery process. We developed water spray reactor by putting eight flat spray nozzles horizontally inside a cylinder shaped reactor made from clear acrylic material with the dimension of inner diameter around 20 cm and 50 cm height. Two ports were placed at the upper part of the reactor. One functioned as the air inlet and the other one in the middle served as a gas suction port. The latter was joint in parallel with acid tank for ammonia recovery. Feed water was pumped into the reactor via eight clear vinyl tubes connecting each nozzle by the bottom part. Air blower was installed to enable stripping of ammonia from liquid phase. The result showed that water flow of 10 L/min and air flow at 120 L/min yielded higher mass transfer coefficient ($KLa = 0.0114\ min^{-1}$) which was proportionally associated with higher ammonia removal efficiency (%). We also noticed that nozzle with orifice diameter of 2.4 mm affected on higher removal efficiency compared those of 1.6 and 3.6 mm nozzles. The dynamics of temperature and pH during the experiments were observed. Initial water temperature was set to ~28oC and the temperature gradually increased until the end of the run (~55°C). No additional heating nor heat adjustment was applied. Alkaline pH was favored by adding NaOH 1 mol/L into the feed water prior to running so that pH was approximately ~11. pH steadily declined to reaching pH~10 after 7-hour run. Air consumption of our reactor was 0.08 (s^{-1}) with the total volume of feed water of 25 L and air flow rate at 2 L/s. Interestingly, other air stripping devices consumed slightly higher air consumptions. Packed tower had 0.42 (s^{-1}) and water-sparged aerocyclone reactor required 0.19 (s^{-1}). Future application of water spray reactor may include simultaneous air stripping technique for natural zeolite regeneration.

VPA-033

THE LOOMING PROBLEM OF WIND TURBINE BLADE WASTE IN CHINA: EXPLORING OPTIONS FOR RECYCLING BLADE WASTE

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Renewable energy sources are expected to account for two-thirds of the global energy supply by 2050, increasing from around 15% share in 2015. The installed capacity of wind power reached 651GW in 2019, supplying about 6% of the global electricity demand, and is expected to rise to 4,000GW by 2050 - seven times the present level. China has the largest wind power capacity of any country, making up 37% of the total global installed capacity. As a result, the generation of composite blade waste from manufacturing and retired wind turbines is increasing rapidly. In this paper, we quantify the amount of waste generated from three phases, manufacturing (MAN), operation & maintenance (O&M), and end of life (EOL), on the national, regional and provincial scales until 2050 in China, based on field surveys and robust modelling for the years 1989 to 2018. The environmental and cost impacts of waste treatment options of blade wastes are for the first time evaluated using a bottom-up approach, including conventional treatment routes (landfill, incineration) and current recycling technologies. Based on current installations and future projections, approximately 7.7 to 23.1 Mt (million tonnes) of wind turbine blade waste is cumulatively generated in China from now until 2050 for different development scenarios. At present, various technologies exist to recycle glass fibre waste from wind turbine blades, but these solutions are at different levels of maturity and are not always commercially available, cost-competitive, and environmentally sustainable. Mechanical recycling, an existing technology (TRL 7-8), (with landfill or incineration of residual materials) achieves the lowest greenhouse gas emissions impact (a cumulative reduction of 7.5 to 9.4 MtCO2eq (million tonnes of CO2eq), relative to 1.4 MtCO2eq from landfill by 2050) and the lowest cumulative cost impacts (a return of $3.4 billion to $3.9 billion) compared to a cost of $1.3 billion if disposed in landfill. The results will serve a significant role in informing the decision-makers in planning wind power development and waste management strategies to face the wind turbine blade waste tide.

VPA-034

ECUADORIAN SYSTEM OF INTEGRAL MANAGEMENT FOR USED TIRES (NFU) SEGINUS

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Currently in Ecuador, around 5 million tires are consumed and discarded annually, due to this, the national authorities decided to create environmental regulations that allow for proper use of end-of-life tires, thus preventing the contamination of all types of ecosystems.
SEGINUS is the first collective system for the comprehensive management of end-of-life tires in Latin America, it is a non-profit organization made up of all the actors in the tire marketing chain, that articulate the recycling management of NFU (end of life tires)
nationwide in harmony with the environment. We are made up of 52 tire importers and the local producer from Ecuador, who represent 80% of the tire market, has the collaboration of 25 companies that are dedicated to recycling management and business. As a corporation, we use an algorithm that performs a combinatorial operation between the request and the type of treatment to reduce costs and times and integrates all the parties involved, through an Intelligent Platform for Sustainable Traceability (PITS). SEGINUS is certified under the ISO 9001: 2015 quality standard, which gives full confidence to our adhered members and strategic actors of the high-quality standards of the recycling management that is handled. Currently three Management Systems are being implemented, the ISO 14001 Environmental Management System, ISO 27001Information Security System and ISO 22301 Business Continuity Management System.
This recycling is carried out through different types of treatment, which include reducing the consumption of fossil fuels, recovering raw materials and handicrafts. The different uses that are carried out by that the corporation gives to used tires are pyrolysis, granules, cogeneration of energy and handicrafts. SEGINUS has recycled over 65% of imported tires annually for 3 years in a row, collecting in more than 3.500 generation points, with this it has managed to reduce 85.598 tons of CO_2, which is equivalent to 1.112 cars stop circulating for 1 year. Thanks to our management model and the participation of all members of the management chain, SEGINUS was selected from more than 1,000 projects worldwide, winning the Recircle Awards in the Best Business Innovation Award category, which makes us a model. benchmark of circular economy around the world. We have had the opportunity to present our model in countries such as Colombia, Mexico, Argentina, Chile, Peru and Costa Rica, in order to replicate this management in other types of waste.

VIRTUAL POSTER PRESENTATIONS

VPA-035

STABILIZATION ASSESSMENT OF MERCURY CONTAMINATED SOIL USINGS TARFISH

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There are about 2,600 abandoned mines in the Republic of Korea and about half of them are associated with serious heavy metal or toxic metalloid release problems. Transportation of heavy metals like mercury (Hg) into the plants at orchards located near abandoned mines is an example of this issue. High levels of mercury were observed in orchard soils that are in need of remediation. The stabilization process is one of the widely used techniques used to immobilize heavy metals in contaminated soil and waste. In this study, two types of starfish, [Asterias amurensis(ASF)] and [Asterina pectinifera(PSF)] were used as stabilizing agents to immobilize Hg in contaminated soil. A total dosage of less than 10 wt% of ASF and PSF was applied to the contaminated soil. A curing period of 28 days was investigated following the treatment. The effectiveness of the stabilization process was evaluated using 1N HCl extraction tests. Overall, the stabilization results indicated that a decrease in Hg leachability was observed with increased dosage of ASF and PSF. A reduction of more than 80% in Hg leachability was obtained with the 10 wt% ASF and PSF treatments. Moreover, the ASF treatment outperformed the PSF treatment. It was found that effective Hg immobilization was most probably associated with the sulfur content in the starfish. Scaning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDX) analyses identified an insoluble HgS compound which could be responsible for effective Hg immobilization.

VPA-036

A CHEMOMETRICS APPROACH TOWARDS IMPROVING PLASTIC WASTE SORTING

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The heterogeneity of plastic waste entering the recycling industry is one of the key contributions to low plastic recycling rate globally. Apart from the polymer resin types, quality factors like contamination and degradation also affect the recyclability of plastic waste. Developing a rapid inline sorting system to identify high quality recyclable plastic from other plastic waste would be a big step towards optimization of the plastic recycling industry. However, sorting of plastic waste still tends to be rely on manual processes to varying degrees in the recycling industry today.
Chemometrics, which involves the use of statistical and machine learning tools for the analysis of chemical data, has been proven as an effective technique for classifying common polymers. However, the effectiveness of chemometric techniques in dealing with heterogenous polymer samples that more closely resemble waste received at a recycling plant has not been explored. In this work, several deep learning neural network architectures built with Raman spectra were used to effectively separate three commonly recycled plastics – polyethylene (PE), polyethylene terephthalate (PET) and polypropylene (PP) from a mixed polymer dataset consisting of over 20 different polymers with an accuracy of 0.964. This work shows the potential of applying chemometrics for inline sorting of mixed polymer waste. Future work can be done to build models than can further quantify the quality of the plastic waste. This providers recyclers with the information needed to determine the best end-of-life treatment for each plastic waste.

VPA-037

LIFE CYCLE ASSESSMENT OF WASTEWATER TREATMENT - THE POSITION OF THE AFRICAN CONTINENT

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Life Cycle Assessment (LCA) has proved to be a veritable tool for sustainability studies. Wastewater Treatment (WWT) that hitherto reduces pollution and cleanses wastewater has been established to have various environmental impacts within its life cycle. A systematic overview of WWT using LCAs was carried out as an attempt to appraise the environmental impacts peculiar to WWT in Africa and highlight the technical and methodological features. The systematic review checklist of the Standardised Technique for Assessing and Reporting Reviews developed on the basis of the Preferred Reporting Items for Systematic reviews and Meta-Analyses statement protocol was used to ensure accuracy. Systematically crafted strings of keywords were used in databases to search for articles that address the theme of this review. More than 70% of the studies were done in South Africa and Egypt, while Africa's largest economy - Nigeria, has none. While LCA covers the life cycle of WWT from source to sink, the operational stage was the most reported. The nature of the feed solution treated ranged from raw river water, municipal wastewater to acid mine drains. The ReCiPe and CML were the most used Life Cycle Impact Assessment methods. Primary data on sludge characterisation were absent in most studies. Potable water was recovered in 25% of the studies, Soil conditioners 19%, Energy 25%, and others included salt and metals. Activated sludge process and ozonation were the unit processes with the highest impacts. Climate change was the most affected impact category, and electricity generation from fossil fuels was the major contributor to adverse environmental impacts. Economic costs were reported using mainly the CAPEX and OPEX approaches. Despite the small amount of WWT LCAs in Africa, there is a need for increased injection of renewable energy into the energy mix and an improved rate of material recovery to offset environmental impacts and financial costs.

Keywords : Africa, resource recovery, sustainability, wastewater treatment, environmental impact

VPA-038

ALL-ORGANIC SUSTAINABLE POLYMER NANOCOMPOSITES BY IN SITU PREPARATION STRATEGY FOR IMPROVED MECHANICAL PROPERTIES

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The demand for lightweight yet strong structural polymer materials is driving the development of inorganic nanocomposites. They generally consist of a polymer and at least one inorganic component such as carbon nanomaterials, glass fibers, and clays. Despite their enormous value, the use of hybrid nanocomposites poses serious environmental problems and is not recommended in modern sustainable industrial trends. Most nanocomposite waste is landfilled or incinerated. Also, they can exhibit high mechanical properties and develop new functions only if uniform dispersion of the filler in the matrix is achieved. However, in most cases, inorganic particles are poorly dispersed in the polymer matrix due to the weak interaction between the organic and inorganic materials. Alternatively, researchers may be inspired by all-organic nanocomposites in nature. Mineral-deficient load-bearing tissues in invertebrates are attracting attention as high-performance biomaterials because the proteinaceous matrix is fortified with cellulose or chitin as a natural nanofiber structural filler. From a viewpoint of material engineering, natural abundance, biodegradability, and biocompatibility standpoint, nanoscale cellulose and chitin are attractive sources of renewable and sustainable materials. Here, we report and discuss in situ polycondensation methods from natural nanofillers to achieve highly enhanced all-organic nanocomposites that are naturally inspired. Mechanical improvements in in situ prepared nanocomposites are mainly from physical and chemical interactions through polymeric grafting and hydrogen bonding. Also, the dispersion of nanofillers in monomeric state enhances above interfacial interactions with polymer matrix. This field strategy inspires comprehensive possibilities for the sustainable-plastics-industry.

VPA-039

TURNING WOOD DUST WASTE INTO SUBSTRATE SOIL BASE FOR ORGANIC OYSTER MUSHROOM FARMING IN GHANA

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Our study is to mitigate wood dust air pollution from a local sawmill and find a use for abundant sawdust of the Triplochiton scleroxylon known as African Whitewood from consumption of industrial wood products. Magin (2001) states that mitigating wood waste is the key to meet efficiency of primary wood utilization and reduce environmental impact in Africa (Magin, 2001). In Africa, wood waste contributes to severe environmental impacts and also leads to the rapid depletion of the country's resources which constitutes a major setback to sustainable management. Therefore, wood waste is a major driving force to most of the environmental impact in the timber sector of Ghana (Eshun et al., 2011). That African Whitewood sawdust is normally burned and produces thick smoke which causes serious air pollution and severe respiratory problems for local community members. Therefore, disposing of the sawdust has become another major challenge to the community. To mitigate this environmental issue, wood dust was utilized as the substrates can be used for growing organic oyster mushrooms farming. Mushrooms have higher protein content than any other vegetable product and contain a high concentration of essential vitamins and minerals and they can be grown on a variety of waste products including straw, sawdust, coconut coir, cotton waste and banana leaves (Eshun et al., 2011). In this project, we attempted to reuse wood waste/sawdust (1 ton) with 4kg of wheat bran and 20kg of Epsom salt to create soil for organic oyster mushroom farming. Only a small amount of land is required for mushroom cultivation and, when the system has been established, cultivation is relatively simple with techniques and equipment (Block, Tsao, & Han, 1958). We followed six steps including compositing the substrate, bagging, sterilizing, spawning/inoculation, spawning / incubation, cropping and harvesting. Our experiment with wooddust based soil supports maintaining appropriate temperature (65 - 70 F) for growing mushrooms with a normal production cycle (30 days) with ingredients/soil mixing for composting every 6-7 days in order to maintain pH and moisture levels. The purpose of composting was to aid in fungi and bacteria break down and convert the raw materials of the substrate into a more easily accessible nutrient for the growth of mushrooms. However, during the inoculation and spawning, we experienced difficulty to maintain the appropriate soil pH for mushrooms (6-7 pH) and moisture level (65-75%) so that incubation and cropping were not successful. In conclusion, we learned that it is necessary to measure pH and moisture of wood dust soil in order to maximize mushroom production. As a continuing investigation, we are developing microsensors with a raspberry pie to measure pH and moisture level to determine appropriate production steps (compositing the substrate, bagging, sterilizing, spawning / inoculation, spawning running / incubation, cropping and harvesting). This ling of research and development will contribute to making an ideal condition for fungi and bacteria to break down and convert the raw materials of the substrate.

VPA-040

VALORIZATION OF WHEY FOR PRODUCING SUSTAINABLE HYBRID AMYLOID FIBRILS BIOPLASTICS

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Whey is the primary by-product of dairy industries. Since only half of the whey produced is transformed into valuable products such as human or animal feed, the disposal of surplus whey represents a crucial issue for the dairy industries and causes environmental concerns due to the high biological oxygen demand by-product. On the other hand, plastics waste production is a universally challenging problem since its accumulation in the environment is causing devastating effects on the planet's ecosystem. Sustainable and green solutions are urgently needed, and this pairs with increasingly more vital regulations combined with improved ecological awareness. We propose a simple, scalable, water-based process to produce free-standing, transparent, and flexible bioplastics films by combining amyloid fibrils with biodegradable polymers as two main building blocks. Amyloid fibrils can be obtained through denaturation and self-assembly from a broad class of food proteins such as milk, soy, and egg. Whey is used here as a model protein since its valorization creates a valuable opportunity to produce sustainable, biodegradable, and environmentally friendly bioplastics perfectly integrated within a circular economy. Against this background, the sustainability superiority of these bioplastics over common plastics and bioplastic was highlighted via a detailed life cycle assessment, anticipating an essential role of this new class of bioplastics in mitigating the pressing plastics pollution challenge.

VPA-041

RECONSTRUCTING SOILS FROM WASTE: A PROTOCOL FOR IMPROVED SOIL SUSTAINABILITY AND CARBON OFF-SETTING

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Humanity's reliance on soils is difficult to understate; however, globally, soils are often the subject of neglect, mismanagement, exploitation and indifference. Modern agricultural practices, urbanization, contamination and climate change are some of the key factors driving losses of global soil stocks. In addition, human population growth and growing consumerism have resulted in higher levels of waste generation and increased disposal to landfill. The reconstruction of soils comprised of appropriate repurposed materials (e.g. displaced soils and aggregates, agricultural bi-products, dredgings, organic and carbon-rich materials) represents an opportunity to mitigate against some of the negative impacts of soil losses, whilst also reducing the burden on waste disposal systems and lessening the burden on valuable natural soil resources. New approaches are needed to reduce soil and aggregate displacement and to reuse soil-forming materials. In doing so, this represents an opportunity to create a circular economy, whereby displaced materials can be matched with appropriate receiver sites, and can add value to the displaced soils and aggregates through blending with materials that augment and enhance the properties and performance of the resultant soil composite. Such an approach can be tailored to increase carbon sequestration potential (e.g. stable carbon component addition), enhance textural and hydrological properties (e.g. sand or clay addition) and/or remediate (e.g. removal or reduction of contaminants). In order for such an approach to be effective, appropriate regulation and careful management of all materials throughout the process is required. We will present a protocol for the determination of key physical, chemical and biological characteristics of candidate materials and their carbon off-setting potential so that an appropriate receiver location and remediation strategy can be identified and accounted for through life cycle analysis during the construction planning stages.

VPA-042

OCCUPATIONAL EXPOSURE TO VOLATILE ORGANIC COMPOUNDS FOR DELIVERY PERSONS IN TWO-WHEELERS AT GHAZIABAD, INDIA.

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Ghaziabad is a city in the Indian state of Uttar Pradesh that was ranked the second most polluted city in the world in 2020. In the context of the increasing home delivery services, especially of food items, our study estimated the occupational exposure to Volatile Organic Compound (VOCs) by delivery persons in two-wheelers in the city of Ghaziabad. Sampling was carried out for VOCs in 12 different locations within 6 Km radius keeping Delhi Public School, Indrapuram as the center. The 6 Km radius includes many landmarks like the Delhi-Meerut expressway, Sahibabad industrial area, Indrapuram residential zone and Electronic City, Noida. Sampling was carried out using SKC low volume air sampler. Tenax TA was used as an adsorbent. At each location, the duration of sampling was 8 hours at a flow rate of 0.5 liters per minute. Analysis of VOCs was carried out using Gas Chromatography-Mass spectroscopy following USEPA TO-17 guidelines. Out of 54 compounds analyzed, the presence of 19 compounds was detected in the ambient air of Ghaziabad. The concentration of toluene was the highest with a mean of 82 ± 61 μg/m^3. The next highest concentration was for benzene with a mean of 19 ± 13 μg/m^3. The least concentration was observed for N-butyl benzene with a mean of 0.25 ± 0.14 μg/m^3. Among the detected compounds, benzene is a known human carcinogen. The detected possible human carcinogens included carbon tetrachloride, chloroform, dichloromethane, ethylbenzene, naphthalene, styrene, tetrachloroethylene and tetrachloroethene. Minimization of the exposure is possible only by sustainable air quality management techniques. This can be done by minimizing the major source of emission and shifting to green energy, transportation, infrastructure and cost-effective air quality systems. The most effective system will be incorporating citizen science, as awareness and participation of individual citizens are needed to minimize the exposure.

VPA-043

THE REUSE OF BEVERAGE PLASTIC BOTTLES FOR SUPPRESSING EVAPORATION FROM THE WATER SURFACE

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Freshwater scarcity and environmental pollution are two major challenges. Currently, plastic waste is generated at a rate of 400 Mt year^{-1}, of which the dominant portion is plastic packaging materials. However, only 14% of plastic packaging waste produced worldwide is recycled. Being a very slow degradable material (plastic bottles' half-lives is 58 years in the marine environment and requires 450 years to decompose in a landfill), the management of plastic packaging materials is a major problem, especially in developing countries. At the same time, water is a limited resource. Water loss by evaporative from the water surface is substantial; in arid and semi-arid regions up to 50% of reservoirs' capacity is lost by evaporation. Based on the fact that floating materials markedly suppress evaporation, this study investigates the potential reuse of plastic bottles for decreasing evaporation and emphasizing their impacts on the water environment by determining microalga growth. A two-month experiment (May-June 2019) in an outdoor setting (class A-pan) was conducted in northern Egypt. We evaluated the effect of partially water-filled bottles (W-PB) and air-filled bottles (A-PB) on evaporation rate, water temperature, and microalgae growth. In addition to the control (uncovered pans), the pans were covered by W-PB or A-PB, using three replicates. The results revealed that, compared with the control, W-PB and A-PB significantly ($P \leq 0.05$) decreased evaporation rate by 40 and 38%, respectively. During the mid-day, W-PB and A-PB increased the water temperature by 1.4 and 0.78° C, respectively. The presence of W-PB and A-PB decreased microalga dry-weight by 20.0 and 20.9%, respectively. Our results demonstrate that the reuse of plastic bottles could bring many benefits with respect to water scarcity and environmental pollution. Long-term studies at the scale of reservoirs, ponds, or dams, while considering the influence of plastic bottles on water quality are requested.

VPA-044

HOMEGARDENS: A SUSTAINABLE OPTION FOR ORGANIC WASTE MANAGEMENT IN ASSAM, INDIA

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According to the recent Guidelines issued by the United Nations Environment Programme (UNEP) and Global Environmental Strategies (IGES), the decentralised composting method which is often neglected in mainstream solid waste management strategies can play a vital role in organic waste management. This is especially important as organic waste forms a major portion of solid waste generated in Indian states. In Assam, of 1,432 MT/D solid waste generated, more than 60% is organic, at present, the state has one centralized 60 TPD waste to compost plant and three decentralized waste to compost plant. The proper source segregation is integral in designing the decentralised composting plants, however, even after several promotional schemes by the Indian government, the source segregation in Indian states remains gloomy e.g., only 368 of 943 wards perform the source segregation in Assam. Apart from strong administrative laws, systems that exhibit the benefit of source segregation at the more local level can be more successful. This is backed by studies on Knowledge Attitudes and Practices (KAP) principle and behavioural dynamics. Homegardens(HGs) which are an important land use/ land cover pattern in Assam can greatly come in handy in such situations. Traditionally HGs world over has been reported to be fed food and organic wastes generated at households. We propose the HGs should be promoted for the decentralised composting plant at the community level, it can provide a required motivation to the general public regarding waste segregation, as they see its benefits in a more personalised space. Apart from better management of waste, providing sustainability labels to the production of such garden-based composting systems can greatly enhance the income opportunities of the people maintaining it also. Such community composting strategies has been found to have the potential to provide $100/Mg benefit in the Chicago city. Similar feasibility studies in the case of India and especially in the context of Assam are severely lacking. Some NGOs like SAAHAS are trying to do it in residential complexes, however, full-scale policy and academic interest in this topic is severely missing. Also, these HGs based composting systems can contribute significantly to design future sustainable food systems involving more local food significantly reducing the carbon footprint of the food supply chain.

VPA-045

THE IMPACT OF THE CIRCULAR ECONOMY INITIATIVES ON MNCs TEXTILE FIRM'S PREFORMANCE

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The circular economy is gaining more and more attention. Sustainability and circular economy have become mainstreams tendencies in the textile industry. The success of these strategies depends on the perception of added value to customers and its price-effect for profitability. Most consumers value positively sustainable behaviour, but it does not necessarily become on its behaviour as customers. At the moment, the textile sector needs to educate customers with clear communication about their initiatives in these fields. We classified the initiatives based on the enablers and the innovations in six categories: materials, design, production and distribution, use, end of life, and merchandising. This framework has an inner-industry approach, which explains the flows for reuse, recycling, and recovery of the textiles, from the raw materials to the final user. However, that has been completed with a wider environmental view about microfibers and microplastics, labelling and certifications, cases of success in commercialization and customer communication, and recent innovations in technologies. These adaptations are changing the companies' business models introducing targets, systems, and innovations to reduce, reuse, share, redistribute, repair, redesign, upcycle, repurpose, and recycle. Since multinational corporations (MNCs) are driving-force companies for the whole sector our aim is to analyze the implementation of the different circular economy initiatives that MNCs have been implemented and are communicating in the world textile and apparel industry. Our research contributes in two ways; first, we review and propose a comprehensive taxonomy to identify the initiatives, prompting a full view of the circular-economy landscape; second, we connect the initiatives with the financial situation of the companies and their performance.

VPA-046

THE DEVELOPMENT OF A SOLID WASTE SAFETY PLAN : CASE STUDIES FROM SERBIA AND GHANA.

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Inadequate Solid Waste Management (SWM) can cause environmental contamination and health risks. Unfortunately, in some cases, especially in developing countries, solid waste is not adequately managed and related contaminants can both affect human population surrounding the involved areas and waste workers. Consequently, it is crucial to focus on the exposure assessment in reducing the health risks related to solid waste management, developing a site-specific methodology. Safety plans have been developed and promoted by WHO in the last two decades; however, they aimed to reduce risks associated with drinking water (Water Safety Plan), wastewater and sludge management (Sanitation Safety Planning). In the field of solid waste, such a plan has not been fulfilled yet. This presentation will present the first proposal of the Municipal Solid Waste Safety Plan (MSWSP). Case studies using the MSWSP from two very different contexts were evaluated, including an urban center in Serbia and nine rural villages in Ghana, highlighting the versatility of the MSWSP.The proposed MSWSP starts with a health risk assessment matrix that grades the level of risk of various SWM hazards related to leachate, waste combustion, free movement of people and animals around the waste site, and spread of contaminants to the surrounding environment through different pathways. Then, control measures are proposed to mitigate the highest identified risks. The main novelty with respect to the previous safety plans used for water and sanitation consists of cost analysis to include an order of magnitude of the economic needs considering the concept of appropriate technologies. This MSWSP can be used to as a low-cost and effective way to assess relative health risks associated with different exposure pathways to develop targeted recommendations.

VPA-047

STOICHIO METRIC CARBOCATALYSIS ON SULFUR DOPED BIOCHAR: INTERFACIAL $^1O_2$ GENERATED THROUGH EPOXIDE-LIKE C–S–O CONFIGURATION

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Heteroatom doping is regarded promising in biochar development to further reform its nanostructure and carbocatalysis for environmental remediation. However, customized production of electroactive heteroatom doped biochars, e.g., sulfur doped biochar, has been immensely hindered due to complex nonstoichiometric biomass-derived carbon and unpredictable electrochemical state of dopants. Herein, we rationally produced a series of platform wood-derived biochar with customized levels of minerals and redox-active moieties, aiming to unravel the critical factors determining sulfur doping. Calcium (Ca) was found to preferentially coordinate with sulfur to form inactive inorganic sulfur minerals (i.e., $CaSO_4$ and CaS) with impeded catalytic reactivity. After diminishing the inherent Ca minerals beforehand, surface phenoxyl-type radicals (C–O˙) and vacancy defects promoted the formation of an electrophilic C–S–O bonding which guaranteed a high affinity towards peroxymonosulfate (PMS, 2.08 mM g^{-1}) and an enhanced removal of bisphenol A (BPA, 91.1%, 30 min). Scavenging experiments and in-situ Raman analyses indicated that the epoxide-like C–S–O configuration induced the nucleophilic addition of PMS to generate singlet oxygen ($^1O_2$, major product) and hydroxyl radicals (˙OH, minor product) fundamentally through a preservative and stoichiometric interfacial reaction. Overall, this study hurdles the major roadblocks in the science-informed fabrication of sulfur doped biochar and potentially advances its development in niche environmental remediation.

VPA-048

REASSEMBLY OF COAL FLY ASH DERIVED ANALCIME INTO SSZ-13 ZEOLITE VIA INTERZEOLITE CONVERSION FOR NH_3-SCR OF NO

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The synthesis of zeolite via a green route with low cost is necessary for its large-scale application in the chemical industry, pharmacy, and environmental protection. Coal fly ash (CFA), which generally exists as a waste, is a good candidate for synthesizing zeolite for its high population of SiO2 and Al2O3. However, it has a stable micro-spherical structure with complicated composition and is unreactive solid during the synthesis of zeolite. The harmful heavy metals inside it also inhibit the purity and application of the products.Herein, we report a "hydrothermal activation-interzeolite conversion (IZC)" strategy to synthesizing pure SSZ-13, ZSM-5, and BETA zeolites with tunable Si/Al ratio using CFA derived analcite (ANA) as a parent zeolite. The resultant zeolites have regular morphology with low contents of heavy metals below 0.001%. The other impurities (such as iron oxide) can be removed by leaching using diluted HCl (0.1 M). The crystal size and Al placement of the SSZ-13 can be tuned by pH values of the hydrothermal solution and adding seeds. The synthesized Cu-SSZ-13 has high NH3-SCR performance and hydrothermal stability that is comparable to commercial Cu-SSZ-13 zeolite catalyst. The seeds can enhance the decomposition of initial ANA and nucleation of the resultant zeolites. The nucleation and growth of the final zeolites are much faster than that synthesized by the routine hydrothermal synthesis method using gel precursors. The reassembly and evolution of the zeolites during the IZC process follow the solution-mediated transport and crystallization by particle attachment mechanism. The Na+ and OH- ions can migrate onto the surface of the ANA microsphere and trigger its decomposition. The Na+ and Al species induce the formation of primary building units that "copy" the structure of the fragments of seed crystals. The seeds and structure-directing agent collectively boost nucleation and growth. This strategy enables the green and economical route toward preparing pure zeolites with a flexible framework structure and Al placement. It also benefits to discriminating the IZC mechanism.

VPA-049

A NOVEL PROCESS COMBINED MICROPLASTICS SEPARATION AND SUBSEQUENT CARBONIZATION FOR SYNTHESIS OF IRON/CARBON NANOCOMPOSITE AS HETEROGENEOUS CATALYST

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Microplastics (MPs), as emerging contaminants, have gained increasing global attention due to their wide distribution and serious threats. Physical techniques are effective for separating MPs from water environment such as wastewater treatment plants, but the disposal of the separated MPs becomes an emerging problem. A novel strategy of MPs separation and subsequent sustainable disposal is proposed. MPs separation from simulant wastewater was effectively obtained via iron coagulation. Conversion of the coagulated material into carbon material was conducted by facile carbonization. The formation of magnetic carbon/iron nanocomposite was verified by various characterization methods. Carbon/iron nanocomposite was used as heterogeneous catalyst for evaluating the potential degradation of persistent pollutants. The effects of H2O2, pH, and temperature on degradation of target rhodamine B (RhB) were investigated associated with the removal efficiency and kinetic analysis. Under proper conditions, RhB removal of 97.57% was obtained at 20 min. Quenching tests and electron spin resonance spectra verified the dominant role of •OH radical in RhB degradation. Conversion of MPs into effective catalyst for wastewater treatment offers a sustainable strategy for MPs disposal, guided by the “waste treating waste” concept.

VPA-050

APPLICATION OF MAGNETIC BIOCHAR/QUATERNARY PHOSPHONIUM SALT TO COMBAT THE ANTIBIOTIC RESISTOME IN AQUATIC RESISTOME IN AQUATIC ENVIRONMENTS

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The emergence of antibiotic resistance genes (ARGs) has been a multifaceted problem that threatens human and animal health, the global economy, and national and global security. To address this issue, a newly synthesized biochar-based polymer - magnetic biochar/quaternary phosphonium salt (MBQ) - was developed using precipitation of iron oxide on biochar followed by ion exchange with quaternary phosphonium salt (QPS). MBQ was an effective antimicrobial agent against pathogenic bacteria where the dosage of 20 mg/L was enough to completely kill both the Escherichia coli and Staphylococcus aureus. In addition, magnetic biochar modified by quaternary phosphonium salt enhanced the adsorption capacity of extracellular DNA to approximately 9 folds, compared to that of the unmodified. The synergetic antibacterial activity of MBQ was attributed to MBQ nanoparticles penetration, induced oxidative stress and characteristics of QPS as a germicidal agent on the integrity and permeability of cell membrane. Due to the synergistic effect of oxidative damage arising from the formation of •OH, the intercalation of MBQ colloid, and the interaction with released cationic QPS, DNA molecules experienced cleavage and conformational transitions, which facilitated their electrostatic adsorption and deactivation of ARGs. Furthermore, ARGs and mobile genetic elements in water were removed at an efficiency exceeding 92.7%, confirming the excellent performance of MBQ in purifying ARG-contaminated water. From an application perspective, MBQ, as a versatile antibacterial agent and adsorption material, can be a promising candidate in ARG decontamination from aqueous solutions.

Keywords : magnetic biochar; quaternary phosphonium salt; antibiotic resistance genes; antibacterial activity; adsorption

VPA-051

HOLLOW MICRO-NANO REACTOR CONSTRUCTED BY COAL TAR TOWARD ENHANCED ADSORPTION OF CO_2

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Coal tar is a kind of by-product during the gasification, liquefaction, and low-temperature dry distillation, which is composed of aromatic compounds with abundant oxygen and nitrogen functional groups. Thus, it is a promising approach that using coal tar as potential carbon precursors for functional carbon materials for catalysis, adsorption, and separation. Herein, we synthesized porous carbon microspheres as a micro-nano reactor for adsorbing CO_2 using phenotype model compound (phenol resorcinol α-naphthol and 3-aminophenol) and coal tar with distillate at the boiling point of 170-210 ºC as mixed carbon precursors. Compared with single precursors, the prepared carbon microspheres prepared with mixed phenotype model compound has more ordered structure, higher specific surface areas, and more vibration absorption peaks that belong to –OH and –CO, which enables higher CO_2 adsorption amounts. Hollow porous carbon microspheres can be constructed through KOH treatment. It shows increased adsorption performance of CO_2. This route can be successfully extended to coal tar. The prepared carbon microspheres using coal tar as sources have a uniform structure and a high CO_2 adsorption capacity of 4.64mmol/g at a relative pressure of 1.0 atm and 298 K. Which is higher than that prepared by model compounds. This work provides an unusual but facile strategy to fabricate carbon micro-nano reactor using coal tar as a source toward efficient reduction of CO_2 emission.

VPA-052

TURNING WASTE POLYTHYLENE TEREPHTHALATE (PET) WATER BOTTLES INTO VALUABLE ACTIVATED CARBON FOR HIGH-PREFORMANCE ELECTROCHEMICAL WATER DESLINATION

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In view of the growing water crisis and environmental challenges, there is an urgent demand for a sustainable strategy to address the aforementioned issues. In this study, activated carbon derived from waste polyethylene terephthalate (PET) water bottles was successfully developed through a chemical activation method for capacitive deionization (CDI). The activation temperature (700, 800, 900 and 1000oC) was investigated to be related to the surface area and pore structure of PET-derived activated carbons (PETAC). Note that fairly mesoporous activated carbons can be obtained by increasing the activation temperature. Herein, optimum activation temperature for PETAC was found to be 1000oC, namely PETAC-1000, exhibiting the highest BET surface area of 1448 m2/g and mesopore ratio of 41.3%. Based on the cyclic voltammetry, the PETAC-1000 has a high specific capacitance of 107.9 F/g in 1 M NaCl, suggesting great potential of capacitive charge storage. A single-pass CDI is conducted for electrochemical desalination of brackish water. As demonstrated, the PETAC-1000 electrode exhibits high-performance salt adsorption capacity. This can be attributed to the high conductivity, the large surface area and the presence of mesoporosity. This study provides a sustainable solution for simultaneously waste recycling and water desalination.

VPA-053

ADIPOSE-ON-A-CHIP: A PATHOLOGICAL ADIPOSE MODELING FOR ENDOTHELIAL CELL DYSFUNCTION IN OBESITY

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Obesity causes complex alterations in adipose tissue (AT), which include abnormal genetic regulations, polarization of macrophages, excessive accumulation of ECM and dysfunction of the secretion system. These changes in adipose tissue cause metabolic disorders, leading to or exacerbating various diseases such as diabetes, cardiovascular disease, and cancer. Although 2D cultured differentiated adipocytes have contributed in the understanding the physiology of adipose tissue in obesity, they do not recapitulate the complex and dynamic multicellular microenvironment in adipose tissue. Here, we introduce an adipose tissue-on-chip— a 3D adipose tissue construct composed of primary adipocytes embedded within the decellularized extracellular (dECM)-based hydrogel interfaced with microvessels in the microfluidic device. In order to mimic the obese adipose tissue, dECM scaffold was generated from the adipose tissue of obese mice showing distinctive features of ECM compositions in obesity. Primary adipocytes maintained their functions over a week without dedifferentiation and the endothelial cells co-cultured in the device showed higher expression of adhesion molecules (ICAM, VCAM and SELE) mimicking the recruitment of immune cells in obese adipose tissue. This adipose tissue on-a-chip provides a new approach for studying matrix-cell and cell-cell metabolic cross talk in obese adipose tissue in vitro.

VPA-054

RECYCLING OF DISPOSABLE BABY DIAPERS FOR ENHANCING THE GROWTH AND SURVIVAL OF EUCALYPTUS SEEDLINGS SUBJECTED TO DROUGHT

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The potential of afforestation in Egypt is high due to land availability. However, grounds intended for afforestation are light-textured soils, with low water holding capacity (WHC), consequently, a substantial portion of irrigation water is lost by percolation. At the same time, the management of disposable baby diapers (DBD) is a major problem, in particular in developing countries. In Egypt, about 42 million diapers are used daily. Such DBDs contain significant amounts (~30%) of super absorbent polymers (SAP), which can absorb and retain significant amounts of water. Therefore, the potential to reuse DBD for enhancing the soil WHC is great. The objective of this study was to address the potential of recycling DBD for enhancing the growth and survival of Eucalyptus saplings subjected to drought stress.
SAPs were recovered from the DBDs and mixed with soil sandy clay loam at three ratios, i.e., 0.0, 0.75 and 1.5 of SAP. Mixtures were moved to 30 L pots, using five replicates. Under greenhouse conditions, seedlings were cultivated and regularly irrigated till successful establishment, then drought stress was imposed by ceasing irrigation. Daily evapotranspiration and seedlings' growth and survival were measured. Moreover, some chemical soil parameters were determined.
The obtained results revealed that the reuse of DBD increased the survival of the seedlings, in which the seedlings survived (after ceasing irrigation) for 14, 17, and 23 days for 0.0, 0.75, and 1.5%, respectively. Furthermore, the recovered SAPs decreased the evapotranspiration by 21% for both 0.75 and 1.5% treatments. SAPs at 1.5% increased the total dry weight by 10.8%, while SAPs at 0.75% had no effect. The soil moisture at the seedlings' death (wilting points of Eucalyptus), was higher than the control, indicating that not all retained water by the SAPs was available for plant absorption. The chemical soil analysis showed higher Na content due to DBD reuse. In conclusion, the reuse of DBD for the afforestation of Eucalyptus saplings is recommended for its beneficial effect on soil WHC, seedlings growth, and survival under drought stress. However, further studies are required to investigate the effect of the reuse of DBD on soil quality in the long term.

VPA-055

SCIENCE-INFORMED DESIGN OF A SUSTAINABLE FE-BIOCHAR CATALYST FOR MICROWAVE- INDUCED CATALYTIC DEGRADATION OF REFRACTORY ORGANIC CONTAMINANTS

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Rational design of a powerful, sustainable iron biochar catalyst based on science-informed selection of its preparation conditions has become indispensable to promote commercialized application of the emerging microwave-assisted wastewater treatment method due to its high efficiency and low energy as well as chemical consumption. In this study, a series of Fe-biochar catalysts were prepared from waste oak wood via one-step pyrolysis at different temperatures (i.e., 800 and 900 °C) and various Fe loadings (i.e., 1, 5, 10, and 30 wt.%), and tested for their performances, mechanisms, recyclability, and regeneration in removal of a representative refractory organic contaminant, 2,4-dichlorophenoxy acetic acid (2,4-D), under mild (90 °C, 1 min) microwave irradiation. The Fe-biochars prepared at 900 °C presented higher efficiency of 2,4-D removal than those at 800 °C. For the 900 °C Fe-biochars, with the increase of Fe loading, the removal efficiency slightly increased and then drastically decreased, and the maximum value was 85.4% achieved by 5 wt.% of Fe loading. Whereas, for 800 °C Fe-biochars, 1 and 10 wt.% of Fe loading showed relatively higher removal efficiency (34.54 % and 59.91 %, respectively) compared to adjacent loading, while the pristine 800 °C biochar only removed 16.55 % of 2,4-D. Based on the results of the ethanol extraction experiment of reacted biochars, it was found the Fe loading affected the extractable removal by 900 °C biochars and non-extractable removal by 800 °C biochars, respectively. Besides, the most efficient Fe-biochars also showed the highest reusability with negligible Fe leaching, indicating the sustainability of these Fe-biochar catalysts. The formation of highly oxidative hydroxyl (•OH) and singlet oxygen ($^1O_2$) radicals was proved by the quenching test, suggesting the free radical mechanism. This study demonstrated a high-efficiency and environmentally-benign microwave-induced catalytic system for sustainable wastewater treatment.

Keywords : iron biochar composite; graphitic biochar; microwave; catalytic degradation; sustainable wastewater treatment.

VPA-056

THE ROLES OF BIOCHAR AS GREEN ADMIXTURE FOR STABILIZATION/SOLIDIFICATION OF MUNICIPAL SOLID WASTE INCINERATION FLY ASH

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Municipal solid waste incineration fly ash (MIFA) is categorized as a hazardous waste worldwide due to its high concentration of PTEs. This study investigates the role of rice husk biochar and yard waste biochar as green additives on the mechanical performance and stabilization/solidification (S/S) efficacy of cement based MIFA products. Experimental results show that the internal curing effect of biochar can improve cement hydration without changing the hydration process, resulting in higher amount of C-S-H and higher polymerization degree of C-S-H structure. Finally, the substitution of 10% cement by biochar in S/S treated MIFA samples can further enhanced immobilization efficiency of potentially toxic elements and achieved comparable compressive strength, compared with pure cement binder. 20% biochar cement binder exhibited excellent immobilization efficiencies for Pb and other PTEs, successfully fulfilling the compressive strength and leachability requirements for on-site reuse. Therefore, biochar-augmented cement system could be a novel and low-carbon binder for the S/S of MIFA.

VPA-057

MICROPLASTICS CONTAMINATION OF HUMAN SALIVA FROM FACE MASKS

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Pandemic of COVID-19 is the biggest crisis of infectious diseases in the past decades. In this time, face masks are one of the fastest way to slow the spread of diseases by respiratory droplets. But, available Respiratory Protective Equipment (RPE) like respirators, surgical masks, or nano masks mostly contain polymer materials which could be released and inhaled. In this study we tested saliva samples from volunteers for the presence of plastic particles smaller than 5 mm, i.e. microplastics. Samples were self-sampled by volunteers twice a day by rinsing the oral cavity with drinking water. First sample was collected in the morning, when face mask had not been worn for 12 hours, and the second one after half a day when face mask was partly wearing. Samples were filtered using 1um glass fibre filters and microplastics particles were observed by stereomicroscopy. After that, suspected particles composition was determined using FT-IR method. The research is still ongoing, but the data obtained shown that all of the examined samples contain plastic particles smaller than 5 mm. These interim results show that face masks may be possible sources of microplastics contamination of human saliva. However, the effect of the human body has not been certainly proven yet and future research is required. This research may be useful for development of RPE without plastic material, which would eliminate this issue.

VIRTUAL POSTER PRESENTATIONS

VPA-058

BIODEGRADATION OF BIOPLASTICS BY MARINE PHOTOBACTERIUM sp.

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Plastic has become the most abundant part of marine debris, increasing severity of marine pollution. Bioplastic has emerged as a potential alternative for a sustainable marine environment. However, there are few studies on whether bioplastic can be biodegradable by marine microorganisms. Here, we found that PBAT (polybutylene adipate terephthalate), PBS (polybutylene succinate) and PLA (polylactic acid) — bio-degradable or bio-based plastics — are degraded by marine bacterial communities. Through metagenomic analysis, we found an increase in the relative abundance of Photobacterium sp. in the bacterial communities exposed to bioplastic. Further, we isolated Photobacterium sp. that potentially degrade bioplastics, PBS. and PBAT. As a future study, we will find proteins that degrade bioplastic using genomic analysis of isolated marine bacteria. Our results show that bioplastics can be biodegraded by marine microorganisms and are likely to shed light on the development and utilization of marine biological resources.

VPA-059

SELF-CHARGING MASK FILTER FABRICATION VIA MULTI-STACKED PVDF NANOFIBER MEMBRANE ON PA6 MESH SUBSTRATE FOR THE HIGH EFFICIENT PM0.3 FILTRATION

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A filter structure with multi-stacking layers of the PVDF nanofiber membrane-nylon mesh substrate is proposed to low pressure drop and high filtration efficiency of fine particulate matter (0.3PM). Along with the inherent piezoelectric property of the electrospun PVDF nanofiber, electrostatic charge density can be increased through filter bending by triboelectricity between nylon mesh substrates. The air gap between PVDF nanofiber membranes is retained by the nylon mesh substrate. This reduces air flow resistance and preserves electrostatic charges inside the multilayer filter even when continuously exposed to humid air. The superhydrophobic characteristics of PVDF nanofiber membrane assist to remove particulate matter clusters on the nanofiber surface through ethanol dipping after dust collection on a multilayer filter. After the regeneration process of electrostatic charges through the friction of the multilayer filter, the surface potential is restored again as before using the filter without physical damages to the membrane. Since this does not include additional chemical processes on the filter, there is a significant advantage to the stability of the use of facial mask filters. Based on excellent fine particulate matter filtration and regeneration (cleaning and recharging) characteristics, the multilayer filter is eco-friendly as it can be used several times.

VPA-060

INTRODUCTION ON THE ANALYTICAL TECHNIQUES FOR INTENTIONALLY ADDED MICROPLASTICS IN CONSUMER CHEMICAL PRODUCTS IN KOREA

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In recent times, both domestic and international regulations on the use of microplastics have become increasingly stringent and extensive, along with an increasing public awareness of the environmental threats posed by microplastics. In line with this trend, the recent enforcement of the “Chemical Product Safety Act” (2019) in South Korea has banned on the use of microplastics in various consumer chemical products in case of intentional microplastic uses in order to enhance products performance or other purposes, which products are cleaning agents, removers, laundry detergent, bleach, and fabric softeners. Concurrently, analytical methods have been developed for the analysis and quantitative detection of microplastics in the five product groups. The primary analytical methods are consisted with three steps that are sample pretreatment (solvent adequacy), filtration, and measurements (solid observation and solid composition). In the first step, some samples from a product were taken into 500 ml beaker in adequate solvents in order to eliminate hindering chemicals and additional washing with 50% ethanol and distilled water can be involved. The second step is the filtration that pretreated samples from the first step was filtered in the Anodisc (Al2O3, pore size of 0.1 μm) and additional washing can be involved with 50% ethanol and distilled water. The last third step is the measurement microplastic solids and their composition using SEM/EDS (Scanning Electron Microscope/Energy Dispersive X-ray Spectroscopy) and Micro-FTIR (Microscopy Fourier Trasnform Infrared Spectroscopy), respectively. The proposed analytical method is expected to facilitate follow-up monitoring management of products in which microplastic use has been banned in Korea market.

VPA-061

DISTRIBUTION OF MICROPLASTICS IN ORGANS RELATIVE TO THE BODY SIZE OF COMMON CARPS FROM THE HAN RIVER IN SOUTH KOREA

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Although not intended for microplastic (MP) analysis, the National Environmental Specimen Bank (NESB) has been collecting common carp muscle samples since 2012 to monitor the levels of persistent organic pollutants in carp tissues. Prior to the large-scale use of carp muscle samples available with the NESB for MP analysis, it is necessary to examine the characteristics of MP contamination in fish in vivo. First, it should be determined whether the quantity of microplastics (MPs) detected in the sample is correlated with the body size of the carp. Since the muscle samples were collected from carps of various sizes, it is necessary to interpret the results of MP analysis after confirming whether the size of the collected carp affects the detection quantity. Second, the detectability of MPs in carp muscle samples should be evaluated. This study reports a preliminary survey conducted prior to the use of carp tissue samples available with the NESB. Fifteen male carps collected (based on their individual body sizes) from the Han River were used in this study. Tissues were collected from the muscles, gills, and digestive tract. Our analysis revealed no statistically significant correlation between the sizes of carps and the quantity MPs (non-fiber) detected in the three types of biological samples. The carp samples stored at the NESB facility since 2012 were collected from carps of various body sizes in different years and from different sampling regions. In investigations of MP detection in carp samples, the size of individual fish can be considered unlikely to affect the quantity of MPs detected. We evaluated the characteristics of the MPs present in the muscle samples, and found that more than 70% of the detected MPs had a size less than 50 μm. In contrast, the MPs detected in most gill samples had sizes ranging from 20 to 100 μm, and those detected in the digestive tract samples had sizes ranged from 20 to 200 μm. In particular, in the muscle samples, MPs of size smaller than 20 μm were detected at more than 20%, whereas these were rarely detected in the gill and digestive tract samples. Reportedly, MPs with a size less than 150 μm may be absorbed into the body to some extent. The previous MP detection status can be indirectly confirmed in carp muscle samples under long-term storage at the NESB facility. However, additional discussions are required on the method of adjusting the final detected value by estimating the MP blank at the time of collection and treatment of carp samples collected previously.

VPA-062

EVALUATION OF SPATIO-TEMPORAL DYNAMICS OF MICROPLASTICS DEVELOPING A PROCESS-BASED ECO-HYDROLOGY MODEL IN JAPAN

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Contamination of the environment with plastic waste has received more attention from the public, scientists, and policy makers during the last few decades (Kooi et al., 2018). Though some of the models have succeeded to simulate the transport and fate of plastic debris in freshwater systems, it is hard to say that there is still a complete model to elucidate the whole picture of plastic dynamics in the basin scale. One of the authors has so far developed a process-based eco-hydrology model, NICE (National Integrated Catchment-based Eco-hydrology) (Nakayama and Watanabe, 2004), and applied it to various basins from local/regional to continental/global scales. NICE includes surface-groundwater interactions assimilating land surface processes, and can simulate iteratively nonlinear interactions between hydrologic, geomorphic, and ecological processes (water, heat, sediment, nutrient, and carbon cycles, etc.) (Nakayama, 2020). In this study, the authors extended the original NICE to couple with plastic debris (engineered materials) model for freshwater systems, and applied it to all the first-class river basins in entire Japan (109 river basins). The new model included the advection, dispersion, diffusion, settling, dissolution and deterioration due to light and temperature, but assumed no interaction with suspended matter (heteroaggregation), resuspension, biofouling, and effect of wind, etc. The authors also assumed microplastics as spherical particles with constant size and density for model simplification. NICE simulated how mismanaged plastic waste (MPW) of about 36,000 ton/yr in the entire country (Meijer et al., 2021) is transported from land to river, and finally to the ocean. The model showed the pathways of plastics from land into freshwater bodies, and that much of MPW is transported to the freshwater during rainfall seasons. Further, the model showed that only limited MPW discharged to land flows out into the ocean, similar to plastic loading estimates in the previous study (Nihei et al., 2020). These results help to quantify the impacts of plastic waste on terrestrial and aquatic ecosystems, and find solutions for preventing, recycling, and reuse with sustained use of biodegradable plastics.

VPA-063

THE CURRENT STATUS OF MICROPLASTICS IN THE BOTTLED DRINKING WATER

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Microplastics are ubiquitous across ecosystems, yet the exact state of the exposure to microplastic in our daily life is not clearly investigated. Among a variety of sources to plastic exposures in our daily life, we focused on the drinking water (mineral water) in the plastic bottles which can be purchased from South Korea domestic market. The amount and identity of organic matter in the solid residues obtained by freeze drying of drinking water in the plastic bottle were determined with analytical methods such as dry ashing, centrifugation, Raman analysis, and electron microscopy. The analysis showed the presence of significant amount of organic matter (16 - 152 mg/L) possibly originated from plastic bottle which mainly composed of polyethylene (PE) and small part of polyethylene terephthalate (PET). The amount and composition of solid residues was not changed when the drinking water filtered with 0.2 μm membrane filter before freeze drying. Once condensed organic matters are not soluble in water and its size are ranging from nano and micro scale. We found a series of stress such as light, heat, and mechanical stress to the plastic bottle was not significantly increase the organic substances from the plastic bottle within a month. The potential adverse effect of the organic matters on human health was evaluated with human intestinal Caco-2 cell line and separated organic matters, the results showed no significant toxic effect on the cell viability even in relatively high concentration of organic matters (1.0 mg/mL). The current study indicates the presence of organic matters in the drinking water and the amount is not rapidly increased even in harsh conditions. The organic matters itself expected to be not so harmful because of large size and slow degradation kinetics of polymers. However, the long-term monitoring for the accumulation of organic matters from drinking water are still required because of higher chances of uptake of nanoscale materials.

VPA-064

QUASI-3D PARTICLE TRACKING SIMULATIONS FOR ANALYSIS OF MICROPLASTIC BEHAVIORS IN OPEN CHANNEL FLOWS

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Microplastic (MP) is an environmental pollutant that has been found in bottled water and sea salt and is of concern for human health and water environment. Several researches related to field observations, physio-chemical analysis, and simulations for MPs in the ocean area have been actively reported around the world. The occurrence of MP is closely related to human activities, and river is the main source that transports man-made MP to the ocean. Therefore, for the control and management of MP flowing into the ocean environment, it is necessary to predict the behavior of MP in rivers. In this study, MicroPlastic Tracking in Quasi 3D (MPT-Q3D) model was developed to predict the behavior of MP in open channel flows. The behavior of individual MP particles is computed by the two computational steps, which are the horizontal translation and the vertical mixing steps according to the step-by-step computation algorithm. In the horizontal translation step, a MP particle transports by shear flows and turbulent diffusion. The vertical position of the transported MP is determined by the vertical turbulent diffusion, which shows the parabolic distribution in open channel flows, and the settling velocity according to properties of the MP. The MPT-Q3D was used to simulate transport of Polystyrene (density: 1.07 t/m^3) for flood season in the Han River, which is located in Seoul, Korea. In the study area, two tributaries, which are the Jungnang and Anyang streams, inflow to the Han River, and three islands are located. The simulation results show that MPs are mainly accumulated in left bank of the downstream of the Jungnang stream due to channel curvature. In downstream area, MPs transport along the right bank even though MPs added from the Anyang stream inflow from the left bank. In addition, in the vicinity of Bam Island, the number of MPs in a unit volume increases due to particle trapping caused by the dead zone, which may cause damage to aquatic creatures living in this area.

Acknowledgement
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VPA-065

PRELIMINARY ASSESSMENT OF ASPERGILLUS TERRUS AND ENGYODONTIUM ALBUM FOR THE DEGRADATION OF POLYPROPYLENE

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This research focuses on polypropylene (PP) as it is one of the highest synthetic polymers produced in 2015 of which 68 million tonnes were produced globally. Based on this overwhelming number, it was reported that only 1% of PP being recycled. Since the remaining 99% of PP ended up in landfills or being incinerated, severe environmental issues were raised, including the release of toxic PP additives such as cadmium and lead. To overcome this problem, several approaches utilising physical, chemical, and biological methods have been attempted. A physical method such as recycling was proven to be inefficient in terms of recycling percentage and sorting issues. The chemical method on the other hand will require structural changes of PP as it may be used to produce fuel or gas. This paves the way for the current study where a biological approach has been taken as an attempt to degrade PP in a much eco-friendly way, with low energy consumption and utilising naturally existing organisms. This report focuses on the utilisation of Aspergillus terreus (ATCC 20542) and Engyodontium album (BRIP 61534 a) as PP degrader. PP used in this study were in the form of granule (GPP), film (FPP) and metallised film (MFPP). These PP samples were pre-treated by UV (254 nm wavelength) for 24 hours, heat (200 °C) for 15 minutes and Fenton's reagent for 7 days before incubation with the aforementioned fungi species. After 30 days of incubation, highest gravimetric weight loss was observed for heat-treated MFPP incubated with E. album (37.68%), followed by heat-treated MFPP in A. terreus (21.07%) while the lowest weight loss percentage was observed for Fenton-treated FPP incubated in E. album (0.29%) and Fenton-treated MFPP incubated in A. terreus (0.31%). The gravimetric weight loss perceived were comparable with the biomass produced by these fungi and the analysed reduction rate. Relatively high biomass production was obtained for heat-treated MFPP in A. terreus (1.07 mg/ml) and 0.52 mg/ml for heat-treated MFPP in E. album. The amount of biomass produced by A. terreus and the reduction rate were correlated with gravimetric weight loss (0.73 and 0.99 respectively) while E. album showed the correlation coefficient of 0.52 and 0.99 between gravimetric weight loss with biomass production and reduction rate. The PP samples biodegradation was further validated using Fourier transform infrared (FTIR), thermogravimetric analyser (TGA) and scanning electron microscopy (SEM). These tests revealed the structural and morphological changes of PP samples with fungi treatment. Hence, demonstrated that A. terreus and E. album can grow, change, and utilise PP samples as carbon source with the aid of pre-treatments strategies employed. Consequently, synergistic effects of pre-treatments combined with the utilised fungi species could lead to an ideal polymer waste reduction and disposal strategy in the future.

Keywords : Polypropylene, biodegradation, fungi, Aspergillus terreus, Engyodontium album, pre-treatments

VIRTUAL POSTER PRESENTATIONS

VPA-066

FORENSIC SITE INVESTIGATION FRAMEWORK FOR MARINE MICROPLASTICS

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Microplastics are derived mainly from the mismanaged plastic waste. A major portion of the microplastic generated in the terrestrial environment reaches the marine environment. Microplastics also get formed in the marine environment through the degradation of macroplastic reaching this environment. Although INTERPOL recognizes marine pollution as crime, the "Pollution Crime Forensic Investigation Manual" of INTERPOL does not include the strategies for the investigation of microplastics pollution. Our study was aimed at developing a forensic site investigation framework for marine microplastics. The investigation steps start with determining the type of contamination and ends with determining the source of contamination. The intermediate steps consist of defining a sampling plan, determining the scale of contamination, and analyzing the contamination. The experience gained from the investigations carried out at 37 major beaches laying on the Kerala coastline was used in the development of the framework. Each step was carefully designed to fulfil successful environmental prosecutions ensuring that the techniques adopted and the evidence collected are suitable for presentation in a court of law. Linking the background information and the site details collected during the site investigation with the results of laboratory analysis was seen to help the source apportionment of marine microplastics.

VPA-067

MICROPLASTIC CONTAMINATION IN A STORMWATER DRAIN : CASE STUDY OF DELHI

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Microplastics (MPs) are globally emerging as contaminants of concern in virtually every part of our environment. Due to the ongoing trend of mismanaged plastic wastes in urban cities, MP leakages occur in the nearby canals, drains, streams, or rivers. Delhi is a megacity in Northern India and has an extensive network of drainage system. Najafgarh drain is one of the crucial drains in this system that connects wastewater flows of this city to Yamuna River. Unregulated discharges of wastewater from residential, industrial, and agricultural areas, and large quantities of plastic debris on drains' bank, are the crucial MP sources in this drain and eventually Yamuna River. The present study has been undertaken to critically analyze the extent of this problem in the city. Surface water samples were collected from the drain and river during May 2019 (pre monsoon season) for assessment of MP pollution. MP abundance was found to be gradually increasing in the drain stretch starting from its entry point in Delhi till its final outfall in Wazirabad, indicating the influence of anthropogenic stressors in this drain. The abundance of MP particles in Najafgarh drain occurred in the range of 300-2900 items per m^3. White color, fragmented shape, and polyethylene polymer were the predominant type of MPs detected in the study area. Further, Yamuna River was also found to be contaminated with MPs and interestingly few of the MPs found in the river resembled to those found in the drain, indicating that Najafgarh drain might be acting as an important MP point source for this river. The present study, hence, highlights the importance of investigating MPs in interconnected systems so that necessary actions could be undertaken by the concerned stakeholders for effective management of this problem.
Keywords: Microplastics, Najafgarh drain, Yamuna River, Mismanaged plastic waste

POSTER SESSION 'B'

VPB-001

FROM FOOD WASTE TO CIRCULAR MATERIALS FOR DESIGN: EXPERIMENTING WITH UNCONVENTIONAL SOURCES

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Nowadays, we live in a present that envisions a future characterized by the exponential growth of different types of waste coming from a wide variety of sources. This growth of waste production is followed by decreased availability and increased costs of common raw materials, with their extraction and transformation being more and more impactful. Therefore, humankind is currently engaged in managing waste streams and looking for alternative, unconventional, more sustainable and circular raw materials to fulfil their needs.
One of the most critical waste streams globally is the one generated by the food industry. Studies show that food waste can be a precious organic resource that could be utilized to obtain chemical products, materials, energy sources, and fertilizers. Like the food industry, also the fashion industry is affected by the problem of creating a severe amount of waste. Specifically, the textile and fashion industries, producing primary commodity consumption goods, are among the most polluting industries in the world. This is mainly due to the extensive use of non-renewable materials and hazardous chemicals heavily burdening the environment. It is a fact that nowadays, designers, like many other professionals, are deeply committed as they play a key role in the sustainability transition process using all the resources and knowledge that are part of their expertise. In particular, in design materials, designers directly contribute to creating new material drafts based on circularity. DIY-Materials coming from low-cost experimentations emerging through tinkering processes done using unconventional resources are the most evident phenomena showing designers' commitment to acquiring a role in the transition to sustainability.
This chapter aims to show the rise of these new material experimentations and, in particular, the practices focused on the creation of different materials drafts made with food waste. Through a rich overview of case studies, classified according to the origin of food wastes within the production processes that generate them (from the agricultural, farming, fishing, industrial, distribution chain, commercial, residential), we want to show how the realized material drafts could potentially and concretely follow an industrial scale-up for a new emerging circular economy. These case studies will untangle between different fields (including textile and fashion) and typologies of waste (giving rise to some interesting industrial symbiosis good practices) while generating a positive, sustainable impact and new material scenarios.

VPB-002

SiOx NANOROD SWITCHING DEVICES FOR ARTIFICAL MEMRISTIVE NEURON AND ITS ENERGY-EFFICIENT COMPUTING APPLICATIONS

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Memristor, which simply consists of a switching layer inserted between two electrodes, is one of the most strong candidates to become a device-platform for imitating the principal characteristics of the biological neural network due to

its nonlinear and dynamic electrical characteristics depending on the history of applied electrical programming [1-3]. In this study, we fabricated a nanorod structured SiOx memristor using E-beam evaporator with glancing angle deposition at the wafer-scale and utilized the device as an artificial neuron for probabilistic computing applications. The device can exhibit a low forming voltage (< 2 V), a high ON-OFF ratio (> 105), reliable switching performances, and fast switching time (~40 ns), where the switching event is attributed to the transition between two Si phases (amorphous Si and Si nanocrystal). Notably, the nanorod structured SiOx can lead to the considerable reduction of forming voltage and enhancement of stochastic switching characteristics, when compared with the typical SiOx memristor. Moreover, using voltage pulse trains, the SiOx nanorod memristor with different glancing angles has successfully mimicked fundamental neuronal dynamics called integrate-and-fire processes and stochastic functionalities for the bayesian network in which each node is probabilistic variables. Then, as a proof of concept, we simulated the probabilistic inference for the correlation between three biological genes. Taken all together, the designed SiOx memristor neuron could pave the way for stochastic artificial neurons and its based probabilistic computing technology.

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VPB-003

WHAT IS THE IMPORTANCE OF RECYCLING SILVER FOR THE MANUFACTURING OF SOLAR MODULES TO ACHIEVE NET ZERO BY 2050?

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The adoption and installation of photovoltaics (PV) has seen unprecedent growth in the past decade from 70 GW to 700+ GW. Recently, it became the cheapest source of energy, surpassing fossil fuels. However, an even higher uptake (+60 TW, an ~85-fold growth) is required if we are to reach net zero by 2050. A shortcoming of PV technologies is that modules have a limited lifespan (20-30 years) and will eventually become electronic waste, which creates an essential and unique opportunity for waste management options such as recycling. This is especially true considering the amount of silver contained in PV modules and the silver demand associated with the rapidly increasing capacity of PV production. In this context, we have found that the impact of secondary sourcing of silver from PV recycling can be significant, ranging from 50% of the required silver to 100%, based on current silver consumption and projected consumption trends. For this to be viable, high-efficiency end-of-life processes need to be in place. This includes the collection, delamination and end-processing. To date, end-processing has been able to recover most of the silver (90-95%) effectively, and collection mechanisms are being optimized per jurisdiction, according to the logistic network available. Delamination, however, remain a main challenge when it comes to end-of-life processing. While approaches incorporating thermal processes (e.g., pyrolysis) have been shown to be effective, they are more expensive than other approaches (e.g. chemical and mechanical). The current limitation is mainly financial, as opposed to technological. In addition to the end-of-life considerations, we also discuss the use of silver in PV modules, the possible effects of the adoption of emerging PV cell technologies, and the effect of early loss (i.e. premature decommissioning or failure in reference to the expected lifespan) in the silver consumption analysis.

VPB-004

CUSTOMERS BEHAVIOR IN PRICISING DECISIONS OF WEEE MANAGEMENT: A COMPREHENSIVE LITERATURE REVIEW

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In recent decades, the waste electrical and electronic equipment (WEEE) has been increasing dramatically. Numerous research papers have been published in the pricing decisions disciplines to facilitate the best utilization of WEEE's residual value and optimize stakeholders' profit. However, there is no single review article found focusing on customer-related pricing models. To bridge this gap, this study reviews 111 articles from 2000 to 2021 and conduct bibliometric analysis. The method consists of four steps, which are material collection, content analysis, research areas identification and research evaluation. Five categories have been identified, videlicet, customer willingness to pay, customer environmental preferences, customer bargaining power, customer purchasing power and customer risk sensitivity. The findings of this literature pave a path for future research and deepen the understanding of customers' behavior in response to WEEE management for academics and practitioners.

VPB-005

EFFECT OF CARBON LOADING AMOUNT IN AQUEOUS ZINC-BROMINE BATTERY ELECTRODES: USE OF HOLLOW NANOPOROUS CARBON

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In recent years, the need for wider utilization of renewable energy sources has accelerated the development of electrochemical energy storage systems (ESS). Developing a safe, reliable, high-energy and low-cost ESS is crucial in the transition from a fossil-fuel based society to using renewable, clean energy on a global scale. Among different energy-storage techniques, redox flow batteries such as zinc-bromine based aqueous flow batteries are a promising candidate that offer practical solutions especially associated with scalability and safety. However, the components of traditional designs usually lead to exorbitant prices, further restricting commercialization. Based on this techno-economic understanding, a form of membraneless, flowless system was introduced for applications in zinc-bromine based aqueous flow batteries. With this minimal architecture, the importance of the role of cathodes cannot be emphasized enough. This meaning Br_2/Br^- kinetics, Br_2 complex entrapping capability, and capacity decay are all topics to be addressed to improve efficiency.In this study, a hollow nanoporous carbon material doped with nitrogen was synthesized and coated on graphite felt. The nitrogen doped hollow nanoporous carbon (N-HNC) material was prepared by a one-pot, silica-assisted strategy. With careful tuning of pore sizes and material shape, N-HNCs were tested for their electrochemical properties and applied with various amounts on carbon felts. The N-HNC itself showed low activity for oxygen evolution reactions, as well as hydrogen evolution reactions, which are undesignable side reactions according to measurements such as cyclic voltammetry. Effects of loading mass were noticeable in differences in battery cycle tests conducted at 20 mA/cm^2 and 2 mAh/cm^2 and in performance tests at 20 mA/cm^2 and 24.3 mAh/cm^2. We predict that studies as so will contribute to finding the best slurry compositions for coating cathodic electrodes to acquire maximum performance in future membraneless, flowless zinc-bromine based aqueous flow battery systems.

VPB-006

ESTIMATION OF SOLAR PANEL WASTE BY POPULATION BALANCE MODEL IN SOUTH KOREA

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As the demand of renewable energy keeps growing, the installation of solar panels has been increased. After reaching life-span of solar panels, end-of-life solar panels or solar panel waste is generated. Environmentally sound management of solar panel waste is an issue of concern around the world as it contains valuable materials as well as can cause potential threats to the environment upon disposal. This study examines the estimation of solar panel waste by using population balance model by 2050 in South Korea. The lifespan distribution analysis of solar panels was based on the literature with the Weibull distribution. Based on the results in this study, we found that solar panel waste in 2040 is estimated to be approximately 76,000 ton in South Korea, consisting of 57,000 ton of glass, 7,600 ton of polymers, 6,000 ton of aluminum, 3,800 ton of silicon, and other metals (silver, tin, and lead) for disposal. By 2050, approximately 1.7 million ton of solar panel waste would be accumulatively generated with continued annual increase. Material recycling and recovery from the waste should be implemented for resource conservation towards a circular economy. Refined estimation of the solar panel waste is still needed by conducting sensitive analysis with more reliable data such as its life spans, demands for solar panels, and mass of panel types.

VPB-007

SUSTAINABILITY AND RESILIENCE OF CIRCULAR ECONOMY BUSINESS MODELS BASED ON DIGITAL LEDGER TECHNOLOGIES

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The successful implementation of circular economy business models (CEBMs), such as product as a service (PaaS), product life extension (PLE), resource recovery (RR), circular supplies (CS), shared platforms (SP), and integrated-hybrid business model (I-HBS), offer numerous benefits. These include reducing environmental impacts, moving towards zero waste, increasing economic profits, multiplying revenue streams, and improving resource and energy efficiency. However, it is unclear whether one CEBM is technically feasible and financially viable than the other. Moreover, the implementation of CEBMs in real-world scenarios are limited, thus raising questions about their performance in terms of sustainability and resilience. Lately, it has become common to propose information and communication technologies (ICT) based approaches and tools for data analytics. Whereas in reality, the conventional ICT approaches and tools (e.g., Internet of Things, Energy Internet, Information Management System, Online Information Sharing Platforms, etc.) have not been developed for CEBMs, where the issues such as 'ensuring access to data', 'data ownership,' data sharing,' 'ensuring trust and transparency between the competitors', 'ensuring privacy' and 'property rights' are critical and must be included. With the advancement in digital ledger technologies (DLTs) like Blockchain, Smart Contract that ensure transparency, traceability, and trust between stakeholders, there is a need to explore their application to facilitate the CEBMs implementation at an industrial scale.

The main objective of this study is to investigate the role of DLT in ensuring sustainability and resilience through different CEBMs. For this reason, we selected six case studies (one for each CEBM), PaaS: Swap-Pay-Go Battery Service; PLE: Spent Electric Vehicle Batteries in Interconnected Power System; RR: Material Recovery from End-of-life Solar Photovoltaics; CS: Circularise Wastewater Streams in Industrial Symbiosis; SP: Dynamic Grapevoltaics Farms; I-HBS: Industrial Symbiosis-based Multi Energy Systems. We integrated the novel DLT (nDLT) into each CEBM with the goal to maximize both sustainability and resilience. The resulting nDLT strategies for CEBMs are, PaaS: Blockchain-Internet of Things (BC-IoT); PLE: Blockchain-based Participatory Smart Contracts (BC-PSC); RR: Blockchain-based Material Passports (BC-MP); CS: Blockchain-based Waste Trading Platform (BC-WTP); SP: Blockchain Food-Energy-Water Smart Contract (BlockFEW-SC); I-HBS: Blockchain-based Dynamic Peer-to-Peer (B-DP2P). Since the scope of the selected case studies is broad and the system design is different, a mixed-methods approach that combines Resilience, Performance, Life Cycle Analysis and Techno-Economic assessments (RePLiCATE) is adopted.

Using the RePLiCATE approach, we evaluated the six nDLTs for different CEBMs to analyse the tradeoffs between resilience, sustainability, performance, and financial vailability. Here are a few of the results resulting from the RePLiCATE analysis. For the Swap-Pay-Go Battery Service CEBM, we find that it is sustainable only when resilience is maintained at 100% by BC-IOT. The global warming potential and swapping price increased as the resilience index decreased. In the Spent Electric Vehicle Batteries in Interconnected Power System, the BC-PSC facilitated the spent battery participation and mitigated the load frequency resilience issue more sustainably than connected electric vehicles as auxiliary power source. The resulting revenues are 122.27%, 100.22% and 66.67% higher than that of the total investments made on spent battery charging at off-peak, mid-peak and on-peak, respectively. In Material Recovery from End-of-life Solar Photovoltaics CEBM, the BC-MP measured critical materials' circularity potential and promoted the recovered commodity trading with its marketplace. In Circularise Wastewater Streams in Industrial Symbiosis and Industrial Symbiosis-based Multi Energy Systems, the nDLT strategies (BC-WTP and B-DP2P) facilitated the system recovery process by establishing a relationship with a potential partner. In such instances, the observed resilience index for the industrial symbiosis network (ISN) varied between 16-40%; however, the associated cost for adaptation still unclear due to the supply chain and ISN dynamics issues. With the Dynamic Grapevoltaics Farms, the solar power sector can mitigate a land footprint of 1.984 ha/MW. The observed life cycle emission from the wine and table grape produced under this shared business practice is 0.081 and 0.107 kgCO2/kg, respectively. Also, the BlockFEW-SC offered early-warning measures and helped promote climate-smart and resilient grape and solar farming practices which are multifunctional in terms of rainwater harvesting, and symbiotic agriculture-energy networks.

Overall, we observed that the proposed nDLT strategy have the potential to mitigate the challenges faced by the CEBMs by ensuring resilient operation, and informing the decisions on sustainability. Lastly, we critically examined each nDLT and the selected case study's system design to identify hurdles and related challenges. Based on these, we further explored the opportunities for improvement for nDLT integration in CEBMs.

VPB-008

SUSTAINABLE SCALE BOUNDARIES OF E-WASTE MANAGEMENT

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The trend of global demand for consumer electronic products has been increasing steadily for the past three decades. This phenomenon is accompanied by the equally unsustainable upward trajectory of the accumulation of toxic electronic waste, leading to rampant environmental pollution, adverse human health impacts, and unquenched industry demand for virgin materials that may be acquired from unsustainable and sometimes illicit mining operations. Proposed solutions for the e-waste problem are hampered by different values placed on human labor, health, and environmental quality in different countries. Technological solutions have focused on the use of robots and artificial intelligence to enhance e-waste collection, sorting, dismantling, and recovery of re-usable materials. In the realm of policy, solutions have emphasized protection of labor in the e-waste recycling industry from human exposures and environmental impacts of hazardous substances. Ideally, the technological and policy solutions should be integrated to produce synergistic effects. However, the boundaries and limitations of each strategy are largely unexplored. Therefore, it is not yet possible to understand the sustainability parameters that should guide the scale-up of proposed solutions, and how they may be implemented internationally across countries with differing manufacturing and economic infrastructure. Here we review knowledge on sustainable scale boundaries for specific e-waste solutions, and we identify opportunities for research to generate quantitative and qualitative data on the boundaries and limitations to identify prospects for integrative synergy. Specifically, we address (1) Technological innovation focusing on the use of robotics, artificial intelligence, machine learning, and computer vision technology; (2) Policy and regulatory innovation, focusing on supervisory functions and legal frameworks, including the use of unified coded systems for differentiating waste electronics and the legacy of used or refurbished electronics; and (3) Supply chain considerations, including green manufacturing processes, and the sourcing and adoption of less toxic materials for next generation electronic products.

VPB-009

WORKING TOWARDS ANTIBIOTIC RECOVERY FROM WASTEWATER TO FUEL A CIRCULAR ECONOMY

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Antibiotics have been identified as emerging contaminants and as accelerants for antimicrobial resistance in the environment.1 Ineffective removal of antibiotics during the wastewater treatment (WWT) process leads to elevated concentrations in water bodies, which has a negative impact on ecosystems and human health. Therefore, methods to remove antibiotics from wastewater streams are needed urgently. Metal-organic frameworks (MOFs) are excellent examples of sorbents for WWT, they are porous materials consisting of metal nodes joined together by organic linkers.2

Removal of antibiotics via sorption not only improves water quality but also aligns with circular economy principles by offering the potential for recovery and reuse of antibiotics; challenging the idea that wastewater is just waste, rather than a valuable resource.
However to be used for this application, a MOF must be able to remove antibiotics present in wastewater under application-relevant conditions including, temperature, pH, and antibiotic concentration. In this work, MIL-100(Fe) was synthesised via microwave irradiation and its ability to remove antibiotics from simulated and real wastewater is demonstrated. The MOF structure was examined after immersion in water and the pH of the solutions were monitored throughout to identify any chemical changes. Initial results show a partial breakdown of the MIL 100(Fe) structure when immersed in wastewater as well as the relatively low removal capacity when antibiotics are present in application-relevant concentrations. In addition, noteworthy pH trends were observed during the experiments. This presentation highlights the importance of understanding how contaminant removal is affected when a sorbent is used under application-relevant conditions before investigating the potential for contaminant recovery.

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VPB-010

AI-ASSISTED SUSTAINABLE ROBOTIC SENSORS THROUGH CARBON BLACK

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The global installation of robots was over 2,700,000 units in 2020, stimulating a larger market of robotic sensors. Conventional robotic sensors use metals or piezoelectric ceramics to collect the electronic feedbacks from deformations, yet suffer from complex fabrication, low sensitivity, and small working windows. Recently, nanomaterials (e.g., graphene, MXene, silver nanowire) show high potentials to serve as flexible and stretchable electronics with excellent sensing performances, paving the way for robots in broader applications. However, those nanomaterials are usually expensive and their fabrications include many chemicals and equipment which produce a large number of carbon footprints, thus are not applicable to create a sustainable and low carbon world. In this work, we use carbon black waste as the filler in the elastomeric matrix to obtain the carbon black-filled elastomer composites (abbreviated as CB-E), which are capable of serving as highly stretchable strain sensors (up to 300%). This fabrication scheme ensures the sensors can be batch manufactured at a low cost as well as low carbon footprints. More importantly, the introduction of artificial intelligence could compensate for the inherent shortcomings of CB-E sensor, including nonlinear response, low sensitivity, and large hysteresis, which enables even better performance to one outstanding MXene sensor. We expect this work shows advances in developing sustainable robotic sensors and intelligent systems.

VPB-011

SOIL BIOSOLARIZATION- A FURTURE SOURCE-LINK FOOD WASTE SOLUTION

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Among the different types of waste streams, organic waste has a high potential to be valorized, and yet a large portion is ending up in landfills and turns from resource to pollution. In this on-going study, two different types of food residues were tested as soil amendments to be used in soil biosolarization (SBS). The two were: 1) separated fish residues (SFW) from canteens and 2) tomato pomace (TP) from the tomato sauce industry. SBS is an environment-friendly agricultural technique that serves as an alternative to chemical soil fumigation. Simulation systems, greenhouse trials and field trials were used to examine the potential of these types of residues. In the simulation system both SFW and TP were applied as a soil amendment in high 2% wt and low 0.5% wt ratios. The results showed elevated levels of aerobic soil respiration (measured by the accumulation of CO_2, O_2 and H_2) compared to the control soil. There was no emissions of the greenhouse gas methane during the process that used either the SFW or the TP residues. In the SFW case, analysis by Proton-transfer-reaction mass spectrometry revealed a profile of volatiles found in the soil that was treated with SFW that was different from the control soil. The profile of volatiles from combined soil and SFW included changes in the amounts of compounds such as: Dimethylsulfide, Methanethiol and C9-aldehydes that were previously found to be suppressive against soil-borne plant pathogens. In the TP case, assessment in the field demonstrated 100% weed mortality for mustard and nightshade seeds over five days. Greenhouse studies of the soil treated with SFW and TP were done to assess the impact on consecutive plant crops establishment. The greenhouse study showed no remnant soil phytotoxicity in lettuce seedlings and even improvement of the yield. These results indicate that SFW and TP residues can be used as suitable soil amendments for SBS.

VPB-012

EFFECT OF THE FOOD WASTE COMPOST ON RICE YIELD AND NITROGEN USE EFFICIENCY WITH VARYING NITROGEN APPLICATION RATE

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The amount of national food waste disposal is about 12,830 tons per day in 2019, and the food waste treatment methods are mainly recycling, incineration, and landfill. In particular, waste recycling consists of composting (62%), fodder conversation (38%), and biogasification. It is reported that the food waste compost has a high organic matter content and it increases rice productivity and contributes to the improvement of soil physicochemical properties. However, food waste utilization is still low due to quality instability, odor, and leachate problems. In this study, nitrogen utilization rates were evaluated for varying levels of nitrogen (N) base substitution with food waste compost in rice cultivation and we calculated the appropriate amount of food waste compost to apply to the agricultural land. Based on the nitrogen standard fertilization, the total required amount of N is 9kg/10a. The replacement of 100% of total N (N9) with food waste compost and the replacement of the base N (5kg/10a) with food waste compost equivalent to either 100% of N in the base fertilization (N5) or 150% (N7.5) were performed. Compared to the NPK treatment group, i.e. a standard application rate for rice, the rice productivity was about 14% high in N5 and showed a tendency to decrease as the nitrogen replacement amount increased (rice yield index: 113.9(N5)>112.9(N7.5)>100(NPK)>81.1(N9)). The nitrogen utilization rate was higher in the case of replacing the nitrogen base fertilization compared to NPK and the case of replacing the total amount of nitrogen (nitrogen utilization rate: 70.9(N7.5)>47.5(N5)>46.3(NPK)>31.6(N9)). Based on these results, the appropriate amount of food waste compost in consideration of rice productivity and nitrogen use efficiency is replacing 5~7.5kg/10a of the nitrogen in the base fertilization with food waste compost. To increase the field applicability, environmental impact assessment on air, water quality, and so on is additionally necessary.

VPB-013

ASSOCIATION BETWEEN URINARY 3-PHENOXYBENZONIC ACID CONCENTRATIONS AND DIABETES IN KOREAN ADULTS: KOREAN NATIONAL ENVIRONMENTAL HEALTH SURVEY 2012-2017

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Pyrethroid insecticides account for more than 30% of the global insecticide market and are frequently used in agriculture settings and residential and public pest control in the general population. While several animal studies have suggested that exposure to pyrethroids can alter glucose homeostasis, there is only limited evidence of the association between environmental pyrethroid exposure and diabetes in humans. This study aimed to report environmental 3-phenoxybenzonic acid (3-PBA) concentrations in urine and evaluate its association with the risk of diabetes in Korean adults. We analyzed data from the Korean National Environmental Health Survey (KoNEHS) Cycle 2 (2012–2014) and Cycle 3 (2015–2017). A total of 10,123 participants aged ≥19 years were included. Multiple logistic regressions were used to calculate the odds ratios (ORs) for diabetes according to log-transformed urinary 3-PBA levels. We also evaluated socio-demographic and behavioral characteristics as potential effect modifiers of these associations. The weighted prevalence of diabetes in KoNEHS Cycle 2 and Cycle 3 was 9.3% and 9.9%, respectively. With adjustments for major confounders, we found a significant dose-response relationships between urinary 3-PBA as quartile and the prevalence of diabetes in pooled data of KoNEHS Cycles 2 and 3. In subgroup analyses, the adverse effects of pyrethroid exposure on diabetes were significantly stronger among those aged 19-39 years (OR 1.52 in 19-39 years vs. OR 1.38 in 40-59 years vs. OR 1.10 in 60 years; p-interaction <0.001), and those who consumed high levels of cotinine (OR 1.20 in participants with low cotinine level vs. OR 1.57 in participants with high cotinine level; p-interaction = 0.020). Our findings highlight the potential diabetes risk of environmental exposure to pyrethroids and should be confirmed in large prospective studies in different populations in the future.

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VPB-014

NUTRITIONAL-BASED TOOLS AND STRATEGIES FOR MINIMIZATION AND VALORIZATION OF FOOD LOSS AND WASTE

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Food loss and waste (FLW) has turned into an issue of great public concern, becoming a critical challenge to achieve the Sustainable Development Goals (SDG), especially SDG 2, related to zero hunger, and SDG 12, referred to sustainable production and consumption patterns. This problem occurs throughout the whole food supply chain, from the initial agriculture production to the final household consumption, generating about 1.3 billion tons of FLW, accounting one-third of the food produced globally. Furthermore, uneaten food represents a waste of resources, such as energy or water, which leads the increase of environmental impacts getting worse climate change and other environmental phenomena, as well as a loss of nutrients that can be used to ensure food security. For these reasons, it is imperative to address FLW management from a nexus approach, highlighting the linkages and interactions between these three fundamental pillars: water, energy, and food. Frequently, nutritional aspects are overlooked when devising strategies to minimize or reduce these impacts, so this work focuses on this variable as one of the fundamental points. For this purpose, we stand out the importance of carrying out the nutritional footprint of FLW, which aims to quantify its nutritional impact by means of a nutrient profiling (NP) model called 'Nutrient Rich Food 9.3' (NRF9.3). The main outcomes prove that the nutritional variable is a key factor when defining strategies, and state that the higher nutritional density of a food, the more importance should be given to its loss and waste management in order to take advantage of that nutrients, evidencing the need to implement the aforementioned tool (NRF9.3). This would make it possible to study and establish different strategies for minimization or valorization, including the recovery of FLW to produce secondary foods, e.g., animal feed, as well as the promotion of food donation that is not going to be consumed to give them a second chance before being discarded.

VPB-015

FABRICATION OF SUSTAINABLE AND BIODEGRADABLE CHITIN MICROPARTICLES FOR SUBSTITUTION OF MICROBEADS

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These days, researchers have been compelled to find sustainable replacements to the plastic microbeads used in personal care products due to a global prohibition on their use. However, existing biodegradable microbeads rarely have mechanical properties and stability that are comparable to commercial exfoliating microbeads, and are rarely as inexpensive as commercial exfoliating microbeads. Even the polymer known for biodegradabilities such as poly(lactic acid) or poly(caprolactone) barely degrades in the aqueous environment even if they are washed out after single use. Here, we show the fabrication of chitin microparticles, which are readily available in personal care products with biodegradable and uniform spherical shape through the reacetylation of chitosan using inverse emulsion system without using toxic or expensive solvent. Chitosan is a second abundant polysaccharide in nature and is renewable polymer from crustacean waste. The chitin microparticles have a greater cleansing efficiency than commercial polyethylene microparticles. Furthermore, they are stable and functional under cosmetic liquid formulation or cleaning solutions for sufficient time. The utilized chitin microparticle degraded completely in the soil without causing harm to the model plant even in the high concentration of 1g/kg soil. Our alternative has the potential to be a competitive and ecologically conscientious microparticle in sustainable cosmetics.

VPB-016

CHARACTERIZATION OF METABOLIC CHANGES OF TOMATO AND LEAFY PERILLA UNDER DIFFERENT ENVIRONMENTAL CONTROL (MINERAL AND WATER SUPPLY)

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Effect of water limitation to metabolites of tomato fruits and perilla leaves was compared in soils with different nutrient conditions (nitrogen-limited vs. nutrient excess for tomato, potassium-limited vs. nutrient excess for perilla). Tomato and perilla plants were cultivated in a glasshouse, and water was supplied either at −30 kPa (sufficient) or −80 kPa (limited) of soil water potential for tomato and either at −65 kPa (sufficient) or −90 kPa (limited) for perilla. For harvested tomato fruits and perilla leaves, we examined primary and secondary metabolites using non-targeted mass spectrometry (MS)-based metabolomic approaches. In case of tomato fruits, water stress decreased amino acids and polyamines in the nutrient excess soil but not in the nitrogen-limited soil. For perilla, water stress decreased sucrose and fructose but increased flavonoids only in the potassium-limited soil and it did not happen in the nutrient excess soil. In conclusion, water stress greatly affected tomato metabolites in the nutrient excess soil but perilla metabolites in the potassium-limited soil. Thus, we suggest that metabolic changes by water stress depend on the crop and soil nutrient status.

VPB-017

CELLULOSE-BASED BIOPLASTIC REPLACEMENT OF SINGLE USE PLASTIC BAGS IN THE COLLECTION AND TREATMENT OF FOOD WASTE VIA ANAEROBIC DIGESTION FOR A ZERO-WASTE CIRCULAR ECONOMY

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It is common knowledge that single use fossil-fuel based plastics results in environmental contamination. However, the collection of food waste as part of municipal solid waste management requires that the organic matter be bagged up to prevent spillage and transmission of diseases, with the consequence of requiring an additional debagging step before anaerobic digestion. Cellulose-based bioplastic bags can be utilised instead for 1) upcycling the cellulose content of agricultural residues, 2) a non-contaminating replacement for fossil fuel-based plastics, and 3) contributing increased methane yield to anaerobic digestion of the food waste. Herein, it is shown unequivocally that the bioplastic bags can be degraded by microbial activity, within the timeframe of commercial anaerobic digesters, produce extra biogas, and be scaled up to a pilot scale of 1000L. These findings would help promote a zero-waste circular economy if the digestate is used for subsequent fertilisation of agriculture.

VPB-018

NEW PERSPECTIVES FOR THE USE OF PHOSPHOGYPSUM AS A SUSTAINABLE BUILDING MATERIAL

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Phosphogypsum (PG) is a waste by-product leftover from the production of either phosphoric acid or phosphate fertilizers, in a way that every tonne of such commercial products yields nearly five tonnes of PG, which is normally discarded in wastewater ponds. Once agriculture is a primary and fundamental activity for humankind, its unstoppable expansion has been causing a growing generation of PG around the world. Annual world PG production is estimated to be around 300 Mt, although its accumulation may exceed 1 billion tonnes only in Florida, which accounts for approximately 80% of the current production in the United States. The main issue with PG is related to the high radioactivity of phosphate ores, which may present high Radium concentrations of about 80%, although fertilizers thereof may concentrate 80% or more of Uranium and Thorium, whether these radionuclides are present in the phosphate ore. Thus, PG is known as a Technologically

Enhanced Naturally Occurring Radioactive Material (TENORM), although only less than 15% of its total production is driven to agriculture or civil construction – mostly in road construction or as an addition for Portland cement, as setting retarder, although some countries restrict the latter. In Brazil, a balance between PG production and consumption has been recently achieved through the mentioned uses and, nevertheless, its accumulation is estimated to be over 200 Mt, especially in the Southern states, wherein dwellings shortage reaches its highest level. Bearing this in mind, during the last two decades, the authors developed a new technique to obtain PG parts with mechanical performance that would hardly be matched by the slurry method. This performance is comparable to that of high-performance concretes (HPC) with the advantage of negligible carbon footprint when compared to them. A couple of affordable houses were built with PG as raw material using the above-mentioned technique, one of them dedicated to radiological measurements – gamma radiation and indoor radon concentration – whose results have shown that the annual increment in the effective dose to the inhabitant will remain far below the safety limits for every reasonable scenario. So, at least in Brazil, PG could help to solve the conundrum of how to create social impact through mass housing without creating an even bigger environmental impact that hinders future generations' access to contemporary natural resources.

VPB-019

HYDROTHERMAL PROCESSING OF AGRICULTURAL PLASTIC WASTE

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Increasing amount of plastic is used in modern agriculture and required to ensure high yield and quality of crops, to reduce water use and to minimize nutrient losses. Due to the widespread use of plastic in agriculture, millions of tons of plastic waste are generated annually, leading to severe soil, water and air pollution. Moreover, a growing concern regarding microplastics that can be integrated into our food chain requires additional technological solution. This study aims to develop an environmentally favorable thermochemical conversion pathway to valorize agricultural plastic waste. Hydrothermal processing (HTP) was tested to convert plastic waste into valuable products, including important monomers for the plastic industry. Subcritical water (300°C; 10 MPa) was used as a solvent in a lab-scale HTP unit. The degradation of nylon-6 and polyethylene terephthalate (PET) and their mixtures was evaluated following a short reaction time of 90 min. Degradation products were characterized, using a variety of chromatography, spectroscopy and microscopy methods. For example, terephthalic acid (TPA), one of two monomers of PET was recovered as a solid product in mass yield of 75%. ε-caprolactam (CPL), the single monomer of nylon-6 was recovered as a liquid product in mass yield of 92.5%. Carbon distribution among solid, liquid and gas products suggests that HTP of nylon-6 resulted in 98% of the carbon in the liquid phase. For PET processing, however, 70% of the carbon was recovered as solid product. The distribution of valuable products into different phases can be beneficial for the processing of multi-layer plastics. Although HTP of plastic is still under development, our results verify its potential for converting mixed plastic waste (PET+nylon-6) into new valuable materials. Further examination of HTP as a depolymerization technology for plastic waste should be conducted with polyolfines (e.g. polyethylene and polypropylene) and their mixtures. The use of end-of-life plastics as a feedstock to produce new pristine plastics can contribute to a circular plastic economy and a more sustainable future.

VPB-020

FUNGAL CONTROL IN CROPLAND FIELDS VIA ENHANCING BELOWGROUND FUNGAL GRAZE WITH WASTE COCONUT HUSKS

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Field control of soil microorganisms is a challenging issue that receives interdisciplinary focus. For instance, the control of soil fungi is important because more than 8000 species of soil-borne plant-pathogenic fungi are threatening biodiversity and food security, and the widespread fungal denitrifiers found in croplands contribute to soil nitrogen loss, global warming and ozone depletion through the emission of nitrous oxide (N_2O). On the other hand, the unavoidable chemical inputs used thus far for fungal control in agricultural soils lead to environmental issues and the emergence of chemical resistance in pathogens. Here, we provide a nature-based solution: increasing the abundance of native fungal grazers (mites) in croplands by modifying their belowground habitat with agricultural wastes (coconut husks) reduces fungal abundance via enhancing the consumption of fungi by mite communities. We mixed coconut husks (chips of a few centimetres in size) into the surface soil (0 ~ 10 cm, ~1% v/v) in cropland fields in three different locations of Japan (Tokyo, Niigata, and Hokkaido). We found that, due to the porous structure, coconut husks could provide favourable habitats for mite communities and therefore lead to two- to three-fold increases in mite abundance in soils in all three fields. The enhanced fungal consumption by the mites due to their increased abundance decreased the soil fungal abundance after fertilizer application by half in the Tokyo and Niigata fields. Furthermore, by coconut husk application, we mitigated fungi-derived impacts, including soil N2O emissions and the plant diseases caused by soil-borne fungal pathogens. We anticipate that this fungal grazer-based approach for fungal control would be a supplement to the chemical-based approach and thus reduce the agrochemical inputs. Furthermore, because coconut husks are agricultural wastes found in huge amounts in developing countries in tropical regions and their disposal is facing pressure based on both economic and environmental costs (e.g., air pollution and CO2 emissions from incineration disposal or burning by householders), this approach for fungal control involving the reuse of coconut husks is anticipated to expand the market for coconut husks and therefore benefit the economy and environment of these developing countries.

VPB-021

BIOREMEDIATION OF ARSENIC USING MICROALGAE BIOFILM GROWN ON BANANA PSEUDOSTEM ORGANIC SUBSTRATE

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Arsenic (As) is recognised as the most toxic class I carcinogen and globally around 300 million people are affected through As contaminated drinking water including vast Indo-Gangetic alluvial plain of India. Among several strategies, use of microalgae for bioremediation of As in aquatic ecosystem is well acclaimed; however, its use for the same is still infancy due to the lack of techno-economic feasibility. To address the issue the present study utilized banana pseudostem (BS) waste, that is generated in huge amount (80 million tonnes/year) in India, as an organic substrate for growing microalgal biofilm. The As removal efficiency of the microalgae bioflim grown on BS was found significantly higher (97.6 ± 1.5 %) as compared to microalgae biofilm grown on synthetic mesh net (74.1 ± 12.2 %). The microalgae biofilm grown on BS was dominated with Chlorophytes whereas synthetic mesh net was dominated with Bacillariophytes. Principal component analysis revealed that As removal by microalgae biofilm was highly correlated with the Nitzschia sp. abundance in BS and moderately correlated with Scenedesmus sp. in synthetic mesh net. In both the treatments, phosphate concentration of treated water had significant effect on As removal efficiency of the microalgae biofilms. It was also found that increase in water As concentration has resulted in higher lipid content and, diversity and richness of microalgae grown. In conclusion the study reveal that the banana pseudostem could be effectively utilized for growing either chlorophytes or bacillariophytes based biofilm and could remove the toxic As from water more efficiently as compared to the synthetic substrate. Hence this technology could effectively be utilized the agriwaste to treat As contaminated water and also paves way for sustainable water treatment processes.

VPB-022

SCALE-UP STUDY FOR PRODUCTION OF VALUE ADDED PRODUCT ‘EXOPOLYSACCHARIDE’ FROM FRUIT WASTE BY BACILLUS sp. SRA4

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Present work focused on exopolysaccharide (EPS) production using Bacillus sp. SRA4 isolated from pomegranate fruit waste. The isolate was identified by 16S rRNA gene sequencing. Fruit wastes were used in formulation of novel production medium as source of carbohydrate. Process was optimized and scale-up to 10 L lab-scale fermenter. At shake-flask, highest EPS production was 17.5 and 9.2 g/L in EPS medium and YEB medium supplemented with sucrose respectively in 144 h incubation. A cost-effective novel medium was formulated using fruits waste. Statistical optimisation and the formulated medium showed 1.2 fold higher EPS production in comparison to the EPS medium. Process was scale-up at 5 and 10 L fermenter, it further showed 2 fold increase in EPS production within 72 h of fermentation run. The developed process showed feasibility to produce EPS using even mixed fruits waste and as the calculation economics of the production cost lowered down to 47.47%.

Key words : Fruit waste, exopolysaccharide, scale up, Bacillus sp., medium formulation

VPB-023

INCORPORATING TRADITIONAL PRACTICES FOR EFFICIENT WASTE SEGREGATION FOR SYNERGETIC URBAN AND RURAL DEVELOPMENT

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Increasing urbanization in India has led to a significant rise in urban solid waste (USW) generation and associated environmental pollution and greenhouse gas emissions (GGE). Segregation of household waste at the source is at the heart of sustainable USW management. However, according to a recent report from Observer Research Foundation, in India, segregation of waste is rarely practised at the source. Therefore, mixed wastes are mostly dumped in the least preferred landfills or incinerated. For efficient segregation, a large number of studies recommends policies for active community participation and behavioural change in people’s attitudes. For waste separation at the household level, there is a need to explore the traditional rural culture of segregating household waste into cow-edible (food waste) and the rest of the waste for reusing, recycling or disposal. The majority of Indians have deep cultural practices and inclination to feed cows as they consider cows as sacred. Since it is a traditional practice, it will be easy to promote active participation for waste segregation, and its adoption will not be difficult. Segregated cow-edible waste can be sent to cow shelters owned by charitable trusts, state governments, temples etc., as cow feed. This can benefit an increasing number of cow shelters in many Indian states, e.g., more than 4000 cow shelters were built since 2017 in Chhattisgarh state alone. Then cow manure from the cow shelter can be utilized for biogas generation for fuel or electricity generation and digestate can be composted for nutrient recovery. According to the livestock survey 2019 of India, there is an increase in the population of cows by 18% and hence there will be a greater number of abandoned stray cows or bulls that generally stay at cow shelters that can be fed through the proposed USW management system. This will be a win-win situation for the rural and urban development as in villages, cow shelters will get free or cheaper feed, cleaner fuel, compost for organic farming. While cities can reduce their GGE and environmental pollutions, can recycle inorganic waste efficiently, manage their stray cow issues, and livelihood creation in both rural and urban areas. Hence, there is a need for a holistic socio-economic feasibility study of the proposed waste management system incorporating traditional practice. Thus, this can open a way for achieving a circular economy and tradition driven sustainability transition.

VIRTUAL POSTER PRESENTATIONS

POSTER SESSION 'C'

VPC-001

AVAILABILITY AND POTENTIAL OF TEFF (ERAGROSTIS TEF) STRAW FOR BIO-REFINING; AN OVERVIEW

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Generation of waste from agricultural sector has continued to increase globally and its management remains a challenge. These residues are naturally available lignocellulosic biomass and rich in high carbon content that can be harnessed for the production of bioenergy and other bio-based products. A massive amount of teff straw is generated annually and discarded as waste during teff grain harvest. The straw is left without any value addition and often subjected to open burning which contributes to carbon emissions. The paper reviews the availability of teff straw and reports recent progress on the utilization of the straw for the synthesis of different valuable products. The review also provides insight on the potential of teff straw as promising biorefinery feedstock and the benefits it delivers. Development of bio refinery based plant for optimum valorization of agricultural byproducts would be a way forward towards a cleaner and sustainable environment.

Key words : Teff straw; Agricultural residues; Biorefinery; Sustainability

VPC-002

APPLICATION OF ARTIFICIAL INTELLIGENCE ON PREDICTING BIOFUEL PRODUCTION OF BIOMASS AGRICULTURE WASTE THROUGH A THERMOCHEMICAL CONVERSION TECHNIQUE

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The artificial neural network is one kind of artificial intelligence in the computing system that aims to process information as the way neurons in the human brain. The ability of an artificial neural network is recognized to be remarkable to predict biofuel production via a thermochemical conversion technique (microwave irradiation pyrolysis) of agriculture waste, namely, spent mushroom substrate. In this present study, the Taguchi orthogonal array is utilized to design the multiple factors and levels of experiment parameters. The important parameters in this study are particle size (355, 500, and 1000 μm), power (80, 90, and 100%), catalyst (MgO, 10, 20, and 30 wt%), and magnetic agent (10, 20, and 30 wt%). The highest biofuel production is accomplished using a combination of 355 μm particle, 100% power, 30 wt% catalysts, and 30 wt% magnetic agents. In the prediction, the artificial neural network architecture is employed with a combination layer of 1-1-1 for input, hidden (4 neurons), and output (2 targets), respectively. The high linear regression values for biochar (0.999) and bio-oil (0.998) productions through ANN indicate that ANN with a quick propagation algorithm scheme is an appropriate method to predict biofuel production with a high fit quality outcome.

Key words : Artificial intelligence, neural network, microwave irradiation, agriculture waste, spent mushroom substrate.

VPC-003

MICROALGAL BIOCHAR PRODUCTION VIA MICROWAVE TORREFACTION ENHANCED WITH THE USE OF METAL OXIDE AS CATALYST

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Microalgal biochar is produced using microwave torrefaction of the Chlorella vulgaris FSP-E residues wherein magnesium oxide is employed as microwave absorbers to enhance the heating rate and reaction. Using the Taguchi experimental design (TED) and optimization, and Analysis of Variance (ANOVA), the effect of three parameters, namely, microwave power, catalyst concentration, and duration to the response variable, energy yield, are investigated. Both TED and ANOVA results confirm the significant effects of microwave power and catalyst concentration, while the duration is found to have a slight effect on the resulting energy yield. The results of the calorific test show that the calorific values of the produced biochar (21.12-26.22 $MJ{\cdot}kg^{-1}$) are better than blend coal and approach that of bituminous coal. The maximum extents of deoxygenation and carbonization achieved are 48.33% and 35.23%, respectively, when the MW power is set at 630 W, duration at 25 min, and MgO concentration at 5 wt%. The optimal combination of the parameters is low MW power (450 W), low duration (25 min), and high catalyst concentration (10 wt% MgO). Since the highest upgrading energy index (UEI) values are also achieved in the optimal conditions, it confirms that better energy efficiency favors light torrefaction conditions with maximized catalyst concentration to produce the maximum energy yield while consuming the least electricity input.

Key words : Microwave torrefaction; catalytic torrefaction; thermal degradation; microalgae; biochar

VPC-004

COMPREHENSIVE ARTIFICAL NEURAL NETWORK MODEL FOR GASIFICATION PROCESS PREDICTION

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Accurate modelling of gasification production is crucial for effective process design and intensification. An accurate prediction of these parameters is deemed essential for further environmental and economic system analysis. A feedforward artificial neural network has been developed to predict the outputs of biomass and waste gasification. Specifically, the process' syngas, char, and tar yields are predicted, as well as the syngas composition (N_2, H_2, CO, CO_2, CH_4, and C_2H_n) and lower heating value (LHV). Whilst existing models often considered only a specific reactor and feedstock combination, the developed model is the first model applicable to a wide range of feedstock types (woody biomass, herbaceous biomass, plastics, municipal solid waste, and sewage sludge) and reactor options (fixed bed and fluidised bed). This allows for the use of a large data set for model development. The model's generalisation capability has been maximised by the novel use of categorical data (e.g. gasifying agent, reactor type, bed material, and system scale) so that the model is of high practicality for general process design. An optimisation superstructure was implemented to systematically compare and identify the best hyperparameter combinations, which has not been done previously. For this, various training algorithms,

transfer functions, and hidden layer neuron options were considered. The models' performance was assessed using the root-mean-square error (RMSE) and coefficient of determination (R^2). The best performing network resulted in RMSE = 0.067 and R^2 = 0.947. The network was trained using Levenberg-Marquardt backpropagation and the hyperbolic tangent sigmoid transfer function for the hidden layers. 16 and 15 hidden layer neurons were used for the 1st and 2nd hidden layer, respectively. Comparable networks (RMSE = 0.072 and R^2 = 0.948) were trained using a single hidden layer with the log-sigmoid transfer function and Bayesian regularisation backpropagation for model training. Ultimately, the model was found to predict the gasification outputs well over a wide range of gasification and feedstock options.

VPC-005

FORMULATION AND OPTIMIZATION OF NOVEL CARBON CAPTURING PHOSPHORUS FERTILIZER

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Poor supply of phosphorus (P) for plant nutrition is a huge barrier to sustaining crop production in global tropical soils suffering also from various degradations including acidification and exhaustion of organic matter. Exclusive reliance on imported and costly synthetic phosphatic fertilizers adds financial burden to millions of farmers in tropical countries due to poor P utilization efficiency by crops from those products, and calls for developing solutions based upon local resources and with low environmental footprints. Here, we report a novel biochar-based phosphatic fertilizer (BPFs) for addressing the widespread issue of soil P constraint in degraded tropical soils, with high potential for soil carbon (C) retention and thus improving the soil quality. We co-pyrolyzed distillation waste biomass (DWB) of lemongrass (Cymbopogon flexuosus) with a low-grade rock phosphate (LRP) at various ratios to produce BPFs, and assessed the products for their biochar yields, C retention potentials, liming values, and major nutrient contents including total nitrogen (N) and P, and water- and citrate-soluble P. The co-pyrolysis method significantly ($p < 0.05$) increased the biochar yield, C retention, liming value and total P content in BBFs as compared to the pristine biochar. The above results translated into significantly ($p < 0.05$) higher water- and citrate-soluble P in BBFs as compared to LRP. The BPF with LRP and DWB ratio 1: 6 was equally effective as triple super phosphate (TSP) and more effective than the pristine biochar in improving plant P availably in an acidic tropical soil via a slow P release mechanism tandem with crop P requirements. The alkaline nature of BBFs indicated a great promise of this C-retaining fertilizer material for ameliorating acidic tropical soils and thereby enhancing plant P nutrition. Manufacturing value-added and efficient phosphatic fertilizers using locally available crop residues and LRP, as demonstrated in this study, could be a scalable option for sustainable recycling of agricultural wastes and ameliorating P-poor and C-deficient tropical degraded soils.

VPC-006

VALORIZATION OF RURAL ABATTOIR WASTE AS FERTILIZER FOR SUSTAINABLE AGRICULTURAL PRODUCTION AND SOCIO-ECONOMIC DEVELOPMENT

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Rural slaughterhouses comprise a large part of the meat producing industry which generates substantial quantities of organic waste daily following animal slaughtering. They usually discard their waste materials either by landfilling or to the local sewage systems without any treatment as sophisticated and capital intensive waste management technologies are difficult to apply in such abattoirs due to lack of infrastructural facilities and economic restrictions resulting in environmental as well as public health hazards. Bovine blood and rumen digestive materials are the wastes which do not have any reuse/ resale value. On the other hand, untreated animal waste can incorporate toxic organic pollutants in the agro-ecosystem and increase the number of antibiotic resistant bacteria in soil. An eco-friendly and cost-effective recycling system is thus essential to limit the practice of open waste disposal and to reduce the risk of spreading diseases. Waste blood and rumen digesta (in 3:1 ratio) were mixed properly and dried at 90-110 °C for 3-4 hrs using a novel helical ribbon mixer dryer to obtain 'bovine-blood-rumen-digesta-mixture' (BBRDM) as end product having 16% final moisture. The recycling unit consist of three parts: (a) cylindrical drying vessel assembled on a movable cart for easy relocation, (b) helical ribbon-shaped mixing spindle with sharp edges for uniform mixing and equal distribution of heat, and (c) burner as heat source for diesel and liquefied petroleum gas (LPG) that easily slid below the feed vessel, and installed in a rural abattoir for pilot-scale production of the fertilizer. The N/P/K content of BBRDM was approximately 8:1:2 with a C/N ratio of 4.68. Scanning electron microscopy coupled with energy dispersive spectroscopy (SEM-EDS) analysis showed the presence of microelements namely calcium, zinc, iron, boron and selenium in BBRDM that are essential for crop improvement. Proper thermal treatment made this mixture suitable for agricultural applications as we found two-fold higher vegetable yield in soils fertilized with BBRDM compared to commercially available fertilizers during each season of cultivation. High organic content and total nitrogen of BBRDM allowed faster proliferation of soil copiotrophs including Proteobacteria, Bacteroidetes, Firmicutes and Planctomycetes as revealed by V3-V4 16S rRNA gene sequencing, those are beneficial to soil health. The metagenomics study also confirmed the absence of slaughterhouse pathogens in BBRDM fertilized soils. Reutilization of slaughterhouse wastes as an organic fertilizer provided a win-win situation for both the slaughterhouse owners as well as local farmers and promoted the attainment of circular bio-economy and environmental sustainability. This in-situ waste management system may be advantageously adopted in rural slaughterhouses not only in India but also in other developing countries.

Keywords : abattoir waste; circular economy; organic fertilizer; low-cost recycling; agricultural production; socio-economic development

VPC-007

BIOCHAR PRODUCED FROM THE MAJOR AGRICULTURAL RESIDUES IN THE PHILIPPINES AS ADSORBENT FOR CARBON DIOXIDE

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With 47% of its 30 million hectares of land devoted to agriculture, the Philippines produces millions of crop residues annually. These residues are commonly burned in the open field as the most economical disposal method. Among the impacts of open burning, carbon dioxide emissions play a significant role in the degradation of the environment and the well-being of living creatures. This study promotes agricultural residues utilization to minimize the drastic effects of CO_2 emissions on the atmosphere. In particular, this study evaluated the potential of biochar produced from the major crop residues in the Philippines, namely rice husk, rice straw, coconut husk, corn husk, and sugarcane bagasse, as an adsorbent for CO_2. Specifically, the biochar yield, surface characteristics, selectivity to CO_2, adsorption capacity, and regenerability of the different biochar were investigated. Moreover, the biomasses were subjected to different pyrolysis temperatures of 400, 500, and 600 ℃ to examine the effect of pyrolysis temperature on the resulting biochar. Characterization of the biochar showed that the pyrolysis process produced porous biochar with good potential for carbon dioxide capture. Among the biochar made at 600 ℃, the biochar from sugarcane bagasse showed the highest CO_2 adsorption of 4.3wt%. Meanwhile, among the biochar produced at 500 oC and 400 ℃, corn husk with adsorption of 3.4wt% and coconut husk with adsorption of 2.7wt% showed the highest, respectively. Generally, the results for all the biochar pyrolyzed at the three temperatures showed that higher pyrolysis temperature produced biochar with more favorable adsorption for carbon dioxide.

VPC-008

FORMULATED BIOCHARS TO OPTIMISE CARBON CAPTURE AND SOIL FERTILITY BENEFITS

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Climate zones are experiencing increasing periods of drought that is increasing desertification. Sandy soils in these zones respond positively in terms of increased soil fertility through increases in water retention and water capacity and soil organic carbon (SOC) after biochar application.
•Increased soil water content (field capacity, wilting point or plant available water);
•Increased SOC in loamy sand and sandy loam soils in arid cool and warm environments.
Increased formulation steps to optimise the effectiveness of the biochar should be considered when developing an application strategy as an alternative to simply charring lignocellulosic material because formulated biochars increases the potential to:
• lower rates of application for the same or better positive effect on soil fertility;
• more targetted application to the rhizosphere with colloidal mixtures;
• targetted immobilisation of toxic contaminants.
Against these advantages however, the additional capital and operating costs have to be weighed for each extra step in biochar formulation, such as; mineral and biosolid addition, particle size reduction, pelletising and colloidal suspension.
If a regional community was interested in carbon drawdown to generate carbon credits while at the same time increasing regional soil fertility, what factors should be considered and what is the likely balance between biochar formulation, feedstock, process methods. for 3 formulation types from high carbon and low nutrient and mineral concentration. We examine the interplay of these factors using data typical of Australian regional and metropolitan centres to identify the sweet spot for those wanting to participate in the voluntary carbon markets through the production of biochar for improving soil fertility using 3 generic formulations, from a relatively high carbon low nutrient and mineral concentrations to low carbon and high nutrient and mineral concentrations.

VPC-009

HIGHER PERFORMANCE IN TOUGHNESS OF ISOSORBIDE BASED POLY(ARYLENE ETHER KETONE) THROUGH IN-SITU POLYMERIZATION WITH CELLULOSE NANOFIBER

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In the polymer industry, isosorbide is a promising monomer as the biomaterials for achieving a sustainable society and high Tg. However, sometimes high Tg makes polymer too brittle that polymer can have high tensile strength but low toughness values. Therefore, we attempted to synthesize nanocomposite to improve toughness while maintaining tensile strength. Here, we synthesized isosorbide-based poly(arylene ether ketone)(PAEK) through in-situ polymerization with cellulose nanofiber(CNF) as a filler. The composites showed a slightly higher tensile strength but 50% improvement in toughness than neat PAEK. The fracture surface was analyzed using scanning electron microscope, and the structure was analyzed through dynamic mechanical analysis and rheometer. And thermal stability was confirmed using differential scanning calorimetry, thermogravimetric analysis, coefficient of thermal expansion.

VPC-010

'IN-SITU' PREPARATION OF TISSUE PAPER DERIVED POROUS CARBON/POLYTHIPHENE COMPOSITE ELECTRODE FOR ASSYMETRIC SUPERCAPACITOR APPLICATION

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Biowaste referred to any residual materials from animals, plants and other organic matter. Being a rich source of carbon, biowaste can be converted into activated carbon with facile synthesis approach. Incorporation of pseudocapacitance material (such as conducting polymer) to activated carbon may impart pseudocapacitance characteristics to the material which could enhance the electrochemical properties of the electrode material. In this work, tissue paper was utilized as biowaste precursor and pre-carbonized via hydrothermal carbonization and subsequently activated chemically with KOH at 800 ℃ which yield activated carbon T-800. Afterwards, composite of T-800 with polythiophene(T-800/PTP) was synthesized via chemical oxidative polymerization. XRD and Raman spectra confirmed the formation of composite material. When tested in three electrode system in 1M H2SO4 electrolyte, T-800/PTP composite material shows much better performance when compared to PTP and T-800 rendering higher specific capacitance of 634 F/g compared to T-800 (260 F/g) and PTP (95 F/g) at current density of 0.5 A/g. In addition, asymmetrical supercapacitor device T-800//T-800/PTP was fabricated in aqueous electrolyte 1M H2SO4 which delivered ultra-high energy density of 70.8 Wh/kg at decent power density of 377.5 W/kg. Our research provides a new supply of an electroactive carbon material that is low-cost, environmentally benign, and long-lasting, with tremendous promise for supercapacitor applications.

Keywords : biowaste, hydrothermal, composite, activated carbon (AC), supercapacitor

VPC-011

VALORISATION OF VARIOUS TYPES OF PAPER WASTES FOR LEVULINIC ACID PRODUCTION

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Paper waste is unavoidable and constitutes a major waste stream in present society. A significant amount of paper wastes generated every year are burdening landfills across the world, whereas only a fraction of generated paper waste is being recycled. Efficient recycling of paper wastes could be even more challenging in the absence of proper recycling facilities. This situation drives society to seek a cost-effective and sustainable approach to recycling and valorising paper waste. Paper is usually manufactured from lignocellulosic raw materials, such as wood, bamboo, straw, bagasse etc. It contains a high proportion of cellulosic fibre, which could be valorised to produce sugars and chemicals in biorefineries. Recent studies demonstrated paper towel waste as a viable lignocellulosic substrate to synthesise platform chemicals through thermocatalytic treatment in various green solvent systems. However, depending on raw materials and pulp making process, paper waste characteristics could vary, which might influence the valorisation process i.e., catalytic hydrolysis/dehydration and the yield of the target product would vary. This research investigates various types of paper waste streams to produce levulinic acid (LA) as a target product through acid catalysis. To distinguish the raw materials from different sources, pulping process, and other relevant characteristics, virgin papers were purchased from selected suppliers and utilised as feedstock in the experiment, such as printing paper, packaging paper, newspaper, paper cutleries, napkins etc. This research presents useful insights regarding the feasible valorisation of paper wastes originated from diverse sources and their influential characteristics on LA production.

Keywords : Biorefinery, Lignocellulose, Paper recycling, Platform chemical, Circular economy.

VPC-012

ANAEROBIC CO-DIGESTION OF AGRICULTURAL RESIDUES AND SELECTED ORGANIC WASTE MATERIALS FOR BIOGAS PRODUCTION IN EGYPT

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Agriculture is one of the main highly contributing sectors to the Egyptian national economy. According to world development indicators of 2020, it presents 11.5% to Egypt's GDP. This massive agricultural production of different crops exceeds 52,492,000 tons in 2019/2018. After conducting calculations based on the rate of agricultural residue production per area cultivated, the results show that there is more than 25,638,260 tons of agricultural residue produced in 2019/2018. Open field burning of such residues was mainstream over the past decades in Egypt, the fact that has led to several recorded incidents of high pollution loads of NOx and CO, in addition to health costs of an estimated 0.7 billion EGP per year. Therefore, agricultural waste management, and especially conversion to energy, was the focus of the Egyptian Environmental protection agency. Anerobic digestion is now a mature waste-to-energy conversion technology with which biomethanation of the agricultural residues, such as rice straw and corn stalks, can take place. However, due to its lignocellulosic nature, and the high percentage of carbon to nitrogen ratio, anaerobic co-digestion of such wastes with additional substrates, such as food waste or animal manure, had offered a more technically and economically viable route towards the digestion of lignocellulosic wastes. In this project, we develop a crop substrate selection matrix, based on which a techno-economic decision can be taken on agri-waste residues, and the viability of their processing by means of co-digestion anaerobically. The matrix considers the operational and economic realities prevailing in Egypt since the year 2020, especially the environmental regulations pertaining to residue burning, and farming rationalization due to water stress.

VPC-013

ECONOMIC, ENERGY AND ENVIRONMENTAL ANALYSIS OF SWINE WASTE USE IN BRAZIL: OPPORTUNITIES AND CHALLENGES

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In view of the worsening of global warming, nations are directing efforts in the construction of renewable energy matrices. Specifically regarding to swine manure biomass, Brazil can contribute to the generation of jobs, boost the national production chain, and create and strengthen green competitive advantages. Thus, the purpose of this research is to carry out an economic, energy and environmental analysis of this waste in order to evaluate the following proposition: given the economic, environmental, energy and social scenario in Brazil, the generation of electricity, biogas and fertilizers, as well as its potential for replacing diesel from swine manure can contribute to sustainable development in the country. Therefore, the method used was the economic analysis of breeding units of 100 to 500 pigs of 25 kg to 100 kg with 252 days of operation 10 hours/day. As well as the use of canvas biodigester and 29% efficiency motor generator for an electricity price range: USD 35.35/MWh, USD 65.35/MWh, USD 95.35 MWh, USD 125.35 MWh and USD 155.35 MWh. Also, the price of urea in USD is 7.06/m3, simple superphosphate in USD is 0.61/m3 and potassium chloride in USD is 0.62/m3, the taxes on the sale of electricity and fertilizers in 34%, minimum attractiveness rate of 12% pa and the carbon credit price at US$ 63.37/t CO2. The results found indicate the feasibility for the entire range of creation with the sale of both fertilizers and electricity at the price of USD 35.35/MWh. As for the exclusive sale of electricity, it is only feasible to raise 200 to 500 hogs at a price of USD 125.35/MWh and for the entire range of creation at a price of 155.35/MWh. To replace diesel, with the usage of 10% of the biogas generated, there is economic viability starting from the creation of 200 pigs. The importance of the three dimensions analysis can be concluded, not only for the livestock units, but also for the entire country, especially in the southern region, which concentrates the largest number of breeding. However, it is necessary that not only the energy from this waste is valued, but also all its socio-environmental externalities, especially in regulated and energy-free environments.

VPC-014

MANAGEMENT OF TOXIC PAPER MILL WASTES THROUGH VERMITECHNOLOGY: A COMPREHENSIVE ECOTECHNOLOGICAL INSIGHT TOWARDS WASTE VALORIZATION

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Among several technologies of solid waste management, vermicomposting has been proven to play effective roles in valorization of wastes through the synergistic action of earthworms' and associated microbes. Owing to high organic content, paper mill sludges (PMS) were properly processed, sundried followed by mixing up with fully dried farm yard manure (cowdung) and straw in different ratios. The present research study had utilised Eisenia fetida for the period of 60 days. A significant decrease in dry weight of primary PMS (77%) and secondary PMS (76%) were perceived through thermogravimetric (TG) analysis. The biodegradation of complex xenobiotics such as lignin, cellulose, etc. were observed in spectral bands of FTIR spectroscopy which had ascribed to degree of mineralization among compost samples. A significant correlation between the decrease of the C/N ratio and the rise of the 2921/1633 peak ratio of FTIR had conferred the maturity among vermicompost samples. Furthermore, the presence of different macromolecular humic acid-like substances such as benzene dicarboxylic acid, propanedioic acid, glutaric acid, etc. were found in the vermicompost samples through GC–MS analysis. In addition to such qualitative enhancement, microbial diversity was established using PLFA biomarkers which had revealed a huge bottleneck in terms of microbial populaces designating ecological succession upon vermicomposting. Furthermore, the study had documented an evidence the removal through reduction of different metallic components lead, zinc, chromium and copper from the sludge samples. The study had noticed enrichment of different types of extracellular enzymes such as aminopeptidases, esterases, glycosyl hydrolases etc. using modern upgraded API-ZYM TM technology to demonstrate the role of such enzymes in biodegradation of solid sludges. Several bacterial isolates (common to both vermicompost and earthworm Eisenia fetida) were identified using 16 srRNA sequencing to identify the source of such extracellular enzymes. Thus, the prevailing research has well acknowledged the impact of vermicomposting in biodegradation of organic sludges and will open up a new vista of valorization in context of sustainable waste management.

Keywords : Valorization; Organic sludge; Biodegradation; Enzymes; PLFA biomarkers

VPC-015

RECOMBINANT PROTEIN PRODUCTION YIELD INCREASED BY FLAGELLA SYNTHESIS MUTATION IN ESCHERICHIA COLI

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Protein production requires a significant amount of intracellular energy. Eliminating the flagella has been proposed to help Escherichia coli improve protein production by reducing energy consumption. In this study, the gene encoding a subunit of FlhC, a master regulator of flagella assembly, was deleted to reduce the expression of flagella related genes. FlhC knockout in the ptsG-deleted strain triggered significant growth retardation with increased ATP levels and a higher NADPH/NADPC ratio. Metabolic flux analysis using a 13C-labeled carbon substrate showed increased fluxes toward the pentose phosphate and tricarboxylic acid cycle pathways in the flhC and ptsG deleted strains. Introduction of a high copy number plasmid or overexpression of the recombinant protein in this strain restored growth rate without increasing glucose consumption. These results suggest that the metabolic burden caused by flhC deletion was resolved by recombinant protein production. The recombinant enhanced green fluorescent protein yield per glucose consumption increased 1.81-fold in the flhC mutant strain. Thus, our study demonstrates that high-yield production of the recombinant protein was achieved with reduced flagella formation.

VPC-016

CATALYTIC CO-HYDROTHERMAL CARBONIZARION OF FOOD WASTE DIGESTATE AND YARD WASTE FOR ENVIRONMENTAL/ENERGY APPLICATIONS

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Catalytic co-hydrothermal carbonization of food waste digestate (FWD) and yard waste (YW) blend was conducted to enhance the hydrochar properties for environmental/energy application. To enhance the application capacity of hydrochar, organic (organic acid and solvent) and inorganic (mineral acid and oxidant) catalytic systems were applied. Results indicated that blending FWD and YW with ratio of 1:1 could achieve higher comprehensive combustion index than FWD-derived hydrochar. Catalytic system with 1 M citric acid exhibited the highest higher heating value (HHV; 25.7 MJ kg^{-1}), while system with 0.5 M HCl achieved comparable HHV (24.7 MJ kg^{-1}) with better combustion stability. Hydrochar catalyzed by water-ethanol system and 0.5 M HNO_3 obtained higher surface reactivity with atomic O/C ratio of 0.41 and 0.47, respectively. Although YW-derived hydrochar achieved high HHV (23.2 MJ kg^{-1}) with stable combustion behavior, co-hydrothermal of YW and FWD could be a possible solution to valorize FWD for sustainable waste management and circular economy.

VPC-017

ENGINEERED HIERARCHICAL POROUS CARBON FROM BIOMASS WASTE AS A HIGH-PERFORMANCE ELECTRODE FOR CAPACITIVE DEIONIZATION

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Valorization of biomass waste to engineered nanoporous carbon materials for environmental applications (e.g., adsorption, catalyst and energy storage) has receiving increasing attention in recent years. Inspired by energy storage technology (i.e, supercapacitor), capacitive deionization (CDI) with nanoporous electrodes is a promising electrochemical technology to remove salt ions or charged contaminants from aqueous solutions. In this present work, the hierarchically porous carbon (HPC) materials were derived from waste biomass (e.g., loofa sponge, husk rice and activated biochar) and utilized as a high-performance electrode for CDI applications. Note that the pore properties can be manipulated by controlling the activation process, including KOH etching, CO2 gasification, and temperature. As a result, the resultant HPC electrodes had the desirable pore structures of high specific surface area, micrometer-scale channels and both meso-/micropores. By utilizing the HPC electrode at a low potential electric field (1.2 V), the ions can be successfully removed during the charging step via the electrical double-layer formation. Notably, the CDI is a low-energy input and regenerable process with the potential of energy recovery. Moreover, the HPC electrodes can be further used to remove various unwanted ions from water such as heavy metals, nutrient and arsenic. The findings indicate that CDI with biomass waste-derived HPC electrodes has great potential for brackish water desalination, groundwater remediation, wastewater reclamation, and resource recovery.

VPC-018

ENVIRONMENTAL SUSTAINABILITY OF EMERGING FOOD WASTE BIOVALORIZATION PROCESS: A DYNAMIC LIFE CYCLE ASSESSMENT (dLCA) APPROACH TO GUIDE THE SUSTAINABLE SCALE-UP OF WASTE-DERIVED SOPHOROLIPID PRODUCTION

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Microbial biosurfactants have been gaining attention as a potential replacement to synthetic surfactants as they can be produced from renewable feedstocks, have lower environmental toxicity, and are highly biodegradable. Sophorolipids (SLs) are among the most promising biosurfactants, as they hold the largest share of the biosurfactant market. Currently, researchers are developing novel approaches for SL production that utilize renewable feedstocks and advanced separation technologies. However, challenges still exist regarding the consumption of materials, enzymes, and electricity, that are primarily fossil derived. Researchers lack a clear understanding of the associated environmental impacts. Therefore, it is imperative to quantify and optimize the environmental impacts of this emerging technology early in its design phase to guide a sustainable scale-up. It is necessary to take a collaborative perspective, wherein life cycle assessment (LCA) experts work with experimentalists to quantify environmental impacts and provide recommendations for improvements in the novel waste-derived SL production pathways. Studies that have analyzed the environmental sustainability of microbial biosurfactant production are very scarce in the literature. Hence, in this work, we perform LCA to evaluate the environmental sustainability of SL production. Specifically, we apply the dynamic LCA (dLCA) framework that quantifies the environmental impacts of a process in an iterative manner. The first traversal of the dLCA was associated with selecting an optimal waste feedstock for SL production and identified food waste as a promising feedstock. The second traversal compared the alternative fermentation processes with different separation techniques. It highlighted that the fed-batch fermentation of food waste integrated with the in-situ separation technique resulted in the least environmental impacts. The third traversal of dLCA integrated with techno-economic analysis (TEA) evaluated the latest advancements in industrial-scale SL production. A systematic investigation of the two potential pathways that produce SL crystals and syrup was conducted. The Ashby-like charts based on the LCA and TEA results at the pilot plant scale highlighted the trade-offs between systemic environmental costs and economic benefits associated with various design decisions. These results highlight the value of the dLCA framework to guide the future advancement of emerging waste biovalorization processes as they mature to ensure environmental and economic sustainability on scale-up.

Keywords : Waste Valorization; Sophorolipids; Biosurfactants; Life Cycle Assessment; Techno-Economic Analysis; dynamic Life Cycle Assessment; Process Optimization.

VPC-019

A UNIVERSAL STRATEGY FOR PREPARATION OF CARBON SUPERSTRUCTURES FROM BIOMASS

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Three-dimensional carbon superstructures have great potential for applications in various fields, as their integrated structure enhances the exposure of active sites and lowers the diffusion resistance for reactants. However, their cost-effectively synthesis remains a great challenge. Herein, we report a universal strategy for the fabrication of large-sized carbon superstructures with a series of biomass derivatives. In this process, the spheroidizing growth of biomass hydrochar as an assembly drive and the flakiness process from organically lamellar crystal are combined. They can induce the formation of subunits for assembling the superstructure body that further blooms to carbon superstructures via pyrolysis. The flowers-like carbon superstructure with i. e. starch as the starting feedstock possessed large surface area and pore volume (1010.5 m2/g, 1.80 cm3/g), high nitrogen content (14.6 wt %) and thin nanosheets structure (1.5 nm in thickness), showing low ion diffusion resistance and outstanding rate capability as an electrode for supercapacitors and high activity towards hydrogenation of o-chloronitrobenzene. The carbon superstructures with other morphology were also obtained via the use of other biomass derivatives such as polysaccharide, bio-oil and swine manure, confirming the universality of the strategy.

VPC-020

ASSESSMENT OF STARFISH (ASTERINA PECTINIFERA) DERIVED BIOCHAR FOR THE REMOVAL OF Pb, Zn, Cu AND Cd IN CONTAMINATED SOLUTION

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Heavy metal pollution is increasing due to the treatment of industrial and agricultural wastes as a result of human activities and is a serious problem worldwide. $CaCO_3$ is known as an effective heavy metal removal agent through both adsorption and precipitation mechanisms. Therefore, it was judged that the natural starfish (SF) which is mainly composed of $CaCO_3$could be environmentally and economically applicable to the removal of heavy metals in wastewater. In this study, Starfish (Asterina Pectinifera, SF) derived biochar was produced by pyrolysis at 700℃ for 2 hours in anaerobic conditions which was designated as PSF700. Afterward, the characteristics at the surface of SF and PSF700 were evaluated by SEM, XRD, BET, elementary and FT-IR analyses. Also, the removal capacity of PSF700 was evaluated for contaminated solutions containing Pb, Zn, Cu, and Cd. As a result of the XRD analysis, PSF700 was transformed into CaO and $Ca(OH)_2$ by pyrolysis. SEM and BET analyses showed a large number of pores and an increase in the surface area for PSF700 upon pyrolysis. Accordingly, the surface of PSF700 by pyrolysis was significantly improved for heavy metals removal. The batch experiment was performed by injecting 10mL of heavy metal solution into a 15ml conical tube and the amount of PSF700 tested ranged from 0.05 to 1.0g. The batch results showed that Pb removal was 57~99%, Zn removal was 91~99%, Cu removal was 98~99%, and Cd removal was almost 100%. Therefore, PSF700 should be considered for use as a natural waste resource for the removal of heavy metals based on its environmental and economical viability.

VPC-021

BIOLOGICALLY ENHANCED BIOCHAR FOR BIOLOGICAL WATER TREATMENT

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Biologically-Enhanced Biochar (BEB) is a cost-effective, sustainable option for water treatment rooted in effective waste valorisation, especially in agrarian economies with easy access to abundant biomass in the form of crop residue and organic wastes. With scope for both home-scale and industrial-scale production, biochar is a carbon-rich product of a pyrolytic thermochemical conversion of biomass produced under oxygen-deficient conditions. Biochar has gained wide attention due to its carbon-sequestration potential and multi-functional nature, leading to its use in several energy and environment applications. Biochar are great microbial inoculum carriers and these immobilized microbes can reproduce on the biochar surface and pores, eventually forming BEBs and facilitate removal of several organic-inorganic contaminants via a combined adsorption and biodegradation process. Exhausted BEBs which could also contain rich nutrients such N, P, K can also be used as soil additives.
We discuss the scope, potential benefits (economic and environmental) and challenges of sustainable biological water treatment using 'Biologically-Enhanced Biochar' or BEB and discuss the various processes occurring in BEB systems. We highlight the need to correlate biochar properties to biofilm development, which can eventually determine process efficiency. We also demonstrate the various opportunities in adopting BEB as a cheaper and more viable alternative in Low and Middle Income Countries and compare it to the current benchmark, 'Biological Activated Carbon'. We focus on the recent advances in the areas of data science, mathematical modelling and molecular biology to systematically and sustainably design BEB filters, unlike the largely empirical design approaches seen in water treatment. We support this hypothesis and our perspectives with our successful proof-of-concept study, where we biologically enhance coconut shell biochar using naturally occurring microbes and efficiently eliminate the cyanotoxin Microcystin-LR in water.

VPC-022

WALNUT SHELL-DERIVED BIOCHAR VALORIZATION FOR ECO-EFFICIENT REMOVAL OF ARSENIC FROM INDO-GANGETIC SUB-TROPICAL SILTY LOAMS: PROMOTING SUSTAINABLE MANAGEMENT OF ARSENIC POLLUTION

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Walnut (Juglans sp.) production has increased from 1.78 million tons in 2005 to 4.5 million tons in 2019. Since >60% of walnut fruit is composed of husks and shells, huge quantities of waste is generated after obtaining valuable kernels during its processing. Powdered walnut shells have been used as adsorbent materials, but certain areas of the world burn these shells as fuel which pollutes the environment. Presence of >1/3rd of lignin and minimal hydrophobic components in walnut shells indicate immense potential for its valorization into highly stable carbon rich-biochar, which could be used as adsorbent of metal(loid)s. In the present study, walnut shell-derived biochar prepared at 500°C was evaluated for possible soil amendment on the basis of arsenic adsorption and beneficial physico-chemical properties. Low H/C ratio (derived from CHNS analyser) and thermo-gravimetric analysis indicated high biochar stability, while field emission scanning electron microscope and spectroscopic studies revealed pore-rich surface and presence of minerals and active surface

functional groups (carboxyl, carbonyl, amide, and hydroxyl) indicating its potential for arsenic sequestration. Peak shifting was observed in x-ray diffraction and fourier-transform infrared plots implying involvement of arsenic chemisorption. Brunauer–Emmett–Teller analysis confirmed high surface area of produced sorbent (148.05 m^2g-1). Lastly, adsorption studies revealed maximum arsenic removal (88.8±0.04%) at 8 ppm initial concentration, 5% dose, 25°C temperature, and 30 min contact time, while Isotherm, Kinetic and Thermodynamic studies showed probable role of chemisorption, physisorption, ion-exchange, and diffusion for arsenic sequestration. Present investigation proposes valorization of nutrient-rich walnut fruit waste into thermo-stable biochar for remediation of arsenic pollution from soil/water dynamic systems, safe production of food crops, and stepping towards sustainable strengthening of ecosystem health.

VPC-023

STRUCTURE-PROPERTY RELATIONSHIP OF THERMOPLASTIC POLYURETHANE COMPOSITES WITH INCLUSION OF MODIFIED MICROCRYSTALLINE CELLULOSE

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With growing interest of eco-friendly polymer composites, many researchers employed cellulose as a filler for polymer composites. In particular, microcrystalline cellulose (MCC) obtained by acid treatment of cellulose has advantages such as high crystallinity and mechanical properties originating from strong intermolecular hydrogen bonding. However, too strong interaction among MCCs can lead to aggregation of fillers in polymer composites, reducing the interfacial areas and reinforcement effects between the polymer matrix and filler. In this research, we employed three different chemically modified microcrystalline cellulose (m-MCC) where hydroxyl groups of MCC were substituted by either methyl (-CH3) or hydroxypropyl (-CH2CH(OH)CH3) groups: (1) low substitution degree with methyl group (HP-0), (2) medium substitution degree with methyl and hydroxypropyl groups (HP-low), and (3) high substitution degree with methyl and hydroxypropyl groups (HP-high). Three different types of m-MCCs were compounded with ester type thermoplastic polyurethane (TPU) by an extrusion process. As the chemical substitution of hydroxyl group by methyl or hydroxypropyl functional groups can reduce the number of hydrogen bonding sites or increase m-MCC intermolecular distances, both crystallinity of m-MCCs and polymer-filler interaction can also be manipulated. In this presentation, we will discuss structure-property relationships of TPU-MCC composites with focuses on correlation of crystallinity and dispersion of m-MCC with mechanical properties of the TPU-MCC composites.

VPC-024

DECISION SUPPORT SYSTEM FOR FOOD WASTE VALORIZATION BASED ON DATA-DRIVEN OPTIMIZATION FOR NEGATIVE CARBON EMISSIONS

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The energy return of investment (EROI) and net life-cycle global warming potential (GWP) of these conversions coupled with CCS were evaluated based on the optimal conversion conditions for bioenergy and biochar produced from food waste, with the products applied for electricity generation and carbon sequestration in soils. We find that AD shows the highest EROI (15.45 and 1.31) and lowest net GWP (373.25 and -213.46 kg CO2-eq/t food waste) for waste to energy (WtE), without and with CCS integrated, respectively. For waste to energy and biochar (WtE/B) conversions, the net GWP significantly decreased compared with WtE. For WtE/B + CCS, HTL is the most promising technology for both EROI and net GWP. Generally, AD + CCS is the most effective approach for negative carbon emission after the operational conditions are optimized. This work provides valuable insights for selecting the most economic and sustainable technologies to valorize food waste and form a circular economy.

VPC-025

THE GLOBAL POTENTIAL OF RENEWABLE AND NEGATIVE EMISSION TECHNOLOGIES TOWARDS CLIMATE NEUTRALITY

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Under the common vision of humanity to reduce carbon emissions, renewable energy and negative emission technologies are promising technologies in the blueprint of low-carbon transition of energy systems. However, hybrid renewable energy systems combined with negative emission technologies, such as solar-wind-biomass-biochar systems, which have a synthetic effect and broad potential in building low-carbon energy systems, remain under-explored. Here, we quantify the potential role of such systems in the low-carbon transition of the global energy system and recommend preferred sites for technology implementation. The specific technologies for each region are selected using mixed-integer linear programming. The result shows that the proposed system can achieve net-zero emissions when solar and wind technologies are used in conjunction with gasification and pyrolysis of biomass. Furthermore, it is also possible to remove carbon dioxide at a rate of 3.23 Mt CO2-eq/y globally at balanced cost-effectiveness. The results indicate that more than 60% of the negative emissions can be met by implementing the proposed technologies in the top ten biomass-rich countries, including Brazil, the United States, Russia, China, and India etc. Our results show the global distribution of renewable energy and potential of negative emission technologies, which demonstrate the economic and carbon sequestration feasibility of negative-emission hybrid renewable energy systems in most countries of the world. We anticipate that our findings will help countries refine their emission reduction targets, agree on a global commitment to reduce emissions, and design sustainable energy systems that benefit the world as a whole.

VPC-026

BIOMARKER OF PYROGENIC ORGANIC MATTER AND INTERMEDIATE DEGRADATION PRODUCTS

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Pyrogenic organic matter (PyOM) is mainly composed of incompletely combusted organic compounds with a high aromatic component, and may play an important role in the global carbon cycle. The biomarkers and degradation products of PyOM are proposed similar to graphite and lignin, yet little is known about its intermediate degradation products. This study deciphers the fragment patterns of various lignin monomer and PyOM made at different temperatures, and explores their X-ray Absorption Near Edge Structure (XANES) properties by using soft X-ray coupled reflection time-of-flight mass spectrometer with orthogonal acceleration (OA-R-TOF-MS) at the National Synchrotron Radiation Center (TLS 05B1 station). A synchrotron radiation light source was used to excite the inner electrons from specific molecular orbitals (carbon K shell) and the chemical finger-print of functional groups have been characterized. The features of different lignin monomers and different functional groups have been summarized and semi-quantified, which generate useful biomarker index for differentiating the source of wood plant (soft vs hard wood) and understanding the aromaticity and the oxidation level of carbon in natural samples. Summarizing the spectral peak positions of different functional groups help predict possible degradation products from natural lignin and PyOM. Spectral fitting provides a semi-quantitative model for characterizing different organic carbon with aromatic features.

Keywords : Pyrogenic organic matter (PyOM), Lignin, X-ray absorption near edge structure (XANES), biomarkers, degradation

VPC-027

LIFE CYCLE ASSESSMENT ON MIXED COMBUSTION OF INDUSTRIAL SOLID WASTE WITH HIGH HEATING VALUE AND MUNICIPAL SOLID WASTE

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The industrialization process of China has achieved remarkable economic and social development in recent decades, which companies with excessive production of industrial solid waste(ISW). It took up a large amount of land and led to potential environmental problems such as air, water, soil pollution. With the increasing awareness of environmental protection and the better vision to build a pattern of sustainable economy, the comprehensive utilization of ISW is becoming a challenging and promising research field. In this work, a waste incineration power plant in Foshan city (Guangdong Province, China) was selected as the research object. Its novel incineration scheme by mix ISW and MSW was evaluated, which aims to improve power generation efficiency. The comprehensive environmental impact assessment of this refuse incineration-power generation technology was also carried out by life cycle assessment. Results show that compared with landfill treatment, the carbon emission of ISW disposal by incineration power generation is reduced by 89.7%, and the non-CO2 greenhouse gas emission is reduced by 99.1%. At the same time, compared with the average on-grid power of China Southern Power Grid, the average power generation carbon emission of this power plant is reduced by 78.7%, and the non-CO2 greenhouse gas emission is reduced by 84.3%. The superiority of disposal of ISW in the incineration power plant is illustrated from the solid waste treatment perspective and power generation perspective. In addition, the variation of environmental impacts with the mix ratio of industrial solid waste was estimated using life cycle assessment (LCA). The energy conservation and emission reduction index(ECER) obtained by selecting multiple environmental impact indicators was used to compare the Comprehensive environmental impact of different ISW proportions. Results show that the ECER value increases with the increased mix ratio of ISW, but the ECER value only increases by 6.5% while the mix ratio of ISW increased from 20% to 40%. Also, the minor impact on the contribution ratio of each link in the power generation system indicates that the environmental impact would not significantly change to co-dispose a large proportion of industrial solid waste in refuse incineration power generation.

VPC-028

INSIGHT INTO MECHANISMS OF BALL-MILLED BIOCHAR ADDITION ON SOIL TETRACYCLINE DEGRADATION ENHANCEMENT: PHYSCIOCHEMICAL PROPERTIES AND MICROBIAL COMMUNITY STRUCTURE

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A set of soil under the addition of ball-milled biochar (BM-biochar) from different feedstocks (wheat straw (WS) and rice husk (RH)) and pyrolysis temperature (300 °C, 500 °C, and 700 °C) was established to analyze the tetracycline (TC) degradation performance enhancement and greenhouse gas (CO_2 and N_2O) emission reduction from various angles, including physicochemical properties of soil and microbial community structure. Results revealed that the KCl-leachable TC concentrations and total amount of TC in soil decreased from 0.0064 to 0.0037 mg/L and from 2.17 to 0.079 mg/kg, respectively, after the addition of BMWS500, suggesting the adsorption and degradation of TC by the promoting effect of biochars on microorganisms. The soil pH, CO_2, and N_2O emissions decreased after the addition of unmillied and BM-biochars, while ball milling reduced the inhibitory effect of biochar on CO_2 emission. The addition of BM-biochar changed the microbial community diversity. The relative abundance of bacterium and fungus such as Proteobacteria, Acidobacteria, Chlorofexi, Mortierella, and Chaetomium increased due to BM-biochar addition, which promoted the degradation of TC and gave rise to more healthy soil environment for plant or microbes. The larger specific surface area, π–π interactions, hydrophobic interaction, and hydrogen bonding are account for better degradation of TC by BM-biochars. This work elucidated the management of organic contaminants in real soil by BM-biochar.

Keywords : Biochar; Ball milling; Tetracycline; Biodegradation; Soil microorganisms

VPC-029

VALORIZATION OF WASTE PLASTICS INTO STIFF CARBON FOAM

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Carbon foams are lightweight materials that are usually electrically conductive but thermally non-conductive due to the presence of air spaces in their cell. Carbon foams contain no volatile matter and are non-combustible. Carbon foams have numerous applications such as thermal and sound insulation, electrodes, energy storage, filtration, and adsorption. However, the availability of cheap precursors for the synthesis of porous three-dimensional carbon foams remains a challenge. On the other hand, waste plastics, which are generally immune to natural degradation cycles have serious environmental impacts due to poor management. This work presents a green and facile method of utilizing waste polystyrene plastics from end-of-life disposable cutleries as a cheap precursor for producing carbon foam. The waste polystyrene plastics were washed, dried and carbonized in an enclosed stainless steel autoclave at 600 oC under autogenic pressure to produce carbon char (graphite). The synthesized graphitic carbon was mixed with lignin (fluxing agent) at a ratio of 1:1 w/w in a ceramic cup. The ceramic cup is placed in a microwave and exposed to microwave irradiation. The microwave heating causes the epoxy to devolatilize which causes the cake to rise. The risen cake was compressed several times until the epoxy completely decomposes, and the cake no longer rises. The resultant cake was allowed to cool to form a rigid carbon foam. The produced carbon foam was characterized using scanning electron microscope (SEM), transmission electron microscope (TEM), Brunauer Emmett Teller (BET) surface area analysis, energy dispersion X-rays spectroscopy (EDX), X-Ray diffraction (XRD), Fourier transform infrared (FTIR), thermal constants analyzer and universal compression tester. The stiff carbon foam was compared with other commercial thermal insulation carbon foams to assess its commercial potential. It was proven that the synthesized stiff carbon foam in this work is a promising material for thermal insulation and other applications. The upcycling of waste enriched the economic feasibility of the prepared material. Moreover, the utilization of waste plastics provides a sustainable and profitable approach to managing waste plastics.

VPC-030

BIOPLASTIC FILM PRODUCTION USING KAPPAPHYCUS ALVAREZII AND ITS DEGRADATION STUDY USING DEEP SEA MARINE MICROORGANISM CONSORTIA

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Kappaphycus alvarezii, a red seaweed having value added polymer such as carrageenan. In this study, whole seaweed of Kappaphycus (3%, 4% and 5% dry weight) was used for bioplastic film development using a plasticizer polyethylene glycol (PEG 3000). 10 days maximum bioplastic degradation was 88 %.

VPC-031

LIGNIN DERIVED ACTIVATED CARBON FOR THE MOISTURE DRIVEN ENERGY HARVESTING APPLICATIONS

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Lignin is the second most abundant biopolymer available locally yet on a global scale. This is normally burnt off to get the energy benefits, but it can also be utilized for several other benefits such as for the production of sustainable materials and even for the energy harvesting applications. Lignin derived activated carbon can be used for the moistute driven energy harvesting applications by way of taking the benefits from the static charge present on the surface of the carbonized lignin. Therefore, in this study, we used the carbonized lignin for the fabrication of lignin-based water evaporative power generators (LB-WEPGs). Mxene was etched from primary phase Max powder and subjected to etching and exfoliation according to previous approach of HF acid. Later on, this mxene and the carbonised lignin along with carbon black were mixed together in an appropriate ratio and bath sonicated for about 1 hrs. Finally, this thick blackish slurry was evenly coated onto the surface of the cellulosic sheet to fabricate the LB-WEPGs. All these sheets were dried in an oven and then were put to the energy harvesting via the water evaporation by putting small amount of deionized water on the one side of the device. The performance of these power generators was evaluated by measuring open-circuit voltage (mV), short-circuit current (μA) and the maximum power obtained from this device was 3.18 MicroWatts with the corresponding voltage of 354 mV. This adapted approach seems to be an acceptable option for bio renewable energy harvesting devices.

VPC-032

PRODUCTION OF TRICHODERMA VIRIDE CONIDIA-BASED BIOCONTROL AGENT FROM CORN COB: SOLID-STATE FERMENTATION IN AN EARTHEN VESSEL

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Corn cob is a prominent substrate for solid-state fermentation of conidia-based biocontrol agents, which extends conidia shelf life while reducing the risk of contamination by other fungi. However, minimal processing should be required to use corn cob as a substrate for reducing cost and increasing the availability of conidia-based biocontrol agents. The present study focused on evaluating the growth and production of a Trichoderma viride conidia-based biocontrol agent using ground corn cobs of particle size 3mm and moisture content of 65.00%. T. viride conidial suspension inoculated in an earthen vessel filled with autoclaved corn cob fines and sealed with a plastic lid secured with cement to prevent contamination. 2.67×109 conidia/g of the dry substrate recovered from an earthen vessel after 21 days. The final preparation's moisture content was reduced to 8.41%, resulting in a granulated T. viride conidia-based biocontrol agent production. Over the ten months of storage in the same earthen vessel, viability dropped from 100%to 71.28%. T. viride showed mycoparasitism

(slide culture assay) and antagonism (dual plate method) against Rhizoctonia solani. T. viride reduced R. solani disease incidence and improved growth of potato plants treated every 7 days for 30 days. Therefore, corn cob can be used as the only substrate for economical, sustainable, and affordable Trichoderma viride conidia-based biocontrol agent production in an earthen vessel.

Keywords : Trichoderma viride, Corn cob, Conidia-based biocontrol products, Earthen vessel.

VPC-033

GENERALIZED ADDITIVE MODELS PREDICT BIOCHAR ELEMENTAL COMPOSITION DETERMINED BY DIFFERENT METHODS

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Biochar is one value-added product derived by pyrolyzing waste biomass, and its elemental composition is widely determined using ultimate analysis, energy dispersive X-ray spectroscopy (EDX), and X-ray photoelectron spectroscopy (XPS). However, models that describe relationships between biochar elemental composition determined using these methods are lacking. We used the elemental composition of more than 100 biochars determined using ultimate analysis, EDX, and XPS methods to develop relationships among these methods using linear regression and generalized additive modelling. The relationships were best described by the generalized additive model with a thin plate spline (TPS), and model performance significantly improved by adding a feedstock-dependent grouping variable. Elemental carbon concentration determined by the different methods was significantly related (R2 = 0.82–0.88) by the TPS. Nitrogen concentration was significantly related by TPS (R2 = 0.77) between the ultimate and XPS methods, but was not detected by the EDX method. A strongly significant relationship (R2 = 0.83–0.86) was found for oxygen concentration between the ultimate and both spectroscopic methods, but a weak one (R2 < 0.54) between the XPS and EDX methods. Min/max accuracy reached 80% and above during testing, confirming that the best-fit models would predict carbon, nitrogen and oxygen concentrations with small variations for several biochars. We conclude that the elemental composition of biochars is affected by the method used for its determination and the generalized additive models developed can be used to predict the elemental composition analyzed using different methods

VPC-034

LIGNIN-FIRST BIOREFINERY FOR THE ENHANCED PRODUCTION OF AROMATICS FROM BIOMASS

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It is well acknowledged that lignin constitutes the second most abundant biopolymer on earth and accounts for 10-30 wt.% of lignocellulosic biomass. Unfortunately, in spite of lignin's abundance, a historical misconception of lignin as presenting a subordinate valorization opportunity, persists. Indeed, the possibility of utilizing lignin as a renewable and sustainable natural source of aromatic compounds has been consistently ignored in existing biomass biorefinery systems, with lignin typically combusted as an energy source. The harsh delignification processes employed in conventional biorefineries

prioritize polysaccharide extraction at the expense of lignin valorization. These harsh delignification processes negatively influence lignin structure by converting the C–O ether bonds to a recalcitrant network of C–C bonds, thus reducing lignin utility as a viable biorefinery resource. Therefore, the present study sought to investigate the so-called 'lignin-first' biorefinery based on waste pomace (WP) as the renewable biomass resource. To this regard, the process variables of temperature (100-260 ℃), time (0.5-12 h), alcohol/water ratio v/v (0:1-1:0), and Fe^{3+}/H_2O_2 molar ratio (10:1-100-1) were investigated to assess their impact on the selective cleavage of the β-ether bonds between lignin molecules in the WP. Investigations were achieved via the response surface experimental method, with the hydrogen source (alcohol/water v/v) established to be the most important factor that influenced the yield of aromatics containing oil. The study determined that imposing the optimal conditions temperature, time, alcohol/water ratio v/v and Fe^{3+}/H_2O_2 molar ratio of 260 ℃, 5 h, 1 and 100 respectively, facilitated an oil product containing aromatics at a yield of ~25 wt.%. Notably, at optimal conditions, Fourier transform infrared analysis showed that some polysaccharides were retained in the solid phase, indicating the viability of employing the solid residue as a carbon source to produce biochemicals (i.e. lactic acid, bioethanol etc). The system thus presents an opportunity for enhanced value extraction from waste pomace.

VPC-035

CARBON-NEUTRAL 2,3-BUTANEDIOL BIOPRODUCTION FROM LIGNOCELLULOSIC BIOREFINERY: AN APPROACH TOWARDS FOOD PLUS FUEL NEXUS

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Transition from petrochemicals to biochemicals using third generation biorefineries are gaining attention in advancing the bioprocessing industry. However, the sustainability of this renewable shift is largely reliant on material cost, energy consumption, food, and carbon while maintaining small overall footprints. Previous studies were majorly focused on calculating the energy and carbon footprints while the social impact (food) of urban biorefinery is almost neglected. This study developed a sustainability index for quantifying the food and carbon benefit indexes with bioproduction of a platform chemical i.e., 2,3- butanediol (2,3-BDO) from lignocellulosic biomass (oil palm empty fruit bunches; OPEFB) as a second-generation feedstock. Organosolv-pretreated OPEFB was evaluated for 2,3-BDO production in comparison with commercial petro-based and bio-based first-generation refineries. The organosolv bioconversion process resulted into >75 g/L 2,3-BDO production from whole-slurry pretreated biomass (both hexose and pentose sugars) with 90% of the maximum theoretical yield. The integration of biorefinery process with oil palm crop industry can result into a sustainability index of 7.3 with 0.52 kg-food and 6.8 kgCO2-e carbon benefits per kg-BDO produced. Substituting from first generation to second generation biorefinery may also help in shifting the food vs. fuel index from −1.04 to +0.52, thus promoting the "food plus fuel nexus". This approach can be served as a benchmark for quantifying the sustainability of green products via food and carbon benefits by establishing the sustainable biorefinery route for future industrial production of biochemicals from renewable biomass in next generation biorefinery.

Keywords : 2,3-butanediol, organosolv pretreatment, whole-slurry fermentation, sustainability index, food plus fuel, biorefinery.

VPC-036

KNOWING THE 'ENVIRONMENTAL' SKELETON OF THE FISHING SECTOR THROUGH THE VALORIZATION OF THE TUNA HEADS, SPINES AND REMAINS

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The fishing sector is particularly affordable from an eco-perspective since represents important dynamics in terms of transport, huge volumes of catches and further manufacturing or packaging. Besides, fish and seafood are key products in balance and healthy diets over the world. Nevertheless, losses are unavoidable, since not all parts of the fish are suitable for human consumption. For instance, around the 60% of a tuna is edible flesh, being half skinless fillets. The rest (~40%) consists on the head, entrails or spins, which are usually transformed into fishmeal or fish oil. Indeed, the FAO expects an increase of the proportion of total fish oil and fishmeal obtained from fish waste from 40 to 45% and from 22 to 28%, respectively, between 2018 and 2030. In the case of remaining meat and broken tuna -resulting from the filleting step and others- the tuna paste is one of the by-products to minimize the waste obtaining an economic yield. Our work evaluates the performance of the whole skeleton of the fishing sector through the supply chain of the tuna -from the catching to the end of life- leading to conclude the main environmental impacts associated and addressing different scenarios in which the fish losses are valorise and, consequently, considered as avoided burdens. To do it, the life cycle assessment methodology has been applied in order to close the loop of the tuna's life and contributing to the circular economy in the sector. Results revealed that valorisation of food losses reduces the environmental impacts more than incineration and landfilling. The environmental characterisation of tuna meat valorisation to produce tuna paste showed that the production of polypropylene and glass for packaging presented the highest consumption of natural resources and the greatest environmental burdens. Packaging is part of the solution to reduce food impacts at the time it should increase shelf-life ensuring the quality and security of products. Moreover, it should be adapted to the new consumer lifestyles that are demanding more portion sized packages in order to reduce food waste. Therefore, in the future, packaging innovation and new technologies will play a key role in food waste prevention.

VPC-037

SCIENTOMETRIC ANALYSIS OF MICROWAVE PYROLYSIS IN BIOCHAR PRODUCTION AND ITS APPLICATION

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Biochar, a carbonaceous product received enormous attention owing to its remarkable role in agro-ecosystems. Being produced by thermochemical conversion using microwave, the characteristics of biochar is more enhanced and utilized for various applications. Inspite of increasing concern and publications growth, the linkage between the research hotspots that overlap with various subjects of microwave biochar research has not been charted out till now. Henceforth, this study adopts the scientometric analysis of aspects of biochar produced through microwave pyrolysis to explicate the research status in terms of systematic and structural description. The scientific manuscripts retrieved from Web of Science related to microwave derived biochar research published over the period of 2010-2021 has been analyzed in terms of structural metrics. The research has evolved from using microwave for sample digestion for characteristic analysis in previous years, whereas, the current research progresses towards cost effective and product selectivity in generating biochar containing low polyaromatic hydrocarbon that minimizes the toxicity of biochar application. Analysing the keywords, research hotspots were found to be "microwave catalytic pyrolysis", "adsorption of dyes, metal contaminants", "engineered biochar" and so on. China stands first in research contribution on application of microwave derived biochar whereas the research in India is still at nascent stage, and there is a need to focus not only on the production but also in agriculture and other potential applications to better realize its sustainability potential at field scale. In a nutshell, this study provide insight to new researchers and other stake holders on microwave derived biochar research and its progression in future.

Keywords : Agriculture; Biochar; Microwave; Research hotspots; Scientometric analysis

VPC-038

VALORISATION OF KITCHEN WASTE TO BIOCHAR FOR CARBON SEQUESTRATION

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Climate Change impacts are inevitable in the current state of the environment with toxic emissions of greenhouse gases (GHGs). With respect to the Paris agreement that addresses the climate change impacts mainly targeting the reduction in greenhouse gas emissions, nations set their Nationally Determined Contributions (NDCs) and explored several climate mitigation options. Recently, Biochar is consider as a significant tool to reduce the greenhouse gas emissions. As the sustainable biochar production has the immense potential to reduce 1.8 gigatonnes of CO2-C equivalent per year that equals to 12% of the anthropogenic emissions. Biochar is a promising method for capturing the carbon in a stabilized form and storing it for several number of years. It's amendment in soil improves the soil fertility and sequester the carbon. Pyrolysis is the most popular thermochemical process to convert organic materials into value added product as biochar. Kitchen waste contains higher concentrations of organic content that can possibly be converted to biochar. The present study aims to valorise the kitchen waste to biochar by pyrolysis conversion, characterise and assess their potential for carbon capture and sequestration. The kitchen based vegetable waste was used in the study. The physico-chemical properties and thermal properties of waste biochar were characterised by pH, electrical conductivity, proximate and ultimate analysis and thermal gravimetric analysis (TGA). Brunauer–Emmett–Teller (BET) surface area, porosity, Fourier Transform Infrared spectroscopy and scanning electron microscopy revealed the surface properties and functional groups of the biochar. The carbon sequestration assessment were carried out in the waste biochar using carbon sequestration and stability tests.

VPC-039

FABRICATION OF THERMOSTABLE MESOPOROUS BIOCHAR-BASED NANOCOMPOSITE FROM FRESHWATER ALGAL MATS FOR TOXIC DYE REMOVAL

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In the present study, biochar-based silver nanocomposite (*n*AgBC) was synthesized by combining (i) silver nanoparticle (*n*Ag), synthesized biochemically using Shorea robusta leaf extract, and (ii) freshwater algal biochar, produced via mild thermal pyrolysis (300 ℃) through chemical co-precipitation and tested for toxic dye removal efficiency. Algal mats, often regarded as unwanted and obnoxious in several water bodies, was collected from Swarnarekha river and used for biochar synthesis, which acted as the composite matrix. Surface morphology, physicochemical characteristics, elemental composition, phase, and stability of *n*AgBC was analyzed using BET, FESEM coupled with EDX, FTIR, XRD, XPS, and TGA, and was found to be mesoporous, heterogeneous, and thermostable having Ag^0 on the surface as doped material and –OH, NH, C=O, SO, and CH as active surface binding sites. The *n*AgBC was employed to adsorb toxic anionic sulfonated azo dye (Congo red), where the maximum adsorption efficiency of 95.92% was achieved (equilibrium uptake capacity: 34.53 mg g-1) for the initial concentration of 18 mg L^{-1}, contact time 60 min, adsorbent dose 0.5 g L^{-1}, and pH 6 at ambient temperature (300 K). The adsorption equilibrium data excellently fitted with Freundlich isotherm model (R^2 = 0.99) and pseudo-second-order kinetics model (R^2 = 0.99) indicating multilayer chemisorption onto the heterogenous *n*AgBC surface. Thermodynamic parameters implied that the adsorption process was exothermic and spontaneous. Furthermore, the results suggested a 5th cycle reusability and considerable efficacy towards real textile industrial effluents. The results suggested outstanding reusability and efficacy towards real textile industrial effluents, where the interactions between Congo red molecules and *n*AgBC were identified as chemisorption, H-bonding, van der Waals interaction, and surface complexation.

VPC-040

GREEN ENERGY PROFDUCTION THROUGH THE SEWAGE SUDGE GASIFICATION: PROCESS SIMLATION AND ECONOMIC EVALUATION

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Hydrogen energy has been increasingly attracting the attention of experts and governments in the world due to its green and clean characteristic. In this regard, searching for sustainable raw materials to achieve the efficient production of high-quality hydrogen is an urgent challenge. Considering that myriad sewage sludge waste produced in coastal cities were directly dumped, it is potential to consider the hydrogen generation through the gasification of sewage sludge. This is a double-win strategy achieving the energy recovery and active waste treatment for policymakers. In this work, the gasification process with sewage sludge feedstocks was studied to provide detailed data for future commercially plant establishment. Specifically, a comprehensive model of the sewage sludge steam gasification process based on Aspen Plus by minimizing Gibbs free energy with restricting chemical reaction equilibrium has been developed. Then essential factors on the syngas production like reaction temperature, pressure, steam to feed ratio were investigated by sensitivity analysis. With the temperature increased the content of hydrogen and carbon monoxide were also raised. In addition, the economic evaluation of the sewage sludge gasification process was finished which has shown its economic feasibility. In summary, steam gasifying agent and high temperatures during the gasification helps to obtain the high-quality syngas for the valorization of sewage sludge waste.
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Keywords : Sewage sludge, Gasification, Waste treatment, Syngas production, Simulation

VPC-041

HOT MICROBES AT WORK! ORGANIC WASTE-TO-HYDROGEN CONVERSION USING A HIGH-TEMPERATURE MICROORGANISM

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High temperature microorganisms have significant applications in biotechnology, including anaerobic degradation of organic waste. Waste treatment at high temperatures has many advantages over conventional anaerobic digestion; organic waste is degraded at faster rates than at ambient temperatures, allowing for higher throughput through a smaller size reactor while generating an energy end product (methane or hydrogen). The hyperthermophilic microorganism, Thermococcus paralvinellae degrades sugar and protein compounds and produces hydrogen as an end product. Because the process occurs at 80°C, pathogens in the waste are killed and heat-sensitive antibiotics such as β-lactams are degraded prior to waste removal. In this study, the growth rate and amount of hydrogen produced per cell are reported when T. paralvinellae was grown on varying concentrations of proteins and sugars separately and in combination to determine the range of organic concentrations the organism can tolerate. Growth rates and hydrogen per cell were consistent within a 20-fold change in sugar (maltose) concentration and within a 10-fold change in protein (tryptone) concentration but differed between the two types of organics. Similarly, the two parameters were consistent when the organism was grown across varying concentrations of sugar and protein in combination but differed in comparison to growth on sugar and protein separately. Furthermore, hydrogen production occurred when T. paralvinellae was grown on kitchen waste such as coffee grounds and green peas, and on brewery wastewater. The results further demonstrate the potential of using T. paralvinellae for waste-to-hydrogen conversion. Further work includes determining the extent of waste degradation and optimization of reactor conditions in a plot-scale bioreactor that can be translated into industrial use.

VPC-042

WASTE PET BOTTLES DERIVED MIL-125 (Ti) AS AN ELECTRODE FOR SUPERCAPACITOR APPLICATIONS

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PET stands for polyethylene terephthalate, a strong, stiff synthetic molecule that belongs to the polyester family of polymers. Despite its many advantages, it has a number of disadvantages as it is widely employed in the production of a wide range of items (e.g., beverage bottles), therefore large-scale recycling has become a serious environmental problem. Herein, we developed MIL-125 (a Ti based MOF) by linking Ti metal salts into the linker terephthalic acid (TPA) which was extracted from the PET bottle waste. Briefly, at first, we extracted TPA linker from waste PET bottles via alkaline hydrolysis, then MIL-125 was developed via simple hydrothermal technique using TPA and titanium isopropoxide. The successful preparation of as obtained MIL-125 was further confirmed via XRD, Raman, FTIR spectra and FESEM characterizations. Furthermore, the as-obtained MIL-125 was employed as an electrode material and electrochemically tested in 1M H2SO4 electrolyte in three-electrode configuration. MIL-125 material rendered high specific capacitance of 127 F/g at a current density of 0.5 A/g along with a long cycle life of 90.5% over 5000 charge-discharge cycles. Our research proves that MIL-125 derived from plastic waste has therefore been proven to be a viable electrode material, which hold tremendous promise for practical supercapacitor applications.

Keywords : PET, Hydrothermal, MOF, Electrode, Supercapacitor

VPC-043

BIOCHAR FOR ENVIRONMENTAL REMEDIATION AND CARBON NEUTRAL

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Biochar is supposed to be an effective measure of waste disposal, for example to solve the problem of agricultural straw waste in China. As biocar can be produced from different biomass and at different pyrolysis temperatures, it is characterized by large surface area, and contains different level of organic components and minerals, which enables wide application of biochar for soil amendment and environmental remediation. In addition, modification of biochar or biochar composite synthesis has enhanced the special properties such as adsorption, catalysis, reduction and oxidation ability of biochar. Carbon neutral is a potential new research area of biochar that related to climate change. First, biochar production is a carbonization process of biomass, which resulted in carbon sequestration itself. Poly-generation technology can result in biochar production and energy production at the same time. The stability of biochar can be as long as 2000 years in soil as indication by ^{14}C isotope simulation technique, which can be enhanced by P modification. Second, biochar can be used to regulate greenhouse gas emission such as CO_2, CH_4 and N_2O in different environment and biological process such as paddy field, upland field and composting process. Third, biochar can be used to adsorb CO_2 and reduce CO_2. Finally, future application and life cycle assessment of biochar is also suggested.

VPC-044

ENHANCED GREEN HYDROGEN PRODUCTION DURING PYROLYSIS OF WASTE BIOMASS USING BALL-MILLED, CHAR SUPPORTED IRON CATALYST

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Hydrogen has long been recognised as a preferred energy source/carrier and recently its relevance has increased as the move to decarbonise the world's energy sources gathers pace. Enhancing the production of green hydrogen from biomass offers an exciting strategy for increasing the value of this renewable feedstock; more so, if achieved through simple pyrolysis rather than gasification; and contributing significantly to the clean fuel evolution.
To pursue this opportunity a new type of char supported iron catalyst was prepared by a simple mechano-chemical method. Agricultural waste, such as almond shell and husk was pyrolysed with the catalyst, initially evaluated using a thermo-gravimetric analyser, and subsequently, further evaluated in a packed bed reactor over a range of pyrolysis temperatures (450 – 750°C). Pyrolysis at 750°C gave char yields from uncatalysed biomass of 29.4%, whereas normalised char yields from catalysed biomass were reduced to 22.5%, 20.0% and 19.8% with catalyst iron loading of 1.5%, 3% and 5%, respectively. Char reductions were accompanied by increases in non-condensable gas production, notably hydrogen increasing from 7.9g/kg biomass to 10.6, 11.8 and 12.3g/kg with catalyst iron loadings of 1.5%, 3% and 5%, respectively. This increased production of hydrogen (>50%), at the expense of CO, was mirrored at pyrolysis temperatures down to and including 650°C. Further, kinetic analysis revealed apparent activation energies lowered by up to 20% for the decomposition of hemicellulose and lignin respectively. Similar performance has been achieved using run-of-mill iron oxide as the catalyst, offering further simplification and catalyst cost reduction.
A simple, environmentally benign, char supported iron oxide catalyst was developed to enhance hydrogen production from waste biomass using relatively low pyrolysis temperatures. This process offers a streamlined pathway to transform waste biomass into green hydrogen and support the development of circular economy.

VPC-045

FLAME-CURTAIN PYROLYSIS AS A LOW-COST AND SUSTAINABLE METHOD FOR THE PRODUCTION OF BIOCHAR FOR ADVANCED APPLICATIONS

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Pine tree biochar produced by flame-curtain pyrolysis, an inexpensive and simple pyrolysis methodology, was used as the starting material for KOH-activated carbon. Flame-curtain pyrolysis is a simple, low-technology methodology that can be performed by non-specialized personnel in developing countries. The elemental analysis of the biochars highlighted the high reproducibility of the process. The N^2 adsorption isotherms indicated that KOH activation was effective for the preparation of high surface area activated carbons from the biochar. The BET specific surface area increased with the quantity of KOH added in the activation process, achieving a maximum value of 3014 $m^2\ g^{-1}$ at 85.7 wt.% of KOH addition. The adsorption

isotherms of all samples were IUPAC type I, establishing their microporous nature. Results from the Mikhail-Brunauer (MP) method and αs plot indicated that the pore size distribution became wider and the pore volume increased, as the KOH content increased. The measured capacitance values followed the same dependence on KOH content. The maximum capacitance value at 1 mV s^{-1} was determined as 200.6 F g^{-1} for the sample prepared at 75 wt.% of KOH addition. The performance of the KOH-activated pine tree biochar compared well to that of other biomass-based carbons. Therefore, pine tree biochar prepared by simple pyrolysis equipment is a suitable precursor for the development of an electric double layer capacitor. This methodology opens up a sustainable valorization route for surplus biochar not applied for soil conditioning purposes.

VPC-046

THE ORGANIC WASTE MANAGEMENT TRANSITION TO CIRCULAR ECONOMY

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The organic fraction of municipal solid waste and the food processing chain waste are generated in large quantities and the current population growth is expected to further exacerbate the challenges they pose. The application of circular economy principles to organic waste management offers the possibility to offset the negative impacts of those human activities and re-balance the nutrients cycle while returning the organic matter into the soil. This article proposes a systematic literature review on qualitative basis over the research about the dynamics that should promote the transition of organic waste management to circular economy and its related environmental sustainability We have limited the analysis to studies that investigates organic waste produced mainly from municipalities and the food supply chain. Our review shows that there are several factors indicated as possible drivers to promote the necessary change in the organic waste management. Some studies consider governmental policies as the main tool to drive the change while other studies explain how technological advances of a particular treatment technology coupled with increased economic benefit can lead to a sustainable transition to circular economy. Few papers claims that the diversification of the waste-based products in a biorefinery promotes the shift towards circular economy, but they do not assess the components required to implement this multi-purpose approach. We also discuss how the studies taken into consideration suggests often the use of LCAs to assess the environmental sustainability of the transition, focusing particularly on parameters like greenhouse gases reduction and economic benefit and overlooking others like biodiversity and nutrients recycle. Though there is common consensus over the fact that the transition towards circular economy would bring valuable benefits in the organic waste management, our review indicates that the current understanding of the dynamics involved is not clear. A more comprehensive and systematic approach is then necessary to build the proper framework for recognizing the most accurate drivers and select the suitable indicators.

Keywords : Organic Waste Management, Circular Economy, Nutrients Recycle, Sustainability, Organic Matter

VPC-047

CARBON DEFECTS IN BIOCHAR FACILITATED NITROGEN DOPING: THE DEGRADATION MECHANISM OF CIPROFLOXACIN IN THE PRESENCE OF PEROXYSULFATE

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Organic nitrogen (N) doping endows biochar with remarkable catalytic ability to activate peroxysulfate for degradation of organics. Herein, a new strategy was proposed by creating defective carbon sites under alkaline conditions to facilitate C-N configuration during thermochemical conversion of 2-methylimidazole as an extrinsic N-dopants. The X-ray photoelectron spectroscopy (XPS) clearly demonstrated that N presented as N-heterocycles of 5- and 6-mumbered rings as pyridinic N (48.5%), pyrrolic N (25.1%) and graphitic N (26.4%) in biochar. As expected, the adsorption capacity of ciprofloxacin by biochar was increased by approximately 5 times after N functionality, partially resulting from its extraordinary surface area (1398 m^2 g^{-1}). Besides, N functionality enhanced ciprofloxacin degradation by up to 40% over pristine biochar in a wide pH range (3-9), in the presence of peroxysulfate. After reaction, the percentage of pyridinic N decreased by 25.4% whereas pyrrolic N was increased by 58.5%, a clear indication of the dominant role of pyridinic N for ciprofloxacin degradation. The degradation mechanisms comprised of radical pathway and mainly non-radical pathway (singlet oxygen 1O2 and direct electron transfer). As per electron paramagnetic resonance, the major reactive species were singlet oxygen with minor contribution from hydroxyl radical. The mass spectrometry analysis proved that ciprofloxacin degradation occurred via cleavage of the piperazine ring attributing to $^1O_2$ followed by the substitution of hydroxyl groups due to hydroxyl radical. This work presented an efficient route to N-doped biochar to catalyse degradation of antibiotics by peroxysulfate with reasonable reusability.

Keywords : Advanced oxidation processes; biochar-based catalyst; nitrogen doping; non-radical pathway; antibiotic degradation in water

VPC-048

COPPER PHYTOEXTRACTION AND BIOMASS UTILIZATION AS ESSENTIAL TRACE ELEMENT FEED SUPPLEMENTS FOR LIVESTOCK

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Copper (Cu) is an essential element that is added to animal feed to stimulate animal growth performance and prevent diseases. The forage crop alfalfa (Medicago sativa L.), after Cu phytoextraction, may have the potential to be recycled as a Cu-biofortified crop for livestock production, beneficially reducing the abuse and input of Cu in agricultural systems. To determinate this possibility, alfalfa was grown in three soils with solely Cu contamination (soils A, B and C with Cu concentrations of 11, 439 and 779 mg kg^{-1}, respectively). Four dosages (0, 0.5, 2 and 5 mmol kg^{-1}, referring as control, EDDS 0.5, EDDS 2 and EDDS 5, respectively) of EDDS ((Ethylenediamine-N,N'-disuccinic acid) were applied to the soils seven days before the first cutting. Results showed that alfalfa could grow well in soil A and B but not in soil C. After applying EDDS, a significant biomass reduction of the first cutting shoot was only observed in soil C with EDDS 5, with a 45% ($P < 0.05$) decrease compared with the control. With EDDS 5, the Cu concentration in the shoots of the first cutting was augmented significantly, with 249%, 3527% and 6711% increase compared to the controls, respectively, in soils A, B and C. However, alfalfa gradually withered away in all soils after the first cutting with this higher EDDS application. The findings suggested that the relatively higher Cu concentration in alfalfa shoot, together with the fast growth rate and easy harvest, make alfalfa plants harvested from soils A and B with the correct dosage of EDDS possible to be considered as a partial Cu supplementation for livestock.

Keywords : Cu phytoextraction, perennial crops, alfalfa, Cu-biofortification, biomass management, feed additives, phytoremediation

VPC-049

NONEGLIGIBLE ROLE OF CRYSTALLNITY ON FE-BIOCHAR'S REDOX REDUCTIVE AMORPHOUS FERROUS MINERAL VERSUS OXIDATIVE FUNCTIONALITY WITH GRAPHITIC CARBON

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Using electroactive Fe-biochars to drive redox reactions for environmental application has attracted increasing attention, while the critical redox moieties remained unclear. To pinpoint the critical redox-active species, a series of Fe-biochars with distinct iron/carbon speciation and crystallinity were manipulated. We found that the rising crystallinity with the increasing pyrolysis temperature apparently affected the redox performance of both iron and carbon phases. Amorphous/low crystalline ferrous mineral with tiny size was the primary electron-donating moiety on the low-temperature Fe-biochar (BCX-Fe-400), leading to the high electron-donating capacity (EDC) of 0.43–1.28 mmol g^{-1}. However, the iron crystallization process decreased the electron-donating potential of the iron minerals on high-temperature Fe-biochar (BCX-Fe-850) with a lower EDC of 0.38–0.44 mmol g^{-1} despite the formation of metallic Fe with a lower valence state. By contrast, the formation of graphitic crystallites with rich edge-type defects on the carbon phase enhanced the electron transfer of abundant oxidative functionality (e.g., carboxyl and quinoid) on BCX-Fe-850, leading to a stronger electron-accepting capacity (EAC, 0.71–1.39 mmol g^{-1}) than BCX-Fe-400 (0.44–0.75 mmol g^{-1}). Therefore, the holistic redox state of Fe-biochars changed from reductive to oxidative with the increasing temperature due to speciation transformation and concomitant crystallization of both iron and carbon. Furthermore, effective Cr(VI) reduction (8.20–22.5 mg g^{-1}) by reductive BCX-Fe-400 and As(III) oxidation (5.34–9.32 mg g^{-1}) by oxidative BCX-Fe-850 evidenced the aforementioned changing pattern of redox reactivity. Overall, we unveiled the role of crystallinity on Fe-biochar's redox reactivity, which can advance the understanding of manipulating redox-active iron-char composites.

VPC-050

MICROBIAL SYNTHESIS OF POLY (3- HYDROXYBUTYRATE-CO-3-HYDROXYVALERATE) FROM FORMATE

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Formate is a promising environmentally friendly and sustainable feedstock synthesized from syngas or carbon dioxide. Methylorubrum extorquens AM1 is a type II methylotroph that can use formate as a carbon source. It accumulates polyhydroxyalkanoates (PHAs) inside the cell, mainly producing poly-3-hydroxybutyrate (PHB), a degradable biopolymer. Owing to its high melting point and stiff nature, however, mechanical property improvement is warranted in the form of copolymerization. To produce the PHA copolymer, poly (3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV), the endogenous gene phaC was deleted and the pathway genes bktB, phaJ1, and phaC2, with broader substrate specificities, were heterologously expressed. To improve the incorporation of 3-hydroxyvalerate (3HV), the expression level of bktB was improved by untranslated region (UTR) engineering, and the endogenous gene phaA was deleted. The engineered M. extorquens produced PHBV with 8.9% 3HV using formate as the sole carbon source. In addition, when propionate and butyrate were supplemented, PHBVs with 3HV portions of up to 70.6% were produced. This study shows that a PHBV copolymer with a high proportion of 3HV can be synthesized using formate, a C1 carbon source, through metabolic engineering and supplementation with short-chain fatty acids.

VPC-051

STARFISH: WASTE FROM THE SEA THAT IS DIFFICULT TO DISPOSE CONVERTED INTO A BIO-BASED PCM

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In recent years, many measures have been drawn to reduce energy consumption in buildings. Among them, research using phase change materials (PCM) is being actively conducted at home and abroad in order to reduce the heating and cooling energy load of buildings. PCM is the most effective method of using heat energy because it can accumulate and release heat in the form of latent heat through phase change. Among PCMs, organic PCM belonging to the alkane series is chemically stable, does not cause phase separation and supercooling, and has a wide phase change temperature range. performance can be achieved. However, since PCM can have very fatal consequences for buildings, such as material corrosion due to leakage and reduced strength of the structure due to phase change to liquid, it is necessary to stabilize the phase of liquid PCM in order to apply PCM to buildings. Therefore, in this study, starfish were impregnated with n-Hexadecane, n-Heptadecane, and n-Octadecane among organic PCMs to prepare a bio-based PCM. Thermal conductivity, heat capacity, and physical and chemical properties of the manufactured bio-based PCM were analyzed using a thermal conductivity analyzer and differential scanning calorimeter (DSC). And in order to confirm the chemical change of the phase stabilization material according to the repeated phase change, the thermal durability was confirmed using a thermal cycler.

VPC-052

TRANSFORMATION AND RECOVERY OF P FROM SEWAGE SLUDGE DURING ANAEROBIC FERMENTATION AND HYDROTHERMAL PROCESSES

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The recovery of phosphorus from sewage sludge was critical due to the depletion of phosphate ore. The present research aims to identify the phosphorus speciation and reveal the phosphorus transformation mechanism of dewatered sewage sludge during hydrothermal conversion (HTC) process, as well as to achieve the high efficiency recovery of phosphorus. Multiple analysis of SMT method, VK diagram, XANES and NMR showed that most phosphorus (>80%) was transferred to the hydrochar and presented as inorganic phosphorus (IP) after the HTC process. A dehydration trend was observed of the HTC process with the increase of sub-critical temperature. Ca-associated phosphorus increased significantly as the temperature increased. The Pyro-P gradually transformed to Ortho-P with the increase of HTC temperature and disappeared at 320 oC. The addition of HCl (6.13 and 12.3 mmol/g) in the HTC process resulted in a high percentage (>80%) of phosphorus transferred to the aqueous phase, and the bioavailability of the residual phosphorus increased significantly. The recovery rate of phosphorus could achieve 98.37% at the pH of 7.52, with the struvite purity of 90.41%. Migration and transformation mechanism of P in waste activated sludge (WAS) during anaerobic fermentation (AF) process and the subsequent hydrothermal conversion (HTC) process were also investigated. Control of pH during the AF processes was found to be significant, whereby the use of acidic (pH = 5.5) or alkaline conditions (pH = 9.5) facilitated the release of either apatite phosphorus (AP) or non-apatite inorganic phosphorus (NAIP) and organic phosphorus, respectively. At the same pH of 9.5, NaOH promoted the transfer of P into liquid phase, and P in the solid phase was mainly in the form of NAIP. In contrast, Ca(OH)2 enhanced the incorporation of P into the solid products, with the P mainly in the form of AP. The subsequent HTC process promoted the NAIP transferred to AP, and the bioavailability of P in the HTC solid products was decreased. The results of this study provide new insights into the selective transfer of phosphorus for resource recovery.

VPC-053

TRUST IN GOVERNMENTAL POLICIES FACILITATING SUSTAINABLE ECOSYSTEMS FOR TACKLING COMPLEX SOCIETAL CHALLENGES

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Trust acts as a social glue that keeps partners in a partnership. It thus represents an alternative governance mechanism, partly by increasing confidence in other partners' commitment to a greater good. Its multidimensional conceptualization highlights the key role of governmental policymaking encouraging sustainability and responsibility. We trust each other when we believe other parties are acting authentically and when we have faith in their judgment and competence; that is, when we think that other parties care. From April to July 2020 we surveyed 7,665 individuals, broadly representative for age and gender, in four European regions in Greece, the Netherlands, Spain, and Norway. We explored how those citizens perceive trade-off dilemmas related to regional policymaking to solve societal challenges in an innovative and sustainable way. In particular, we surveyed specific trust indicators such as trust levels in regional organizations and asked if survey participants want to be engaged in regional policymaking. Our empirical study results stress that at a general level, citizens tend to trust organizations or groups of people when they assess the effects of innovation independently, look at the effects of innovation from different angles, clearly indicate what interests they have, and communicate openly and transparently. These indicators significantly facilitate trust in regional organizations and impact the demands for citizen engagement in the design and evaluation of regional innovation policymaking to tackle societal challenges and create a more sustainable economy and society. Our work highlights the key role of trust in this regard. For instance, common metrics and consistent, accountable, and transparent reporting of sustainable value creation related to a matrix of environmental and social aims, governance objectives, sustainable development goals, and companies' common good are promising ways to increase citizens' trust levels. Promoting trust to create sustainable ecosystems requires a solid governmental regulatory environment around sustainable value creation that includes a diversity among stakeholders. The greater the correlation between trust and sustainability, the greater the value for all stakeholders.

VPC-054

PLASTIC WASTE MANAGEMENT BY EPR TOWARDS A CIRCULAR ECONOMY IN SOUTH KOREA

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Proper management of plastic waste has become an important issue of concern around the world to minimize environmental impacts and marine plastic pollution. Recycling and proper management of plastic waste has been successfully implemented by the extended producer responsibility (EPR) in Korea since 2003. The total volume of recyclables collected by the system reached 1.85 million tons in 2018, an increase of 97 percent compared to 0.93 ton in 2002 prior to implementation of EPR. As the number of products subject to EPR has been continuously increased, the number of producers subject to recycling duty increased by 108 percent in 2007, reaching a total of 5,703 businesses. In this study, current recycling practices of plastic waste by EPR have been critically examined to elucidate outcomes and benefits during waste management as well as current problems related to the establishment of circular economy. We present the outline of the regulatory and institutional landscape with direct and indirect referral to EPR implementation based on its historic evolution including the motivation to opt for EPR as a policy to tackle plastic waste management challenges. We reason the actual implementation arrangements for implementing EPR aspects among various stakeholders and justify how they contribute to the EPR system's success. Finally, we describe not only those characteristics and success factors of Korea's EPR implementation for plastic waste, but also challenges that have been faced and how these were and are tackled in order to improve better plastic waste management through EPR towards a circular economy.

VPC-055

RECYCLING AND MATERIAL FLOW OF POLYETHYLENE TEREPHTHALATE (PET) BOTTLES TOWARDS A CIRCULAR ECONOMY IN SOUTH KOREA

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In recent years, proper management and reduction of single-use plastics (e.g., PET, plastic cups, plastic bags) has emerged as an urgent agenda around the world to prevent marine pollution and the generation of microplastics. Recycling and proper management of PET bottles is needed to avoid plastic pollution as well as to achieve plastic circular economy. In this study, we examined the recycling system and material flow of PET bottles by life cycle stage (production, consumption, collection and recycling and disposal). In South Korea, the PET bottle recycling has been managed by the expanded producer responsibility (EPR) system since 2003. The PET bottle consumption was estimated by available statistics and reports. As a result, annual usage of PET drinking water bottles per capita in South Korea is estimated to be approximately 96 bottles, which is equivalent to 4.9 billion units per year from the country. Recycling rate of PET bottles put on the market was 82% (245,000 tons) in 2019. The trend of the recycling rate is slightly increasing over the past decade due to tightened regulations and recycling target goals of packaging materials by the government. Most recycled PET materials as flake are used for textiles and sheets. In 2020, manufacturing of colored PET bottles is prohibited for better recycling and material recovery. PET bottles with recycled pellet should be manufactured and placed on the market towards a plastic circular economy.

VPC-056

CURRENT STATUS AND MANAGEMENT OF EXCAVATED MATERIALS FROM LANDFILL MINING OPERATIONS IN KOREA

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In this study, the regulations for and separation characteristics of excavated materials containing wastes from landfill mining were investigated, and the characteristics of separated material, such as physical and chemical composition and biodegradability of separated excavated material samples collected from the site, were examined. To evaluate the adequacy of each item based on the management standards for separated materials obtained from excavated materials containing waste, samples of separated combustibles and soils were collected and characterized on a quarterly basis. We aimed to evaluate the adequacy of each item according to the management standards based on the type of separated excavated materials containing waste and determine strategies for improvement. With respect to the acceptance criteria for landfilling waste stabilization, the level equivalent to 10% of the criterion in terms of loss on ignition, which is the standard for bottom ash management at Korean incineration facilities, was found to be appropriate. In addition, it was determined that a method for biological oxygen consumption of respirometric activity should be established to evaluate the biodegradability of landfill waste collected during excavation and separation in relation to landfill mining. As an improvement plan for the management of separated materials after the excavation of landfill waste, the criteria of less than or equal to 20% ash content, which is the Solid Refuse Fuel quality standard, could be fulfilled through the additional separation of the attached soil from separated combustibles. To recycle the separated soil from the excavation material as a cover material in a landfill site or a filler at a construction site, it must meet the organic foreign material content standards for the fill/cover material specified in the recycled aggregate quality standards. To facilitate this, the additional separation process should be systematically incorporated into separation during landfill mining or the subsequent linkage process.

VPC-057

MULTIPHASE CFD AND SPECIES MODEL FOR IN-SITU FAST PYROLYSIS OF SPENT COFFEE WASTE: EXPERIMENTAL VALIDATION AND ANALYSIS

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A valorisation process annexed to a Spent Coffee Waste (SCW) has attractive utility as feedstock for liquid biofuel and offers suitable management of this solid biomass waste. Among the various technologies, fast pyrolysis of SCW solid biomass is the most promising technology to extract biofuels or chemicals. In this work in-situ catalytic and non- catalytic fast pyrolysis of SCW in bubbling fluidized-bed reactor (BFR) is reported. In fast pyrolysis process operating temperature, pressure and residence time play important role to obtained desired bio-oil yield. Therefore, computational fluid dynamics (CFD) based simulations were applied to study and identify effective and robust analysis pathway. Firstly, the multiphase model was developed and validated against the experimentally obtained hydrodynamic profile. Subsequently, the validated hydrodynamic model was coupled with a SCW solid biomass fast pyrolysis kinetic model (species model) for the prediction of product yields (gas, bio-oil, and char). The simulation results of this investigation showed good agreement with the experimentally observed yield distribution. The influences of reactor operating conditions and reactor configuration on the products yield were discussed. Overall, this study provides important guidelines for possible reactor scale-up, intensification and optimization.

Keywords : Spent Coffee Waste; Liquid Bio-oil; Fast Pyrolysis; CFD Multiphase Model; Bubbling Fluidized Bed

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Company History

In 1990 Changed company

- Kyungdong Holdings
- Kyungdong City Gas
- Wonjin Worldwide
- Kyundong Development
- Kyungdong One
- Kyungdong Navien
- Kyungdong Everon

2014
- New business division established
- Patent Registered (Screw Kiln)
- BioChar roduction facility completion

2017
- BioChar demonstration project with RDA (Rural Development Administration) of Korea

2019
- BioChar sales to NACF (National Agricultural Cooperative Federation)
- Patent Registered (Hybrid Biochar)

2020
- BioChar sales to NACF (National Agricultural Cooperative Federation)

"Low Temp. Carbonization Machineries and Low Temp. Biochar Product is the first technology in Korea that is exclusive to Kyungdong."

Our Technology

(Kyungdong BioChar)

- Exclusive carbonization technologydeveloped by Kyungdong
  - Condensing, Waste Heat Recovery and Dry Distillation gas Reheating Technology
- Patent Registered : Heat Treatment Silo (Sep. 2014.)
- Using minimum gas by recycling dry distillation gas and emission gas (energy is only needed in pre-heating process)
- Mass Production Capability: 3.5ton/h (largest in S.Korea)

(Production Process)


01. Raw materials


02. Crushing/Screening


03. Drying


04. Carbonization


08. Release


07. Storing


06. Grinding


05. Cooling

Our Goal

1. Kyungdong BioChar is a eco-friendly agricultural material which is already proven to have outstanding result in soil improving and crop growing from the test results conducted by scientific institutions in/out of the country and through field test. This will make contribution for improving condition of agricultural environment and increase the income in farms.
2. The first BioChar mass production facility in country with stable quality, supply and cost competitiveness which opened opportunities to supply to farms at lower price with development of sales network all throughout the country.
3. Make contribution to increase quality of crops by preventing acidification of soil and damages of crops from salt accumulation which was a long problems faced by domestic agriculture.

Our achievements

1. Our technology has been registered as green company and green technology by the Korean government.
2. Kyungdong Biochar has been certified as an eco-friendly agricultural material by the Korean government.
3. About 20,000 tons of biochar were sold to Nonghyup and local governments

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