VIRTUAL

ENGINEERING SUSTAINABLE DEVELOPMENT

TECHNICAL AND ENGINEERING CHALLENGES OF ADDRESSING SUSTAINABLE DEVELOPMENT

December 15-17, 2020

Co-Organized by the Institute for Sustainability and APRU

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TIPS FOR A SUCCESSFUL MEETING

Say **hello** to everyone.
You might make someone's day.

Introduce yourself to people you don't know.
They may be your next good friends.

Stop and **smile**.
You will brighten the room considerably.

Be **understanding**.
Everybody makes mistakes.

Help those with less experience.
We were all novices at some point.

Respect others.
We all have something valuable to contribute.

Value staff and volunteers.
They are here for you.

Be **kind**.
You will never like everybody, but you can be cordial to all.

Enjoy the meeting!
You can have fun while sharing,learning and networking.

Abstracts appear as submitted by their authors. Neither the American Institute of Chemical Engineers (AIChE) and its entities, nor the employers affiliated with the authors or presenting speakers, are responsible for the content of the abstracts.

TECHNICAL PROGRAM

Conference Co-Chairs

Yong Sik Ok, *Korea University*

William Mitch*, Stanford University*

Organizing Committee

Daniel Tsang, *The Hong Kong Polytechnic University*

Christina Schönleber, *APRU Secretariat*

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Hailong Wang, *Foshan University*

Ondrej Mašek, *University of Edinburgh*

Daniel Alessi, *University of Alberta*

Carol Lin, *City University of Hong Kong*

Taku Fujiwara, *Kochi University*

Jörg Rinklebe, *University of Wuppertal*

Sumin Kim, *Yonsei University*

Pichaya Pattanasattayavong, *Vidyasirimedhi Institute of Science and Technology*

Deyi Hou, *Tsinghua University*

Shuai Deng, *Tianjin University*

Michael Bank, *Institute of Marine Research, Norway*

Jae Won Shim, *Korea University*

Xiangzhou Yuan, *Korea University*

TECHNICAL PROGRAM

9:00 AM	**11:20 AM**	**Day 1 Live Program - 9AM - 12PM Seoul Time - Dec. 16 (Dec. 15 in US)**
		Day 1: Plastics and Sustainability
9:00 AM	**9:15 AM**	**Welcome Address**
		Prof. Yong Sik Ok (Korea University, Korea)
		Dr. Christopher Tremewan (Secretary general of APRU)
		Prof. William Mitch (Stanford University, USA)
9:15 AM	9:20 AM	Break
9:20 AM	**10:10 AM**	**Plenary Speech-Session 1 (Chair: Prof. William Mitch)**
		Ignasi Palou-Rivera, RAPID Manufacturing Institute: Transforming the Process Industries Through Modular Chemical Process Intensification
		Michael Bank, Institute of Marine Research: The Microplastic Cycle: Implications for Environmental Health and Sustainable Development
		Denise Mitrano, ETH Zurich: Small(er) Particles, Big(ger) Problems? Fate, Transport and Implications of Nano- and Microplastics in the Environment
10:10 AM	**10:30 AM**	**Networking break (Chair: Prof. Yong Sik Ok)**
10:30 AM	10:35 AM	Break
10:35 AM	**10:55 AM**	**Technical Session Live 1 Q & A (Chair: Prof. Dongyeop Oh and Prof. Siming You)**
10:55 AM	11:00 AM	Break
11:00 AM	**11:20 AM**	**Keynote 1 Live Q&A (Chair: Prof. Carol Lin)**

9:00 AM	**11:05 AM**	**Day 2 Live Program - 9AM - 12PM Seoul Time - Dec. 17 (Dec. 16 in US)**
		Day 2: Wastewater Treatment and Recycling
9:00 AM	10:15 AM	**Plenary Speech-Session 2 (Chair: Prof. Yong Sik Ok and Prof. William Mitch)**
		William Mitch: Emerging Challenges for the Potable Reuse of Municipal Wastewater
		Daniel CW Tsang, The Hong Kong Polytechnic University: Wood Waste Biochar for Sustainable Industrial Wastewater Treatment
		Christian Sonne, Aarhus University: The Arctic Environment and the UN Sdgs
10:15 AM	10:20 AM	**Break**
10:20 AM	10:40 AM	**Technical Session Live 2 Q & A (Chair: Prof. William Mitch and Prof. Denise Mitrano)**
10:40 AM	10:45 AM	**Break**
10:45 AM	11:05 AM	**Keynote 2 Live Q&A (Chair: Prof. Jingyun Fang and Prof. Daniel C.W. Tsang)**

9:00 AM	**11:45 AM**	**Day 3 Live Program - 9AM - 12PM Seoul Time - Dec. 18 (Dec. 17 in US)**
		Day 3: Waste Valorization for a Sustainable Future
9:00 AM	**9:50 AM**	**Plenary Speech-Session 3 (Chair: Prof. Yong Sik Ok)**
		Xiaonan Wang, National University of Singapore: AI and Machine Learning through Life Cycle of Environmental Systems
		Longbin Huang, The University of Queensland: Strategies for Managing Metal(loid) Pollution from Mine Wastes in the Environment
9:50 AM	9:55 AM	Break
9:55 AM	**10:15 AM**	**Technical Session Live 3 Q & A (Chair: Prof. Dan Alessi and Prof. Longbin Huang)**

10:15 AM	10:20 AM	Break
10:20 AM	**10:40 AM**	**Technical Session Live 4 Q & A (Chair: Prof. Binoy Sarkar and Prof. Ondřej Mašek)**
10:40 AM	10:45 AM	Break
10:45 AM	**11:05 AM**	**Keynote 3 Live Q&A (Chair: Prof. Ondřej Mašek and Prof. Binoy Sarkar)**
11:05 AM	11:10 AM	Break
11:10 AM	**11:30 AM**	**Keynote 4 Live Q&A (Chair: Prof. Xiaonan Wang)**
11:30 AM	**11:45 AM**	**Closing Remarks: Conference Chairs**
		Prof. Yong Sik Ok

DAY 1 - ON-DEMAND SESSIONS - AVAILABLE AHEAD OF LIVE SESSIONS
KEYNOTE SPEECH-SESSION 1 PRE-RECORDED CONTENT ON DEMAND
Jooyoung Park, Korea University: Developing a National Plastics Account of South Korea
Cheng Gu, Nanjing University: Photo-Aging of Microplastics and the Effects on the Environmental Behaviors of Organic Contaminants in Aquatic Environments
Shicheng Zhang, Fudan University: Morphological, Chemical and Physical Changes of Microplastics in Hydrothermal Pretreatment of Sewage Sludge
Dongyeop Oh, Korea Research Institute of Chemical Technology (KRICT): Needs-Matched Developments of Sustainable Plastics and Microplastics
Ondřej Mašek: Role and fate of plastic contaminants in biochar production and applications
Scott Chang, Univ of Alberta: Coexistence of Polyethylene Microplastics and Biochar Increases Ammonium Sorption in an Aqueous Solution
Shuai Deng, Tianjin University: A Journey into the Closed Carbon Loop Based on a Life Cycle Perspective: From CO2 Adsorbent to Cycle
TECHNICAL SESSION 1 PRE-RECORDED CONTENT ON DEMAND
Sammani Ramanayaka, Lancaster University, Ecosphere Resilience Research Center, Faculty of Applied Sciences, University of Sri Jayewardenepura: Phytoavailability and Plant Uptake of Microplastic-Bound Chromium
Meththika Vithanage, Ecosphere Resilience Research Center, Faculty of Applied Sciences, University of Sri Jayewardenepura: Unseen Career for the Entry of Microplastics into the Soil: Compost
Cynthia Mason, Independent: Developing Higher Levels of Sustainability with Digitalization
DAY 2 - ON-DEMAND SESSIONS - AVAILABLE AHEAD OF LIVE SESSIONS
KEYNOTE SPEECH-SESSION 2 PRE-RECORDED CONTENT ON DEMAND
Amit Bhatnagar, LUT University: Algal Biotechnology in Wastewater Treatment and Resource Recovery
Daniel Alessi, University of Alberta: Large-Scale Oil and Gas Wastewater Production Analysis for the Sustainable Development of Hydrocarbon Resources
Cheng Tan, University of California, Riverside: Role of Zerovalent Chromium from Iron Corrosion Scales in Hexavalent Chromium Release in Drinking Water Distribution Systems
Taku Fujiwara, Kochi University: Technical Challenge to Manage Antibiotics in Wastewaters Considering Interlinkages Among Sustainable Development Goals: Development of a Rotating Advanced Oxidation Contactor Equipped with Zeolite/TiO2 Composite Sheets
Nabeel Niazi: Wastewater treatment and reuse: Unfolding facts and discoveries
Jingyun Fang, Sun Yat-Sen University: Abatement of Micropollutants By the UV/Chlorine Processes in Water and Wastewater Treatment
Yi-Hsueh Chuang, National Chiao Tung University, Institute of Environmental Engineering: Feasibility Study on Ultraviolet/Chlorinated Cyanurates Advanced Oxidation Process Treating Drinking Water or Potable Reuse Water

Jose Porro, Cobalt Water Global, Inc.: Decarbonizing Wastewater Treatment Plants with AI and Machine Learning
Chia-Hung Hou, National Taiwan University: Hierarchical Porous Carbon Derived Engineered Biochar As a High-Performance Electrode for Capacitive Deionization
Liu Ye, The University of Queensland: Towards Carbon Neutrality in Urban Wastewater Treatment
SHORT TALK AND POSTER SESSIONS PRE-RECORDED CONTENT ON DEMAND (CHAIR: PROF. JANICE KENNEY AND PROF. BINOY SARKAR)
Yoora Cho, Korea University: Immobilization of Pb in Contaminated Soil with Standard Biochars
Hanseong Shin, Korea University: Designing a Novel Electrode for Alkaline Water Electrolysis Using Biomass-Derived Material
Shreyansi Gupta, AIChE MIT WPU: Paper Making Potential of Corn Husk
Simão P. Cardoso, University of Aveiro: Characterization of a New Activated Carbon Along Loading-Regeneration Cycles for Indoor Air Treatment
Tsz Yan Yu, The University of Queensland: Circular Economy Regulations on Waste Management and the Implementation in Australian Cities
Junyoung Park, Seoul National University: Development of Aptamer That Recognize PFOA and Its Application for Detecting Levels in Water
Jaehyeong Park, Seoul National Univ.: Catalytic Redox Treatment of Fluconazole Using Pd-Rh Bimetallic Catalysts
Juwita ., Gadjah Mada University: Design Review of Slope Reinforcement Using Geoframe with Ggu-Stability Software Case Study: Lido Lakes Hotel Sukabumi West Java Indonesia
TECHNICAL SESSION 2 PRE-RECORDED CONTENT ON DEMAND
Jacob King, Stanford University: GAC-Based Cathodes for Capture and Electrochemical Reduction of Halogenated Contaminants in Water
Cindy Weng, Stanford University: Reductive Electrochemical Activation of Hydrogen Peroxide As an Advanced Oxidation Process to Treat Reverse Osmosis Permeate during Potable Reuse
Sandun Sandanayake, Ecosphere Resilience Research Center, Faculty of Applied Sciences, University of Sri Jayewardenepura: Geogenic Contaminants in Shallow Groundwater in the Areas of Endemic Chronic Kidney Disease of Unknown Etiology, Sri Lanka
Jessica MacDonald, Stanford University: Linking Anaerobic Wastewater Treatment to Non-Potable and Potable Wastewater Reuse
Qudus Rafiu, Raw material research and development council., Feddogroup: Optimization of Activated Carbon Production from Palm Kernel Shell for Treatment of Industrial Wastewaters
DAY 3 - ON-DEMAND SESSIONS - AVAILABLE AHEAD OF LIVE SESSIONS
KEYNOTE SPEECH-SESSION 3 PRE-RECORDED CONTENT ON DEMAND
Binoy Sarkar, Lancaster University: Role of Engineered Minerals in Achieving Sustainable Development Goals
Carol Sze Ki Lin, City University of Hong Kong: Sophorolipid Production from Food Waste
Huiyan Zhang, Southeast University: High Quality Biochar Preparation, Upgrading and Application
Sam Van Haute, Department of Environmental Technology, Food Technology and Molecular Biotechnology, Ghent University Global Campus, Incheon, South Korea, Department of Food Technology, Safety and Health, Faculty of Bioscience Engineering, Ghent University, Coupure Links 653, 9000 Ghent, Belgium: Measuring Circularity in Food Supply Chain Using Life Cycle Assessment; Refining Oil from Olive Kernel
Brian Kolodji, Black Swan, LLC: Eliminating Supplemental Non-Renewable Natural Gas in Biogas Fired Power Generation
Tao Zhang, China Agricultural University: Biomass Waste Valorization to Generate Modified Biochar to Recover Phosphorus from Animal Manure Wastewater
Xiaomin Dou, Beijing Forestry University: Effectively Pretreating Spiramycin from Antibiotic Production Wastewater through Hydrolyzing Its Functional Groups Using Solid Superacid TiO2/so4
TECHNICAL SESSION 3 PRE-RECORDED CONTENT ON DEMAND
Xinni Xiong, The Hong Kong Polytechnic University: Recycling Humins from Rice Waste Valorisation for Catalyst Synthesis in Biorefinery

Ario Fahimi, University of Brescia: Environmental Sustainability Evaluation of Technologies to Recover Phosphorous from Incinerated Waste Streams
Norman Fraley, Wake Forest University: Continuous Flow System for the Heterogeneous Catalytic Production of Advanced Biofuels
Oshadi Hettithanthri, University of Sri Jayewardenepura: Enhanced Removal of Antibiotics from Biochar Colloids
Sudha Sahu, IIT Guwahati, Govt. Kamla Nehru Girls College: Characterization of Phosphate Solubilizing Bacteria Isolated from Municipal Solid Waste Dumping Site Soils
Xiaomeng Hu, City University of Hong Kong: Guiding Environmental Sustainability of Emerging Waste-Derived Sophorolipid Production By Adopting a Dynamic Life Cycle Assessment (dLCA) Approach
TECHNICAL SESSION 4 PRE-RECORDED CONTENT ON DEMAND
Kumuduni Niroshika Palansooriya, Korea University: Machine Learning-Based Prediction of Immobilization Efficiency of Potentially Toxic Elements in Biochar Amended Soils
Giuseppe Bonifazi, Sapienza - Università di Roma: A NOVEL Approach to Investigate Bromine Content in E-Waste Plastic By Short Wave Infrared Spectroscopy
Pavani Dulanja Dissanayake, Korea Biochar Research Center, APRU Sustainable Waste Management Program & Division of Environmental Science and Ecological Engineering, Korea University: Biochar Mediated Changes in Soil Contaminated with Metal Halide Perovskite Solar Cell Waste
Sherif A. Khalifa, Drexel University: Environmental Impacts of Upscaled Mixed Cation Perovskite Precursors for Emerging Lead Halide Perovskite Solar Cells
Patima Chaichana, Chulalongkorn University: Gap Analysis of Current Discarded Solar Photovoltaic Panels Management between Germany and Thailand
Antonella Cornelio, University of Brescia: New Porous Materials Derived from Industrial By-Products for Nanoparticles Capture
Chao-Shun Yang, National Taipei University of Technology: The Multiple Intelligence of the Intelligent Building
KEYNOTE SPEECH-SESSION 4 PRE-RECORDED CONTENT ON DEMAND
Youn-Sang Bae, Yonsei University: Metal-Organic Framework Adsorbents for Industrially Important and Challenging Separations
Jin Shang, City University of Hong Kong Shenzhen Research Institute, City University of Hong Kong: Porphyrin-Based Metal-Organic Frameworks As Low-Temperature NO2 Adsorbent
Janice Kenney, MacEwan University: Pharmaceutical Sorption to Iron Oxides
Ryo Yoshiie, Nagoya university: The Effect of Flue Gas Recirculation on Nox Emission from Char Combustion
Siming You, University of Glasgow: Techno-Economic Feasibility of Distributed Waste-to-Hydrogen Systems to Support Green Transport in Glasgow
Yeshui Zhang, University College London: Thermal Conversion of Carbonaceous Waste for Carbon Nanotube Production

Latest complete conference information available at www.aiche.org/esd.

Plenary Speaker Biographies

Michael S. Bank
Institute of Marine Research

Dr. Michael S. Bank works as a Senior Scientist in the Department of Contaminants and Biohazards at the Institute of Marine Research in Bergen, Norway. Michael also serves as an Adjunct Associate Professor of Contaminants and Complex Systems at University of Massachusetts, Amherst in the USA and is also an Associate Editor at the journal Chemosphere. His research is highly interdisciplinary and has its theoretical basis in Bayesian mathematical modeling, contaminant biology, environmental toxicology, and environmental governance. Specifically, his interests are focused on three principle themes (a) How do contaminants affect organisms, including humans, (b) How can contaminants in ecosystem compartments be modeled using isotopic niches, Bayesian statistics and information theory, and (c) How can this information be used in a scientific translation and environmental governance context. Dr. Bank's work primarily deals with real data sets that tend to be large in nature and that consider broad spatial and temporal scales. Michael serves on several expert committees and does advising on contaminants for several international environmental agencies.

Choonglai Cho
ASEM SMEs Eco-Innovation Center (ASEIC)

• Dr. Cho is the secretary general of ASEM SMEs Eco-Innovation Center (ASEIC), and a professor at the Graduate School of Management of Technology at Korea University. Also he has worked with SK Innovation, SK telecom and SK China as a vice president and an executive vice president, in charge of various departments such as environmental management strategy, CSR, PR and new business development.
• He also has served in various government works, as an advisor to the 'Minister of Environment', a national delegate to the 'ISO TC207', and a committee member of 'Korea PCSD' and 'National Council of Science and Technology'.
• He received a BA in Chemical Engineering from Korea University, MS in Civil & Environmental Engineering from Carnegie Mellon University and Ph.D. in Environmental System Engineering from Korea University.

Cheng Gu
Nanjing University

Cheng Gu, Professor in School of the Environment, Nanjing University. Prof. Gu obtained his PhD in Environmental Chemistry from University of Wisconsin-Madison, USA. Then he worked as a postdoctor in Michigan State University, USA. He joined Nanjing University as a professor since 2011. He is currently the Changjiang Scholar Distinguished Professor and the recipient of National Science Fund for Excellent Young Scholars. He is also the Chief Scientist for National Key Research and Development Plans. Prof. Gu's research focuses on the transformation of organic contaminants in natural environment. He has published over 80 scientific papers on high impact journals and was issued 8 national and international patents. He is the associated editor of Bulletin of Environmental Contamination and Toxicology and journal editor for Environmental Chemistry.

Ondřej Mašek
UK Biochar Research Centre and University of Edinburgh

Technologies for biochar production and utilisation of by-products (oil and gas) for bio-fuels and bio-energy generation. Thermochemical conversion of carbonaceous materials (gasification, pyrolysis, combustion, etc.). CO2 capture and transport technologies (post-combustion, pre-combustion, oxy-combustion and advanced capture technologies).

Current Research Interests include technologies for biochar production and utilisation of by-products (oil and gas) for bio-fuels and bio-energy generation. Thermochemical conversion of carbonaceous materials (gasification, pyrolysis, combustion, etc.). CO2 capture and transport technologies (post-combustion, pre-combustion, oxy-combustion and advanced capture technologies).

William Mitch
Stanford University

Bill Mitch received a B.A. in Anthropology (Archaeology) from Harvard University in 1993. During his studies, he excavated at Mayan sites in Belize and surveyed sites dating from 2,000 B.C. in Louisiana. He switched fields by receiving a M.S. degree in Civil and Environmental Engineering at UC Berkeley. He worked for 3 years in environmental consulting, receiving his P.E. license in Civil Engineering in California. Returning to UC Berkeley in 2000, he received his PhD in Civil and Environmental Engineering in 2003. He moved to Yale as an assistant professor after graduation. His dissertation received the AEESP Outstanding Doctoral Dissertation Award in 2004. At Yale, he serves as the faculty advisor for the Yale Student Chapter of Engineers without Borders. In 2007, he won a NSF CAREER Award. He moved to Stanford University as an associate professor in 2013. Employing a fundamental understanding of organic chemical reaction pathways, his research explores links between public health, engineering and sustainability. Topics of current interest include: Public Health and Emerging Carcinogens, Global Warming and Oceanography, Sustainability and Persistent Organic Pollutants (POPs), Engineering for Sustainable Wastewater Recycling, and Carbon Sequestration. Bill is also a co-director of the Association of Pacific Rim University Sustainable Waste Management (APRU SWM) program.

Denise M. Mitrano
ETH Zurich

Denise M. Mitrano is an assistant professor at ETH Zurich in the Environmental Systems Science Department. As an environmental analytical chemist, her research focuses on the distribution and impacts of anthropogenic materials in technical and environmental systems. She is particularly interested in developing analytical tools to systematically understand the mechanisms and processes driving the fate, transport and biological interactions of particles, such as natural colloids, engineered nanomaterials and nano- and microplastics. In this context, her research group uses these results to assess risks of anthropogenic materials. An interest in a "safer by design" approach for both nanomaterials and plastics is exemplified by working on the boundaries of environmental science, materials science and policy to promote sustainability and environmental health and safety of new materials.

Jooyoung Park
Graduate School of Energy and Environment (KU-KIST Green School), Korea University

Jooyoung Park is an Associate Professor at the Graduate School of Energy and Environment (KU-KIST Green School), Korea University. Her research broadly aims to understand the impact of socio-economic systems on the environment by analyzing the flows and transformation of physical materials (e.g., products, carbon, water) and underlying social, organizational, and institutional factors that govern them. Specifically, she has focused on three main topics: 1) technological innovation and business behaviors for a circular economy, 2) business collaborations and eco-industrial development, and 3) evaluation of environmental policy (e.g., extended producer responsibility). Before joining Green School, she was an Assistant Professor at the School of Management, Universidad de los Andes, located in Bogota, Colombia. She has a Ph.D. in environmental studies from Yale University and M.S. and B.S. in environmental engineering from Seoul National University, South Korea.

Siming You
University of Glasgow

Dr. Siming You is a Lecturer in the James Watt School of Engineering of Glasgow University. Before joining the School, he worked as a Research Fellow at NUS (National University of Singapore) Environmental Research Institute. He also served as a Postdoctoral Fellow at Nanyang Technological University and the Massachusetts Institute of Technology in 2014 and 2015, respectively. Dr. You received his Ph.D. in Thermo-fluids from Nanyang Technological University in 2014. He has an area of expertise in the design and analysis of waste management and waste-to-resource generation, and the valorization of waste-derived products like biochar and hydrogen. Dr. You was awarded the Outstanding Young Researcher Award by the American Institute of Chemical Engineering, Singapore Local Section in 2018. He serves as a guest editor for various special issues in prestigious journals including "Waste-to-Hydrogen and Related Technologies", 2019 in Applied Energy, "Waste Lignin to Resources", 2019 in Bioresource Technology, and "Sustainable Energy Technologies for Energy Saving and Carbon Emission Reduction", 2017 in Applied Energy. He also sits in the Editorial Board of a leading journal on waste management - Journal of Hazardous Materials.

Keynote Speaker Biographies

Daniel S. Alessi
University of Alberta

Daniel S. Alessi is an Associate Professor in the Department of Earth and Atmospheric Sciences at the University of Alberta, who specializes in environmental geochemistry and geomicrobiology. Since 2013, his research group has focused on understanding the surface chemistry and reactivity of environmental materials such as iron oxides, bacteria, and biochar, on lithium extraction from oilfield brines, and on improving our knowledge of the water cycle in unconventional oil and gas operations. Dr. Alessi holds the Encana Chair in Water Resources at the University of Alberta, and was named a 2017-2018 Petro-Canada Young Innovator.

Youn-Sang Bae
Yonsei University

Prof. Youn-Sang Bae completed his B. S. (1999), M. S. (2001) and Ph. D. (2006) in chemical engineering from Yonsei University, Korea. His Ph.D. research was about the development of adsorptive separation processes for various applications. After his Ph.D., he worked as a postdoctoral fellow and a research professor at the department of chemical & Biological engineering in Northwestern University, USA. At Northwestern University, he worked on the development of metal-organic frameworks (MOFs) for hydrogen storage and various gas separations. In 2012, he moved to the department of chemical and biomolecular engineering at Yonsei University as an assistant professor. He is currently a full professor at the same department. His research focuses on the development of nanoporous materials for use in adsorption-related applications including capture of greenhouse gases such as CO2 and SF6, storage of methane and hydrogen, industrially important and challenging separations such as olefin/paraffin separation, CO recovery from iron industry and CH4/N2 separation, removal of toxic chemicals such as VOCs and radon, and water purification. Recently, his research has been extended to catalytic conversions, electrocatalytic sensors and mixed-matrix membranes. For the molecular-level understanding of adsorption behaviors in the nanoporous materials, he has been also utilizing various molecular modeling techniques including Monte Carlo simulations, density functional theory calculations, high-throughput screening, and machine learning.

Sareeya Bureekaew
Vidyasirimedhi Institute of Science and Technology

Scott Chang
University of Alberta

Dr. Scott Chang is a Professor at the University of Alberta and a guest professor of Zhejiang A&F University. His main research interests are in forest soils, biogeochemistry, and the application of soil science in land reclamation, agriculture, forestry, and global change. Dr. Chang is currently a regional editor for Biology and Fertility of Soils, and an editorial board member for Pedosphere and Biochar. He is a Fellow of the Soil Science Society of America, American Society of Agronomy, and the Canadian Society of Soil Science.

Ong Hwai Chyuan
University of Malaya, Malaysia

Ong Hwai Chyuan obtained his B.Eng. (Hons.) in Mechanical Engineering from Faculty of Engineering, University of Malaya with distinction. Then, he obtained Ph.D. in Mechanical Engineering from the same university in December 2012. Upon the completion of his studies, he is appointed as Lecturer at Department of Mechanical Engineering, University of Malaya. He is also a Chartered Engineer of Engineering Council (CEng) under Institution of Mechanical Engineers (IMechE), United Kingdom. His research interests are wide-ranging under the general umbrella of renewable energy system. However, his main interests are biofuel & bioenergy, energy efficiency and policy, solar thermal system and green technology & environmental issue.
He has published more than 120 high impact SCI journal papers with H-index more than 30 (WOS). He is listed as Highly Cited Researchers 2019 (Engineering) by Clarivate Analytics. In 2018 & 2017, he received the Malaysia's Research Star Award (frontier researcher) and in 2016, he received the Malaysia's Rising Star Award (young researcher) by Ministry of Higher Education and Clarivate Analytics. Currently, he serves as Associate Editor of Alexandria Engineering Journal, Journal of Renewable and Sustainable Energy, guest editor in Energies, and editorial board member for few other journals. Ong is also Core Group Member of APRU Sustainable Waste Management (SWM) program

Shuai Deng
Tianjin University

Shuai Deng, is an Associate Professor at the School of Mechanical engineering of Tianjin University since 2017. His research interests are thermodynamics and heat&mass transfer. He concentrates on applying these fundamental investigations to seperation of mixtured gas, particularly, heat-driven seperation, e.g., seperation technologies for CO2 capture, power/refrigeration system using zeotropic mixtures, multi-function energy system using mixtured working fluids.

Xiaomin Dou
Beijing Forestry University

Dr. Xiaomin Dou received his Ph.D. degree from the Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China in 2006. He is presently an associate professor at the College of Environmental Science and Engineering, Beijing Forestry University, China. His recent research interests include pretreating pharmaceutical wastewater through physical-chemical methods, converting biomass to value-added functional materials, and mitigating hazardous ions (As, F and Sb, etc.) from water. He has published 57 peer-reviewed scientific papers on the above-mentioned fields with more than 2400 citations.

Taku Fujiwara
Kochi University

Dr. Fujiwara is currently a Professor at Kochi University, Japan. He received a Diploma and Master Degree from Kyoto University, Japan, both in Sanitary Engineering. He received his Ph.D. degree in Environmental Engineering from Kyoto University in 1999. He teaches river basin management, water quality analysis and control, environment management in rural areas, among others. His research interests include (a) removal of micro-contaminants in wastewaters using functional materials, (b) nitrous oxide emission from wastewater treatment systems, (c) development of energy saving wastewater treatment systems, (d) diffuse pollution control in agricultural areas, (e) cascading material-cycle systems for producing values from wastes and wastewater.

Dr. Fujiwara is the author or co-author of 95 refereed journal publications including 39 Japanese publications. He has been a director of Japan Society on Water Environment (JSWE) since 2013, which jointly established International Water Association (IWA) Japan National Committee (IWA-JNC) with the Japan Water Works Association. He was a chair of 9th IWA International Symposium on Waste Management Problems in Agro-Industries (AGRO'2014), and served as a vice-chair of 10TH IWA SYMPOSIUM ON WASTE MANAGEMENT PROBLEMS IN AGRO-INDUSTRIES (AGRO'2019) held in Rhodos, Greece, 19-21 June, 2019. He is also a chair of research committee for water reclamation and material-cycle in agro-industries, JSWE.

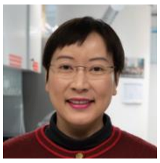
Dr. Fujiwara received several awards including the Best Paper Award for Young Researchers by Japan Sewage Works Association (2009), JSWE-IDEA International Activity Award by JSWE (2014), Distinguished Researcher Award by Kochi University (2015), JSWE Technology Award by JSWE (2016), and Reviewers Award for Grants-in-Aid for Scientific Research by Japan Society for the Promotion of Science (JSPS) (2014, 2017).

He is a member of Editorial board of Journal of Material Cycles and Waste Management since 2015, and a section editor of Resource Recovery, Environnmetal Quality Management, since 2020. He is an advisory board member of International Conference on the "Challenges in Environmental Science and Engineering".

Longbin Huang
University of Queensland

Shih-Hao Jien
National Pingtung University of Science and Technology

Sutha Khaodhiar
Chulalongkorn University



Carol Sze Ki Lin
City University of Hong Kong

Dr. Carol Lin is currently an Associate Professor in the School of Energy and Environment at the City University of Hong Kong. She was a Visiting Assistant Professor at the Bioengineering Program in the Department of Chemical and Biomolecular Engineering at the HKUST from January 2010 to June 2011. Prior to this, she was a postdoctoral researcher in the research group of Professor Wim Soetaert at the Centre of Expertise – Industrial Biotechnology and Biocatalysis (InBio.be) at the Ghent University in Belgium. Dr. Carol Lin graduated in Chemical and Materials Engineering from the University of Auckland, New Zealand with a 1st class honours degree. Her PhD was carried out within the Satake Centre for Grain Process Engineering (SCGPE) in the School of Chemical Engineering and Analytical Science at the University of Manchester, England. In collaboration with the Green Chemistry Centre of Excellence at the University of York, her research focused on novel wheat-based biorefining strategies for the production of succinic acid. Her current research interests focus on the valorization of food waste through conversion into commercially valuable products such as the production of biofuels, bio-degradable polymer and specialty chemicals. Her research work on 'Starbucks Biorefinery' strategy for sustainable production of succinic acid has been highlighted by the American Chemical Society (ACS) in the 244th meeting in Philadelphia, USA as well as in numerous high profile media venues such as Time Magazine (US Edition), BBC News, CNN and the South China Morning Post in Hong Kong. Dr. Lin is also editorial board member of several biotechnology and energy related journals. She has published over 100 papers with several scientific manuscripts in top impact factor journals including Chemical Society Reviews, Energy and Environmental Sciences; editor of 2 books, co-authored 13 book chapters and published 3 patents. She gave over 100 oral presentations including 13 keynote and 5 plenary talk in the following countries: Australia, Belgium, China, Colombia, France, Germany, Greece, Hong Kong, India, Indonesia, The Netherlands, New Zealand, Portugal, Serbia, Singapore, South Korea, Spain, Switzerland, Taiwan, the UK and USA.

Nabeel Khan Niazi
University of Agriculture Faisalabad

Dr Nabeel Khan Niazi is an Assistant Professor in the Institute of Soil and Environmental Sciences (ISES) at the University of Agriculture Faisalabad (UAF), Pakistan. Nabeel did his BSc (Hons) Agri and MSc (Hons) Agri degrees in Soil and Environmental Sciences from the University of Agriculture Faisalabad (Pakistan). He got his PhD from The University of Sydney (Australia) in 2012. His teaching and research focuses on Soil and Environmental Chemistry & Environmental Remediation area with particular focus on soil and water systems.
Dr Niazi was involved in the research work on arsenic contaminated soils historically contaminated with arsenical pesticides and herbicides, in Australia. He employed X-ray absorption fine structure (XAFS) spectroscopy and a sequential extraction procedure to evaluate the speciation and bioavailability of arsenic in contaminated soils, and compared the two arsenic hyperaccumulating fern species to determine their potential for remediation of an arsenic-contaminated site. He also

used geostatistical model to precisely estimate the arsenic contamination level at the arsenic-contaminated cattle-dip sites, and used this model to monitor changes in soil arsenic content after remediation efforts.

His current research interests focus on the environmental soil chemistry including the speciation of arsenic in soil, water and plant matrices. He has published over 8 research articles on in peer-reviewed international journals, including 2 articles in Environmental Science & Technology – the number 1 journal in the field of 'Environmental Sciences and Environmental Engineering'. In addition, he has also authored over 18 conference abstracts published in different national/international conferences (total career publications 26 including journal articles, conference abstracts/proceedings).

Nabeel through his own initiative won a prize of $750 and was awarded a certificate of appreciation by the Australian Society of Soil Science Inc. (ASSSI) for one of the best paper presented and published in the 19th World Congress of Soil Science, Brisbane, 1–6 August, 2010.

In recognition of the outstanding work and oral and poster presentations at the 7th International Conference of Phytotechnologies in Parma, Italy, Sep 2010, Nabeel was awarded 150 Euro and a certificate of appreciation for his scientific contribution.

Dongyeop Oh
Korea Research Institute of Chemical Technology

Yong Sik Ok
Korea Biochar Research Center, Division of Environmental Science and Ecological Engineering, Korea University
http://yongsikok.korea.ac.kr/

Dr. Ok is a full professor at and global research director of Korea University in Seoul, Korea. His academic background covers waste management, the bioavailability of emerging contaminants, and bioenergy and value-added products (such as biochar). Professor Ok also has experience in fundamental soil science and the remediation of various contaminants in soils and sediments. Together with graduate students and colleagues, Professor Ok has published over 600 research papers, 60 of which have been ranked as Web of Science ESI top papers (56 nominated as "highly cited papers" [HCPs] and 4 nominated as "hot papers") since 2009. He has been a Web of Science Highly Cited Researcher (HCR) since 2018. In 2019, he became the first Korean to be selected as an HCR in the field of Environment and Ecology. He maintains a worldwide professional network through his service as an Editor (former Co-Editor in Chief) of the Journal of Hazardous Materials, Co-Editor for Critical Reviews in Environmental Science and Technology, Associate Editor for Environmental Pollution and Bioresource Technology, and as a member of the editorial boards of Renewable and Sustainable Energy Reviews, Chemical Engineering Journal, Chemosphere, and Journal of Analytical and Applied Pyrolysis, along with several other top journals. Professor Ok has served in a number of positions worldwide including as honorary professor at the University of Queensland (Australia), visiting professor at Tsinghua University (China), adjunct professor at the University of Wuppertal (Germany), and guest professor at Ghent University (Belgium). He currently serves as Director of the Sustainable Waste Management Program for the Association of Pacific Rim Universities (APRU). He has served as chairman of numerous major conferences such as Engineering Sustainable Development 2019, organized by the APRU and the Institute for Sustainability of the American Institute of Chemical Engineers (AIChE).

Patryk Oleszczuk
University of Maria Skłodowska-Curie

Dr Oleszczuk is a Professor of Environmental Chemistry and Head of Environmental Chemistry Department at Maria Curie-Sklodowska University, Poland. His research interest includes: (1) ecotoxicology and environmental chemistry, (2) fate of organic and inorganic contaminants in environmental (soil, water, sediments) and anthropogenic samples (sewage sludges, composts, food); (3) nanoparticles in the environment (fate, determination, sorption of organic contaminants, toxicity); (4) waste (mainly sewage sludge and compost) management and utilization; (5) biochar properties and applications. Dr. Oleszczuk has more than eighteen years of research experience on contaminants such as polycyclic aromatic hydrocarbons, nanomaterials and heavy metals in natural and engineered environment. He has published more than one hundred peer-reviewed high impact journal papers on the above topics and is a frequent invited speaker at many international conferences and universities.
Dr Oleszczuk obtained MS degree from Maria Curie-Sklodowska University, Poland in 1999 and Ph.D degree from University of Life Sciences in Lublin, Poland in 2004. After the graduation, Dr. Oleszczuk worked in University of Life Sciences in Lublin, Poland seven years from 2000 to 2007 and then moved to University of Massachusetts in Amherst, USA as a postdoc research associate between 2007 and 2009. Dr Oleszczuk joined Maria Curie-Sklodowska University as a professor since September 2012. Dr. Oleszczuk received several awards including Award from Prime Minister of Polish Government, The Polityka Foundation "Stay with us", Group Award of Polish Minister of the Environment, Award for "Young Scientist" from Polish Academy of Science, Fellowship for "Start" from the Foundation for Polish Science. As a principal investigator, Dr. Oleszczuk is being in charge of more than 10 Federal projects.

Jörg Rinklebe
Chief Editor for Special Issues and Associate Editor of the Journal of Hazardous Materials and Chief Editor for Special Issues and Associate Editor, Environmental Pollution

- Vice-President of the International Society of Trace Element Biogeochemistry (ISTEB)
- Adjunct Professor at the University of Southern Queensland, Australia
- Visiting Professor at the Sejong University, Seoul, South Korea
- Guest Professor at the China Jiliang University, Hangzhou, Zhejiang, China
- Honorable Ambassador for Gangwon Province, Korea

Chief Editor for Special Issues and Associate Editor of the Journal of Hazardous Materials https://ees.elsevier.com/hazmat/default.asp

Chief Editor for Special Issues and Associate Editor, Environmental Pollution
Editor of Critical Reviews in Environmental Science and Technology (CREST) https://www.tandfonline.com/toc/best20/current
Awards:
Award for internationalisation of research and teaching: Weltlöwe
Research interests:
- Biogeochemistry of trace elements and nutrients in wetland soils, sediments, waters, and plants

- Global soil and groundwater pollution
- Remediation of soil and groundwater
- Biochar
- Soil microbiology
- Nano materials

Chularat Sakdaronnarong
Mahidol University

Binoy Sarkar
Lancaster Environment Centre (LEC) of Lancaster University

Dr Binoy Sarkar is a Lecturer at the Lancaster Environment Centre (LEC) of Lancaster University. Previously he was a Research Associate at University of Sheffield, and a Research Fellow at University of South Australia from where he also received his PhD. Dr Sarkar's research aims to improve the understanding of physio-bio-chemical phenomena occurring at the surfaces and interfaces of minerals and other particulate materials (for example, biochar, nanoparticles, plastics). The applied sides of his work extend to atmospheric carbon dioxide capture and carbon sequestration in soils, and remediation of conventional and emerging contaminants in soil and water environments.
Dr Sarkar is an awardee of the Australian Endeavour Research Fellowship (pursued at Indiana University), Desai-Biswas Gold Medal and Geof Proudfoot Award. He was also an Honorary Adjunct Research Fellow at University of South Australia.
Dr Sarkar is an Associate Editor of Clays and Clay Minerals, and European Journal of Soil Science, and an Editorial Board Member of Critical Reviews in Environmental Science and Technology and Minerals. He also served as Guest Editor of multiple special issues in Journal of Hazardous Materials, European Journal of Soil Science, Applied Clay Science, Clays and Clay Minerals, and Journal of Soils and Sediments. Website: https://www.lancaster.ac.uk/lec/about-us/people/binoy-sarkar

Christian Sonne
Aarhus University

Since may 1998 educated in various arctic field work and logistics in West Greenland, East Greenland and Canada (see list in CV appendix). Has specialized in the biological effects from metal and organic contaminants on internal organs (histopathology, immunohistochemistry and TEM), skeletal system (BMD via DXA scanning), immune system (IDT, cytokine and APP analyses), endocrine system (RIA, HPLC) and blood chemistry in arctic top predators. Additionally specialised in surgical field implantations of intraabdominally (-coelomic) and subcutaneously satellite transmitters (PTTs) in common and king eider (Somateria molissima, Somateria spectabilis), Brünnich´s Guillemot (Uria lomvia) and red knot (Calidris c. canutus) in Canada, Greenland and Holland.

Daniel C.W. Tsang
Hong Kong Polytechnic University

Dr. Daniel C.W. Tsang research emphasizes a strong link to real-life environmental challenges in the regional context. To ensure sustainable urban development, we need to enhance our engineering infrastructure and create new ways in which we manage contaminated land, solid waste, and urban water. Our research group aims to develop cost-effective and low-impact solutions that are informed by fundamental science of natural and engineered systems. Specific topics are: Environmental assessment and sustainable remediation of contaminated land; Biomass valorisation of food waste, wood waste, agro-waste, and wastewater sludge; Stormwater harvesting and industrial wastewater treatment for resilient water cycle.

Meththika Vithanage

University of Sri Jayewardenepura

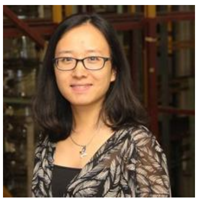
Dr. Meththika Vithanage is a Senior Lecturer at the University of Sri Jayewardenepura, Sri Lanka, an Adjunct Associate Research Professor at the University of Southern Queensland, Australia and Visiting Associate Research Professor of the National Institute of Fundamental Studies, Kandy, Sri Lanka. Dr. Vithanage's research approach builds on environmental science; key/emerging pollutants in the environment, assess their fate and transport and remediate those using geo/bio/nano materials. She is a Young Affiliate of the Third World Academy of Sciences and she became the Chairperson of the Young Scientists Forum in 2017. She was awarded as the Best Young Scientist, 2018 and 2016 by the Young Scientist Forum of the National Science and Technology Commission and National Science Foundation of Sri Lanka. Recently she was selected as one of the Early Career Women Scientists by the Organization for Women Scientists in the Developing Countries, Italy. She has contributed over 130 Science Citation Indexed journal articles, over 30 book chapters and three co-edited books published by Elsevier Inc. Her citation record is now passed 3300 with an H index of 28.

Xiaonan Wang
National University of Singapore (NUS)

Dr Xiaonan Wang is an assistant professor and a promising female scientist in the Department of Chemical and Biomolecular Engineering, National University of Singapore (NUS). She received her BEng from Tsinghua University in 2011 and PhD from University of California, Davis in 2015. After working as a postdoctoral researcher at Imperial College London, she joined NUS to lead the Smart Systems Engineering research group since 2017. She is also the deputy director of the Accelerated Materials Development for Manufacturing programme in Singapore. Her research focuses on the development of intelligent computational methods including multi-scale modelling, optimization, data analytics and machine learning for applications in energy, manufacturing and environmental systems to support smart and sustainable development. Her team has built a systematic planning platform for smart city and engineering development that combines model-based and data-driven approaches for overall economic, environmental and social benefits improvements. She has published more than 50 peer-reviewed journal papers and conference proceedings, chaired more than 10 international conferences, delivered more than 40 invited talks on five continents, and served on editorial board of journals such as Applied Energy and Frontiers in Blockchain. She was recognized as an IChemE Global Awards 2017 Young Researcher finalist and several best paper awards at IEEE and Applied Energy Conferences.

Yusuke Yamauchi
The University of Queensland

Professor Yamauchi is focussed on design of novel nanocrystals and nanoporous materials toward various applications including batteries, fuel cells, solar cells, chemical sensors, field emitters, and photonic devices. Specifically, nanoporous metals with metallic frameworks can be produced by using surfactant-based synthesis with electrochemical methods. Owing to their metallic frameworks, nanoporous metals with high electroconductivity and high surface areas hold promise for a wide range of electrochemical applications. Furthermore, he has developed several approaches for orientation controls of tubular nanochannels. The macroscopic-scale controls of nanochannels are important for innovative applications such as molecular-scale devices and electrodes with enhanced diffusions of guest species. Professor Yusuke Yamauchi received his Bachelor degree (2003), Master degree (2004), and Ph.D. (2007) from the Waseda University, Japan. After receiving his Ph.D., he joined the National Institute of Materials Science (NIMS), Japan to start his own research group. He led a big team of senior scientists, technical staffs, and more than 30 PhD students/Postdocs. After getting the ARC Future Fellow, in May 2017 he joined the University of Wollongong as a full professor. Currently, he is a senior group leader at AIBN at University of Queensland. Professor Yamauchi has a joint appointment with the School of Chemical Engineering. He concurrently serves as an honorary group leader of NIMS, a visiting/honorary professor at several universities (University of Wollongong, Tianjin University, King Saud University, and Waseda University), and an associate editor of Journal of Materials Chemistry A published by the Royal Society of Chemistry (RSC). He has published more than 500 papers in international refereed journals with > 20,000 citations (h-index > 70). He is selected as one of the Highly-Cited Researchers in Chemistry in 2016 and 2017. He has received many outstanding awards, such as the NISTEP Award by National Institute of Science and Technology Policy (2016), the Chemical Society of Japan (CSJ) Award for Young Chemists (2014), the Young Scientists' Prize of the Commendation for Science and Technology by MEXT (2013), the PCCP Prize by the Royal Society of Chemistry (2013), the Tsukuba Encouragement Prize (2012), the Ceramic Society of Japan (CerSJ) Award (2010), and the Inoue Research Award for Young Scientists (2010).



Liu Ye
The University of Queensland

Dr Liu Ye is an Associate Professor at The University of Queensland in the School of Chemical Engineering. She was awarded her Ph.D. in 2010 and her research focuses on sustainable and cost-effective water and wastewater treatment, including on-line process control, novel technology development, resource recovery and greenhouse gas (GHG) emissions (monitoring, modeling, and mitigation of N2O) from biological wastewater treatment processes. She has more than 90 publications, including 61 fully refereed journal papers (with over 2000 citation and an h-index of 26 (Scopus, Oct 04, 2019)), and is a co-inventor of four patents. Dr. Ye has been awarded over $3M competitive research funding - including two Discovery Projects, Linkage projects, and the Discovery Early Career Researcher Award (DECRA) Fellowship from Australian Research Council - along with several other industry-funded projects. Liu also received more than eight scientific awards (including Research Innovation Award from Australia Water Association, UQ Foundation Research Excellence

Award, etc.), and is an elected management committee member of the (IWA) Specialist Group on Instrumentation, Control, and Automation (ICA). She is also a member of the Australia Association for Engineering Education (AAEE), Engineers Australia (EA) and as a reviewer for 20 international journals. Dr Liu Ye is also affiliated with the Advanced Water Management Centre at UQ.

Ryo Yoshiie
Nagoya University

Educational experience:

1. PhD in Engineering, Tokyo Institute of Technology (March/1997)
2. April/1994~March/1997 , Tokyo Institute of Technology, Graduate School, Division of Integrated Science and Engineering, Department of Energy Science, Doctor Course, Completed

Scientific research and academic experience:

1. Associate professor, Department of Mechanical Science & Engineering, Nagoya University , 2008/01 – present
2. Research associate, Faculty of Engineering, Gifu University , 1997/04 - 2007/12

Representative studies and academic rewards

"Controls of hazardous compounds from coal combustion and gasification processes", R. YOSHIIE, The Japan Institute of Energy Award for Progress, (2015)

"Effects of coal types on ash fragmentation and coalescence behaviors in pulverized coal combustion", Proceedings of the Combustion Institute", 2013, 34(2): p. 2895-2902, R. Yoshie, T. Tsuzuki, Y. Ueki, Y. Nunome, I. Naruse, N. Sato, T. Ito, Y. Matsuzawa, T. Suda, Best paper award of Combustion Society of Japan, (2013)

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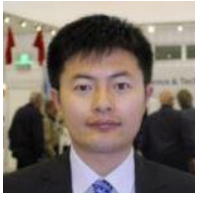
Xiangzhou Yuan
Korea University

Dr. Xiangzhou Yuan is a research professor of Korea University in Seoul, South Korea. His academic background covers clean energy technology, sustainable waste management, and valorization of solid waste into value-added products (i.e., biochar, porous carbon). Dr. Yuan also has an area of expertise in climate change mitigation and wastewater purification. He has registered 4 Korea domestic patents and published about 30 research papers in reputed SCI journals, such Green Chem, Chem Eng J, J Hazard. Mater, Appl Energ. He is also active in servicing as the Outside Director of Sun Brand Industrial Inc. from 2020 and the Key Academic Committee of International Cooperation Research Centre of Carbon Capture in Ultra-low Energy-consumption, Tianjin, China from 2018. He was nominated as the Local organizing committee of 20th International Conference on Heavy Metals in the Environment (ICHMET).



Huiyan Zhang
Southeast University

Dr. Huiyan Zhang is a professor and deputy dean of School of Energy and Environment at Southeast University. His research focuses on biomass conversion into value-added products including transportation fuels, chemicals and carbon materials. At present, he is (co-)author of 3 international and 40 Chinese patents and over 100 international papers (Indexed by SCI) including that published in Science, Energy & Environmental Science. His work has been cited by SCI index more than 4000 times. Prof. Zhang is the winner of the National Nature Science Fund of China for Excellent Young Scholar. He obtained 4 national and international prizes including the first prize of natural science of Ministry of Education, special gold medal of Geneva international inventions Exhibition. He serves as Editorial Board or Guest Editor of 8 Journals, such as Fuel processing Technology, Science of The Total Environment, and so on.

Shicheng Zhang
Fudan University

Shicheng Zhang is a Full Professor at the Department of Environmental Science and Engineering, Fudan University, Shanghai, China, and the Director of Shanghai Technical Service Platform for Pollution Control and Resource Utilization of Organic Wastes. He received his Ph.D. from Northeastern University, China in 2001. After that, he worked as a postdoctoral research fellow in Peking University and Tsinghua University, Beijing, China. In 2005 he joined in the faculty of environmental engineering at Fudan University. From 2007 to 2008, he worked at Iowa State University as a postdoctoral research fellow. From 2011 to 2020, he served as vice chair for the Department of Environmental Science and Engineering at Fudan University. He served as a visiting Professor in the University of York (UK) in 2019.

His research group is focusing on the biofuel, biochemical and bio-based materials production from biomass wastes by chemical, biological and biochemical methods, especially hydrothermal conversion of biomass waste to high value-added products. He serves as an associate Editor of Environmental Engineering Research, an editorial board member of Environmental Sanitation Engineering (in Chinese) and Processes, and has served as guest editors of Bioresource Technology and Green Chemistry. Professor Zhang has been an active member of numerous national and international commissions and committees, and regularly serves as external judge for national and international funding institutions. He currently serves as core group member of the Sustainable Waste Management Program for the Association of Pacific Rim Universities (APRU).

Tao Zhang
College of Resources and Environment, China Agricultural University, China

Tao Zhang is an associate professor at the College of Resources and Environment, China Agricultural University, China. He received his Ph.D from Nanjing University, China in 2011. His academic background covers wastewater treatment, waste management, nutrients recovery and recycling, utilization of agricultural waste.

He is a member of the Expert Function Research Office of Modern Agricultural Industrial Technology System, Ministry of Agriculture, and a director of the Agricultural Environmental Damage Identification and Assessment Branch of the Chinese Society of Agriculture. In addition, he is also a member of the Water Treatment and Reuse Committee of the Chinese Society of Environmental Sciences and a member of the Circular Economy Committee of the Chinese Society of Environmental Sciences. Tao Zhang has won a number of International Invention Exhibition Awards, academic and teaching awards at both provincial and university levels.

PLENARY TALKS

Emerging Challenges in the Design of Treatment Trains for the Potable Reuse of Municipal Wastewater

Prof. William Mitch
Civil and Environmental Engineering
Stanford University

Utilities are increasingly considering municipal wastewater as a local, secure water supply. Purification of municipal wastewater to drinking water quality (potable reuse) is already being conducted at full-scale, typically using a treatment train based on microfiltration (MF), reverse osmosis (RO) and advanced oxidation processes (AOPs). This presentation discusses some of the key technical challenges posed by potable reuse systems. First, RO treatment provides broad-screen physical removal of salts, nutrients, and organic contaminants, but these are rejected into a concentrate stream. The high concentrations of nutrients and contaminants in RO concentrate are raising concerns about RO discharge to marine waters. The presentation discusses a pilot-scale evaluation of ozone/biological activated carbon for removal of nutrients and contaminants prior to discharge, and evaluates whether the concentration of nutrients and contaminants in the RO concentrate stream provides benefits by shrinking the footprint and cost needed to remove these contaminants. Second, the UV/hydrogen peroxide AOP favored in potable reuse trains is inefficient. While researchers are evaluating the UV/free chlorine AOP as a more efficient alternative, the presentation will discuss recent pilot and laboratory studies indicating that these benefits may not be achievable because this AOP produces NDMA, a key contaminant of concern for potable reuse systems. Third, while significant effort is focused on reducing the energy intensity of RO treatment, this presentation summarizes research on an alternative approach of reducing the energy intensity of the upstream switching biological secondary treatment system. In particular, the energy savings associated with switching from aerobic to anaerobic treatment could partially offset the energy cost for RO treatment. However, the presentation would discuss difficulties associated with mitigating the formation of sulfides during anaerobic treatment. Lastly, research is evaluating the potential to use ozone/biological activated carbon (O_3/BAC)-based treatment trains in place of RO, thereby avoiding the energy intensity of RO and issues with RO concentrate discharge. However, the question is whether these trains deliver high quality water. The presentation will briefly describe a comparison between the quality of RO- and O_3/BAC-based potable reuse trains.

Strategies for Managing Metal(loid) Pollution from Mine Wastes in the Environment.

Longbin Huang
Sustainable Minerals Institute, The University of Queensland, Brisbane, Australia

Tailings are nothing like soil but are polymineral wastes containing residue economic metals (e.g. Al, Cu, Pb, Zn) and gangue minerals. Productive and sustainable colonisation of soil microorganisms and plants is inhibited by extreme physical and geochemical conditions, even with remediation inputs of organic matter and fertilisers. Geochemical conditions of the tailings are governed not only by chemical factors (e.g. acidity/alkalinity, soluble solutes and metal(loid)s) already formed in the soluble phase (i.e. porewater), but also the solid phase of reactive minerals. These makes short-term remediation ineffective, such as direct incorporation of organic matter, leading to the failure of even tolerant hyperaccumulators and pioneer plants. As a result, the adoption of ‘soil remediation’ and/or phytoremediation based on hyperaccumulators are largely not suitable and are unsustainable for tailings rehabilitation. The present talk introduces a new and emerging technological pathway of eco-engineering of tailings or mine wastes for hydrogeochemical stabilisation and abatement of acute toxicity. Bioweathering of reactive minerals (e.g. sulfides in sulfidic tailings) can be readily catalysed by extremophiles (i.e. tolerant archaea, bacteria and fungi) upon provision of suitable conditions, such as moist conditions and relevant substrates (such as organic matter, nutrients), leading to feasible and sustainable colonisation of soil microbes and pioneer plants in extensively weathered tailings, together with inorganic/organic amendments. By using ecological engineering approaches combining engineering and geo-microbial ecology principles, the microbial processes would be enhanced by targeted and effective engineering inputs (e.g. water, organics) for achieving rapid exhaustion/depletion of reactive minerals, leading to long-term hydrogeochemical stabilisation. The present paper will use our recent research on sulfidic tailings and Fe-ore tailings for the purpose to draw research attention onto ecological engineering principles and practices. This emerging technology is to deliver cost-effective and feasible technologies for speeding up progressive and sustainable tailings and mine wastes rehabilitation.

Wood Waste Biochar for Sustainable Industrial Wastewater Treatment.

Daniel CW Tsang
Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong, China

Metal-free carbocatalysts attract broad interest as efficient activators in sulfate-radical-based advanced oxidation processes (SR-AOPs) to afford a sustainable, nonradical regime. Nitrogen-doped biochar (NBC) stands out owing to its economical, tunable, and versatile features among its counterpart carbons. Nevertheless, the nature of nitrogen doping, the doping-induced redox-active moieties, and a valid catalytic mechanism towards nitrogen-doped biochar still remain vaguely explored due to its structural complexity. Accordingly, a series of NBCs derived from lignocellulosic waste was fabricated *via* a facile two-stage thermal treatment (pyrolysis-annealing). Mechanochemical ball-milling process coupled with wet ammonia nitrogenation was employed to reach a mild surface doping without compromising the intact graphitic carbon skeleton. The nitrogen species, the structural properties, and the surface chemistry of NBCs can be readily tuned. It was found that specified annealing temperature at the annealing stage could readily regulate the nitrogen species in a sequential order, *i.e.*, amino-N-dominated, pyrrolic- and pyridinic-N-dominated, and graphitic-N-dominated types. The electron-rich oxygen-containing functionalities and sp^2-hybridized carbon matrices could transform nitrogen species *via* the formation of various persistent free radicals. A negative correlation was observed between the activation energies and the G-factors of NBCs, while a positive one was unveiled between the defective levels and degradation reaction rate constants. The evolved carbon-centred persistent free radicals on turbostratic carbon sheets could act as the anchoring sites to achieve a nucleophilic addition, promising the formation of surface-confined radicals and their following conversion towards non-radical oxygen species. Overall, this study unravels the mechanistic nature of nitrogen-doped biochar in the sustainable electrocatalysis.

The Microplastic Cycle: Implications for Environmental Health and Sustainable Development.

Michael Bank
Contaminants and Biohazards, Institute of Marine Research, Bergen, Norway

Microplastic pollution in the environment is an important societal issue that has received widespread attention from scientists, the public and media outlets. Additionally, microplastic pollution has been identified as a priority global sustainable development and pollution issue by environmental governance leaders and policymakers throughout the world. In this presentation I introduce the concept of the 'Microplastic Cycle' and discuss the sources, fate, transport, and effects of microplastics and how they relate to the relevant UN Sustainable Development Goals (UN-SDGs). Since the fluxes of microplastics between ecosystem compartments, including the lithosphere, biosphere, hydrosphere, atmosphere, and

anthroposphere, are not well understood I outline and highlight a series of research avenues and models that can be used to further elucidate the complex processes and drivers of microplastic fate and transport using complex systems theoretical approaches and pedagogy. Finally, using these models I evaluate the importance of mechanistic findings and empirical data in the context of the effectiveness evaluation of the United Nation's Basel Convention's impact on addressing the plastic waste problem in the context of the relevant UN-SDGs. The relationships with environmental and public health will also be discussed.

AI and Machine Learning through Life Cycle of Environmental Systems.

Xiaonan Wang
Department of Chemical and Biomolecular Engineering, National University of Singapore, Singapore, Singapore

The recent rapid development of deep learning enabled artificial intelligence (AI) has brought tremendous new opportunities to many fundamental domains in energy, environmental, and engineering systems [1]. In this talk, I will give a state-of-the-art overview of the ML methods and illustrate how AI can help in many fields we have investigated recently to accelerate sustainable development through waste management, carbon management and smart city. Not only commonly used ML methods e.g., random forest, support vector machine, and neural networks, but the recent developments of ML-in-the-loop through active learning, reinforcement learning, generative adversarial networks etc. are also explored to combine expert knowledge with the data-driven models and automated systems. Furthermore, we have developed a series of interpretable approaches to understand "black-box" ML models and make it more favoured by domain engineers and scientists to achieve abundant findings of complex systems that may embed a huge amount of hidden information.

Our recent developments of ML models and data-driven optimization that can expedite smart systems engineering development will be demonstrated via a series of frontier case studies such as 1) design of global negative emission systems through biochar; 2) multi-step ML-enabled optimized nanoparticles synthesis; and 3) sustainable waste management to recover energy and resources and data-driven optimization for industrial symbiosis [2-4]. Although promising opportunities are identified, many challenges exist at this early stage, such as construction of valuable and open datasets, lack of standard algorithms workflow and fully autonomous experimental platforms, which will be discussed as future directions. In spite of the challenges, it is promising to embrace the dawn of a new data-driven era and promote global collaboration to battle climate change.

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The Arctic Environment and the UN Sdgs.

Christian Sonne
Bioscience, Aarhus University, Roskilde, Denmark

Exposure to long-range transported industrial chemicals, climate change and diseases is posing a risk to the overall health and populations of Arctic wildlife. Since local communities are relying on the same marine food web as marine mammals in the Arctic, it requires a One Health approach to understand the holistic ecosystem health including that of humans. Exposure to persistent organic pollutants (POPs) is having multiple organ-system effects across taxa, including impacts on neuroendocrine disruption, immune suppression and decreased bone density across top predators and local human populations. The warming Arctic climate influence abiotic and biotic long-range transport and exposure pathways of contaminants to the Arctic resulting in increases in POP exposure of both wildlife and human populations. Exposure to vector-borne diseases and zoonosis may increase through range expansion and introduction of invasive species Covid-19 being one of them. It important o investigate the effects of these multiple stressors on wildlife and local human populations using omics to better predict the individual-level health risks. It is within this framework that One Health approaches offer promising opportunities to survey and pinpoint environmental changes that have effects on wildlife and human health under the umbrella of the UN SDGs.

Small(er) Particles, Big(ger) Problems? Fate, Transport and Implications of Nano- and Microplastics in the Environment.

Denise Mitrano
Environmental Systems Science, ETH Zurich, Zurich, Switzerland

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 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.

KEYNOTE SPEECH-SESSION 1

Developing a National Plastics Account of South Korea.

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South Korea is one of the top consumers of plastics, consuming 133 kg per capita, and has recently experienced problems regarding its plastic wastes. In early 2018, after the China's import ban on recyclable wastes, private recycling companies in Seoul and Gyeonggi refused to collect plastic waste, which led to the accumulation of waste piles in apartment complexes and community complaints. In the same and following years, an illegally exported trash to the Philippines was repatriated and the 170,000 tons of smoldering garbage mountain was found in a small farming town of Uiseong. These issues pose questions on what drives the plastic consumption, how its wastes are managed, what the problem hotspots are in the overall plastic management in Korea. To what extent the plastic waste is recycled according to existing policies versus mismanaged outside of the formal management systems? What would be needed for circular transformation of Korea's plastic flows?

To have a first basic understanding of the plastic management in Korea, this study developed a national account of plastics over its life cycle. Our preliminary results showed that in 2017, Korea produced 17,437 ktons of primary resins as well as 7,430 ktons of plastic products, and consumed 6,207 ktons of products. Packaging, building/construction, and households were the three major sectors that consumed 36%, 17%, and 15% of the net plastic consumption, respectively. These sectors were also the major contributors (i.e., 88%) to the plastic waste generation. Out of the 9,559 ktons of plastic waste generated, 68% of them entered into the recycling system, but 48% were eventually sold for material recycling or as a fuel. The Korea's two policy instruments, voluntary agreement and extended producer responsibility, turned out to cover 42% of the plastic products consumed. We will further assess uncertainties of these plastic flows and derive proposals for improved plastic management in Korea.

Photo-Aging of Microplastics and the Effects on the Environmental Behaviors of Organic Contaminants in Aquatic Environments.

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Multiple aging pathways in the aquatic environments and the underlying transformation mechanism were described for microplastics (MPs). The polystyrene and high-density polyethylene microplastics could be altered by heat-activated $K_2S_2O_8$ and Fenton treatments, thus further improving the understanding of their long-term natural aging in aquatic environments. The active oxidizing species generated in advanced oxidation processes are generally free radicals, e.g., hydroxyl radical (OH•) for Fenton and OH•/SO4•$^-$ (sulfate radical anion) for persulfate, and their high redox potentials are likely to enhance the oxidation of microplastics. In our recent study, the photo-alteration was investigated for polyvinyl chloride microplastics (PVC-MPs), and the aging reaction could be facilitated in the presence of low-molecular-weight organic acid (LMWOA) and LMWOA-Fe(III) complex under simulated and natural sunlight irradiation and ambient conditions. The OH• generated from the photolysis of LMWOA or its ferric complexes played a dominant role in enhancing PVC-MP degradation. PVC-MP surface oxidation led to the increase of the specific surface area and affinity towards water, which would further enhance the adsorption of polar contaminants on PVC-MPs and thus increase the health risk of PVC-MPs on aquatic organisms. In addition to enhancing the sorption capacity for hydrophilic antibiotics, aged PVC-MPs exhibited great potential to accelerate the hydrolysis of cephalosporin pharmaceuticals, which could be ascribed to the interfacial hydrogen-bonding interactions between *β*-lactam antibiotics and oxygenated PVC-MPs. The intermolecular hydrogen-bonding force was able to lower the energy gap for the hydrolytic reaction of cephalosporin antibiotics. These researches shed light on the aging reaction of microplastics and the effects on the environmental behaviors of organic contaminants in aquatic environments.

Morphological, Chemical and Physical Changes of Microplastics in Hydrothermal Pretreatment of Sewage Sludge.

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Due to the high retention of microplastics (MPs) in WWTPs, a large amount of MPs are enriched in sewage sludge. A considerable number of these particles may enter the environment after the sludge treatment process. Hydrothermal treatment (HTT) is often used as pretreatment for sludge dewatering or anaerobic digestion. However, little is known regarding the chemical and physical changes of MPs during HTT. We evaluated the effect of HTT on the degradation of polyethylene (PE), polyethylene terephthalate (PS) and Polyvinyl Chloride (PVC). HTT is not enough to completely degrade MPs in the sludge, but it did change the type, shape and surface properties of MPs in sewage sludge, which affected its ability for the absorption of heavy metals and organic pollutants. In addition, HTT also helped to dissolve plastic additives, which had negative effects on the following AD process.

Needs-Matched Developments of Sustainable Plastics and Microplastics.

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More than 300 million tons of plastics are annually produced world widely. A massive amount of non-degradable plastics accumulated in the planet earth intensify the destruction of the ecosystem. There are various sorts of plastics: HDPE, LDPE, PP, PS, PET, Nylon, PVC, PEEK, and PC. Each serves different purposes e.g. plastic bags, toys, bottles, electronic devices, and cosmetics since they have respectively different physical features. The recycling of plastic wastes requires to assort plastic wastes by types because different plastics are not miscible with one another. However, even for plastic engineers, plastic sorting is not an easy process. Moreover, it would be difficult to recycle plastics if they are contaminated or colored. Therefore, the recycling rate of plastics stay low, only less than 9%.

Considering the diversity of plastics, it is not feasible to find a universal material to replace all types of plastics and a universal way to reduce plastic wastes. In this talk, we report needs-matched sustainable plastics and microplastics: 1) tough biodegradable plastics for disposable products, 2) bio-based engineering thermoplastics for electronic and medical devices, 3) bio-based thermoplastic elastomers for replacing unrecyclable rubbers and 4) biodegradable microplastics for personal-care products and rinse-off cosmetics.

Coexistence of Polyethylene Microplastics and Biochar Increases Ammonium Sorption in an Aqueous Solution.

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Biochar is used to remove ammonium (NH_4^+) from wastewater, where microplastics are emerging pollutants. However, whether microplastics can adsorb NH_4^+ or how they will affect the sorption of NH_4^+ by biochars have not been studied. We conducted batch sorption kinetics and isotherm experiments to elucidate the sorption of NH_4^+ on a manure biochar (MBC), a straw biochar (SBC), a wood sawdust biochar (WBC), a polyethylene microplastic (PE), and their combinations. The results showed that PE had a smaller sorption capacity (Qmax = 3.29 mg g^{-1}) but a faster adsorption rate (ks = 0.08 g (mg min)$^{-1}$) for NH_4^+ than biochars (Qmax = 5.67 ~20.54 mg g^{-1}; ks = 0.02 ~ 0.04 g (mg min)$^{-1}$). When PE and biochars coexisted in an aqueous solution, the NH4+ sorption capacity was increased by 17.0% in PE+SBC, 7.1% in PE+MBC, and 8.6% in PE+WBC, which was likely due to the deprotonation of functional groups and the decreases in small molecular-size dissolved organic carbon. We conclude that microplastics can adsorb NH_4^+; moreover, they can enhance the NH_4^+ sorption capacity of biochars. Therefore, when biochar is used for NH_4^+ removal from wastewater, the interaction of biochar and microplastics needs to be considered.

A Journey into the Closed Carbon Loop Based on a Life Cycle Perspective: From CO_2 Adsorbent to Cycle.

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In our previous work, waste polyethylene terephthalate (PET) plastic-derived microporous carbons have been synthesized as one kind of effective CO_2 adsorbents. A pathway to provide cost-effective and promising CO_2 adsorbents for CCS applications, which can also alleviate environmental issues caused by PET plastic waste, has been proposed. As these two stand-alone urgent environment issues can be solved simultaneously, such an attempt can be regarded as an efficient strategy to maintain the sustainable development, therewith, an environmentally-friendly route to close the carbon loop can be preliminary established. However, whether such a strategy can approach the negative emissions is still needs to be quantitative evaluation, which can be analyzed based on a life cycle perspective.

Valorization of waste PET plastic into microporous carbon has been performed successfully as used for CO_2 capture. The PET-derived microporous carbon developed by KOH activation and urea treatment in a one-pot synthesis at 700 °C showed the best performance, which exhibited the highest CO_2 adsorption uptake of 6.23 mmol g−1 at 0 °C and 4.58 mmol g−1 at 25 °C (1 atm). The Langmuir and pseudo second-order models displayed well-fitting relationships with equilibrium and kinetic experimental data obtained. The N-doped microporous carbon showed high CO_2 selectivity over N_2, implying that it is feasible for treating flue gases (10% CO_2 and 90% N_2) at 50 °C. In addition, the CO_2 uptake was not only affected by micropores but also related with nitrogen and oxygen functional groups. Compared to the porous carbon prepared by two-pot synthesis where KOH activation and urea treatment were conducted separately, the porous carbon prepared by one-pot synthesis had higher oxygen contents and higher CO_2 adsorption uptake.

As the microporous carbons we developed show an excellent CO_2 adsorption capacity, which can be considered as potential adsorbents for CO_2 capture. However, the performance evaluation on such one kind of CO_2 adsorbents is still lacking from the perspective of process or cycle, only the basic characterization results are concerned yet, making the one-sided analysis inevitable. Consequently, a whole chain research is considered as one essential approach for providing both comprehensive analysis and generalized evaluation of the sample prepared. A series of temperature swing adsorption (TSA) cycle using the microporous carbon CO_2 adsorbents were numerically simulated, especially, defined cyclic performance indicators were calculated to determine the optimal application scenario.

As the adsorption CO_2 capture cycle using the microporous carbons developed has been optimized though, it is still unclear whether such a solution could approach the aim of negative emissions based on a life cycle perspective. Therefore, a further analysis would be required to provide a comprehensive investigation on the potential life cycle environmental impacts. This study identified that this waste PET bottle-to-CO_2 adsorbent approach could achieve negative CO_2 emission, and thus provide an environmentally-friendly route to close the carbon loop. Using LCA methods, the aims of this research are to: (1) quantify the environmental trade-offs of waste PET-derived AC; (2) explore the possibility of achieving negative emissions through detailed cycle configurations using PET derived microporous carbons as the CO_2 adsorbent; (3) identify the key factors affecting the overall performance of the production chains from a life cycle point of view. Therewith, the practical application potential of such an integrated negative-emissions technology can be found out, the feasibility and rationality analysis of the closed carbon loop proposed in this work would be unrolled.

KEYNOTE SPEECH-SESSION 2

Technical Challenge to Manage Antibiotics in Wastewaters Considering Interlinkages Among Sustainable Development Goals: Development of a Rotating Advanced Oxidation Contactor Equipped with Zeolite/TiO_2 Composite Sheets.

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The overuse of antibiotics to combat illnesses of humans and livestocks results in the discharge of antibiotic residues in wastewaters. Some of the antibiotics are refractory to degradation in conventional wastewater treatment systems, and more than 80 % of wastewater in the world is discharged to the environment without appropriate treatment. Resultantly, the spread of antibiotic-resistant bacteria in aquatic environment raises the risk to human health, and this issue receives great deal of attention all over the world. Indeed, it is a critical issue even in developing countries, where halving the proportion of untreated wastewater is the main target by 2030.

It is widely recognized that advanced oxidation processes (AOPs) are effective for tertiary treatment to remove antibiotics in water. Inhibition of coexisting matters in raw wastewaters and high cost and energy consumption, however, should be overcome before application of AOPs to developing countries for managing antibiotics without conventional treatment systems. Hence, technical challenge for antibiotics management in raw wastewaters should be promoted considering interlinkages among SDG 2 (livestock production), 3 (human health), 6 (water) and 7 (energy consumption). Solar-driven photocatalysis applicable to raw wastewater might be one of the promising options for future AOPs.

The authors have developing a rotating advanced oxidation contactor (RAOC) equipped with zeolite/titanium dioxide (TiO_2) composite sheets and propose it as a technical challenge for antibiotic removal from wastewater, which overcomes drawbacks of conventional photocatalytic reactor. It is applicable to real wastewaters including livestock urine and fresh aquaculture wastewater, and expected to be applied under solar light irradiation. The RAOC can overcome various drawbacks of powdery TiO_2 such as requirement of its recovery from treated water, light attenuation in aqueous phase, and inhibition of photocatalysis by coexisting substances in wastewater.

They originally found that high-silica Y type zeolite (HSZ-385) can selectively adsorb antibiotics by hydrophobic interaction in real wastewaters which contain high concentrations of coexisting substances, and developed pH dependent adsorption model for sulfa-drugs. Additionally, they produced composite sheets which immobilized the zeolite and TiO_2 (P-25) using a papermaking technique, and the sheets were fixed to both sides of a rotating disk. The submerged RAOC can adsorb antibiotics in aqueous phase, and decompose it in air phase by photocatalysis after rotation of the disk. Because very thin water layer is formed on the disk surface exposed to air, light attenuation is mitigated and photocatalysis is promoted. They have clarified the removal mechanisms of antibiotics that both parent micro-contaminants and their transformation byproducts were captured to the sheet and finally decomposed by photocatalysis. This result indicates that RAOC is effective for reducing the risk of treated water. They further explored thermodynamics of removing crotamiton using the RAOC, and demonstrated that temperature rise accelerated removal of crotamiton and its byproducts.

They have investigated the mechanism of removing sulfonamide antibiotic such as sulfamethazine (SMT) and sulfamonomethoxine (SMM) in wastewaters. The RAOC could remove the SMT without consuming urea, and the methylene urea was successfully synthesized from synthetic urine by inserting the RAOC prior to the nitrogen recovery process. Therefore, combined process of RAOC and methylene urea synthesis can achieve the productions of both reclaimed water and safe fertilizer. Besides, the RAOC can be used for removing SMM and its transformation byproducts from fresh aquaculture wastewater and mitigates the inhibitory effects of coexisting substances in the wastewater. The RAOC accomplishes the repeated removal of SMM without exchanging the composite sheets, showing that the RAOC stably and effectively eliminates SMM and its transformation byproducts from the fresh aquaculture wastewater.

In the keynote speech, the authors will firstly present system map of the interlinkages among SDG 2 (livestock production), 3 (human health), 6 (water) and 7 (energy consumption) from the viewpoint of antibiotic management in wastewater. They also will report literature review about the latest findings of antibiotics contamination in water environment, which receives human urine and feces, livestock wastewater, and aquaculture wastewater, especially in developing countries. As for the technical challenge, they will survey AOPs applicable to real wastewaters for removing antibiotics. Feasibility of the AOPs is also discussed from viewpoints of removal efficiencies, energy consumption, required cost, among others. They also will introduce the development history and latest findings of the RAOC research.

Feasibility Study on Ultraviolet/Chlorinated Cyanurates Advanced Oxidation Process Treating Drinking Water or Potable Reuse Water.

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Full-scale ultraviolet (UV)-based advanced oxidation processes (AOPs), in particular UV/hydrogen peroxide (UV/H_2O_2) AOP, have been employed for drinking water treatment or potable reuse. UV/H_2O_2 AOP represents a broad-screen chemical barrier, generating •OH to degrade contaminants passing through the reverse osmosis unit within potable reuse trains. However, AOPs using oxidants other than H_2O_2 has gained growing interest because (1) H_2O_2 features low molar absorptivity at 254 nm (ε_{254nm} = 18.6 $M^{-1}cm^{-1}$) and (2) additional free chlorine is required to quench the residual H_2O_2 at the end of treatment trains. For example, UV/free chlorine AOP has been proposed and tested for its efficacy for the degradations of micropollutants at a pilot-scale facility. While the UV/free chlorine AOP has superior performance for the degradation of micropollutants at acidic pH compared with the UV/H_2O_2 AOP, efficacy of the UV/free chlorine AOP is significantly impaired by increasing pH. This is driven by higher radical scavenging by OCl^- at higher pH, lowering the steady-state concentrations of radicals. Indeed, the steady-state concentration of a radical is governed by the formation rate of the radical and the scavenging rates of the radical in a UV AOP system; enhancement of the formation rate of radical along with reducing radical scavenging rate are the keys to the improvement of a UV AOP. We proposed using chlorinated cyanurates, which are prepared by mixing free chlorine and sodium cyanurate at different ratios, as the alternative oxidants to free chlorine or H_2O_2 in a UV AOP. Chlorinated cyanurates, in particular dichloroisocyanurate, have been widely employed in swimming pool disinfection and drinking water disinfection. Chlorinated cyanurates are structurally similar to *N*-chloroamide that features low reactivity with radicals, such that radical scavenging by oxidant is likely less severe in UV/chlorinated cyanurates AOP compared with UV/free chlorine AOP. In addition, chlorinated cyanurates may exhibit higher molar absorptivity at 254 nm, thereby enhancing the formation rate of radicals from direct photolysis of oxidant. In this study, we confirmed those hypotheses by experimentally measuring the UV absorptivities of different species of chlorinated cyanurates and determining their $k_{\bullet OH}$. Our preliminary testing results indicated that the UV/chlorinated cyanurates AOP was 100%-300% more efficient than the UV/free chlorine AOP regarding the removals of 1,4-dioxane and *N,N*-diethyl-meta-toluamide over a pH range of 5.5 – 6.8.

Large-Scale Oil and Gas Wastewater Production Analysis for the Sustainable Development of Hydrocarbon Resources.

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Hydraulic fracturing (HF) is a water-intensive technology used to recover hydrocarbons from low permeability hydrocarbon-bearing geologic formations. Freshwater typically is used to make up the hydraulic fracturing fluid (HFF) that is injected into wellbores to fracture the rock. The fluids that return, referred to as flowback and produced water (FPW), are highly saline, contain organic compounds indigenous to the formation and from the HFF, and can be costly and challenging to treat, reuse or dispose of. Further adding to the challenge, the volumes and salinity of FPW produced change over time, and water use and supply for HF vary regionally. Thus, new approaches to optimizing the HF water cycle are critical to mitigating its environmental impacts and ensuring its sustainability.

In order to assess the environmental impacts and treatment intensity of FPW, we collected wastewater data from more than 2.2 million conventional and hydraulically fractured wells in North America. Because both salinity and volumes of FPW contribute to FPW treatment intensity or increased impacts to the environment, we calculated a parameter – total produced salts (TPS) – that combines these data to determine the mass of salts produced by a well. By combining TPS with the hydrocarbon energy values produced out of wells in various regions in North America, we developed the Produced Salt Index (PSI) which normalizes the intensity of salt production to energy units. Taken together, the TDS and PSI parameters provide new tools for environmental scientists, government agencies, and industry to track the intensity and sustainability of HF operations.

Role of Zerovalent Chromium from Iron Corrosion Scales in Hexavalent Chromium Release in Drinking Water Distribution Systems.

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In drinking water distribution systems, chromium (Cr) may be extensively accumulated in corrosion scales of iron pipe, and the chromium solids may advertently be oxidized by residual disinfectant chlorine to form hexavalent chromium Cr(VI). Since Cr(VI) is highly toxic and carcinogenic, its release in drinking water is undesirable. This study investigated the mechanisms of Cr(VI) release from cast iron corrosion scales, using two cast iron pipe sections collected from drinking water distribution systems in the United States. The oxidation of iron corrosion scales by residual disinfectant chlorine resulted in the release of Cr(VI) and it exhibited a three-phase kinetics behavior: a fast phase within the first 2 hour, a subsequent transitional phase from 2 to 12 hour and a slow phase from 12 hour to 7 day. X-Ray Absorption Spectroscopy (XAS) analysis confirmed that zerovalent Cr(0) coexisted with trivalent Cr(III) solids in the corrosion scales. Zerovalent Cr(0) exhibited a much higher reactivity than Cr(III) in formation of Cr(VI) by chlorine, which indicated that zerovalent Cr(0) was the main source of Cr(VI) release in drinking water systems. The presence of bromide in drinking water significantly catalyzed Cr(VI) formation. Meanwhile, organic matter and ferrous iron were two dominant reductants consuming chlorine. These findings provides a new insight to understand the Cr(VI) release in drinking water distribution systems, that is, direct oxidation of Cr(0) by chlorine, and emphasizes the importance of controlling Cr(0) reactivity in order to inhibit the formation of Cr(VI) in drinking water.

Abatement of Micropollutants By the UV/Chlorine Processes in Water and Wastewater Treatment.

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The UV/chlor(am)ine processes are emerging advanced oxidation processes (AOPs) that produces both hydroxyl radical (HO•) and halogen radicals. However, the roles of chlorine radicals for the abatement of micropollutants were largely unknown due to the limitation of identification methods and the incomplete knowledge of their reactivity toward micropollutants. We developed the identification methods by using kinetic modeling, chemical probes, and laser flash photolysis to identify and quantify reactive species in the investigated system. This approach allowed us to give insights on differentiation of the roles of specific halogen radicals for the abatement of target micropollutants in water and wastewater treatment. In UV/chlorine, chlorine radicals such as Cl•, $Cl_2^{\bullet-}$ and $ClO^{\bullet}$, play essential roles in the abatement of a variety of micropollutants, particularly those containing electron donating groups, which has been verified by a good linear relationship between the reactivity and negative values of the Hammett constant for aromatic pollutants. The presence of bromide in UV/chlorine produces bromine radicals such as Br• and $Br_2^{\bullet-}$, which also contribute to the transformation of micropollutants. In UV/chloramine, besides HO• and chlorine radicals, the role of nitrogen radicals such as nitrogen oxide (•NO) is also very important in the transformation of micropollutants. Besides the UV/chlor(am)ine processes, halogen radicals exist in many other processes such as the sunlight photolysis of seawater, electrochemical process, and $SO_4^{\bullet-}$- and HO•-based processes in the presence of halides. The findings of the reaction mechanism between halogen radicals and micropollutants can improve the understanding of micropollutants transformation in engineered and natural aquatic systems.

Decarbonizing Wastewater Treatment Plants with AI and Machine Learning.

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Water utilities across the globe are pledging net zero emissions in response to the Paris Agreement and SDGs, some by as early as 2030. To reach net zero greenhouse gas (GHG) emissions, water utilities must address nitrous oxide (N_2O), which is emitted from wastewater treatment plants (WWTPs) when the treatment process is not properly optimized. N_2O is 300 times more detrimental to our climate than CO_2 and can easily make up the majority of WWTPs' carbon footprints. There is a lot of knowledge on how N_2O is produced in the wastewater treatment process and how it can be optimized. This knowledge has been coded using AI techniques and coupled with machine learning so the process data collected at WWTPs can be leveraged to quickly quantify emissions, optimize the treatment process, and eliminate N_2O. This approach has resulted in both 40 percent and 70 percent reductions in the total WWTP greenhouse gas emissions for two facilities in The Netherlands. This paper breaks down the approach and highlights these two case studies. The advantage of this approach is that it can quickly make big reductions in the total GHG emissions, it does not require large capital investments, and has proven to improve the treatment efficiency and reduced energy consumption. As we are in a climate crisis, the time for climate action is now. With AI and machine learning, water utilities have a cost-effective solution to jumpstart their net zero sustainable development.

Hierarchical Porous Carbon Derived Engineered Biochar As a High-Performance Electrode for Capacitive Deionization.

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Capacitive deionization (CDI) using highly porous carbon electrodes is a promising water desalination technology for energy-efficient separation of ions from aqueous solutions. In CDI, ions can be removed on the principle of capacitive ion-storage in the electrical double-layer of charged electrodes and the release of ions is achieved by discharging the electrodes. CDI has primary environmental applications for brackish water desalination, water softening, removal of heavy metals and water reclamation. Note that more efforts are needed to develop more cost-efficient electrode materials with high specific capacitance for electrosorption of ions. In this study, hierarchical porous carbon (HPC) was prepared from rice-husk-derived engineered biochar by a hard template method for CDI. The porous structure of HPC can be well controlled by the activation process. As a result, the HPC had a large specific surface area of 1839 $m^2\ g^{-1}$ with a high mesoporosity (58%). The cyclic voltammetry experiments indicated that the HPC electrode showed good capacitive ion-storage properties with electrical double-layer behavior. Furthermore, CDI experiments were conducted in a single-pass mode for 20 mM NaCl. As demonstrated, the HPC exhibited a promising electrosorption capacity of 8.11 mg g^{-1} as compared to those of other porous carbon electrodes. The energy consumption was 0.064 kWh mol^{-1}, indicative of a low energy-input of water desalination. The significant improvement can be ascribed to the large ion-accessible specific surface area, interconnected pore structure among micropores and mesopores, and large mesoporosity of the HPC electrode.

KEYNOTE SPEECH-SESSION 3

Role of Engineered Minerals in Achieving Sustainable Development Goals.

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The widespread pollution of soil and water environments with a variety of natural and anthropogenic contaminants is an obstruction for global sustainability, and the United Nations therefore set Sustainable Development Goals (SDGs) such as 'Clean Water and Sanitation' and 'Life on Land'. Contaminants in the global soil and water are steadily increasing due to either the prohibitive cost of remediation or lack of a suitable technology to clean up the toxicants.

Natural materials such as clay minerals are inexpensive, highly reactive and available abundantly throughout the world. They hold great potential as environmental clean-up materials, both with and without modification. Natural clay minerals, owing to their intrinsic cation exchange capacity, high surface area and negative surface charge, show considerable affinity to cationic contaminants of both organic and inorganic nature. Additionally, incorporating hydrophobic surfactants, depositing reactive nanoparticles or loading microorganisms on clay minerals can impart remarkable adsorption, catalytic and degradation properties to clean up target environmental contaminants. Major groups of those designer clay minerals include organoclays, nanoscale zero valent iron (nZVI) deposited clays, clay-polymer nanocomposites, clay-carbon composites and bioreactive clays.

This talk highlights recent advances in interdisciplinary research in clay science to find efficient technologies for cleaning up water and soil contaminants. Current results indicate a highly promising future for research and development in this area which potentially can deliver a cost-effective and green solution to the ever-increasing environmental contamination problem, and meet multiple SDGs.

Sophorolipid Production from Food Waste.

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Sophorolipids (SLs) are among the most extensively studied microbial biosurfactants. *Starmerella bombicola* is the most productive strain known for SL production, with a volumetric productivity of up to 3.7 g/L.h (Wang et al., 2019). Recent sustainable development goals of food security, environmental protection, material and energy efficiency are the key drivers for the valorization of food waste. In the present work, the production of biosurfactant SLs from several (food) waste streams was investigated. Food waste obtained from a local restaurant was subjected to enzymatic hydrolysis for 16 h, yielding a hydrolysate containing about 100 g/L glucose and 2.4 g/L free amino nitrogen. The hydrolysate was subsequently used for SLs fed-batch fermentation and reached titer of 115.2 g/L in 92 h with an overall volumetric productivity of 1.25 g/L.h (Kaur et al., 2019). Further improvement of fermentation system and strategy has been developed using a semi-continuous integrated production-separation system. An average volumetric productivity of 2.43 g/L.h and an overall SLs yield of 0.73 g/g was achieved within 240 h. Moreover, the potential of sustaining high production efficiency during long-term fermentation times (480 h) was investigated and an overall productivity and SLs yield of 2.39 g/L.h and 0.73 g/g were obtained, respectively (Wang et al., 2020a). This laboratory experiment was further evaluated with TEA simulation. It was found that the most profitable option led to high NPV (US$183,598,000), IRR (36.17%), ROI (43.87%) and payback years (2.28 years) (Wang et al., 2020b). It should be stressed that SLs price need to lower to allow SLs to penetrate the market.

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Measuring Circularity in Food Supply Chain Using Life Cycle Assessment; Refining Oil from Olive Kernel.

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Valorization of food waste could be considered as an effective strategy toward moving a circular food supply chain. In this regard, measuring the circularity of the food waste valorization systems is highly important in order to a better understanding of multiple environmental impacts. Therefore, this study investigated the circularity of a food waste valorization system (refining oil from olive kernel) using LCA methodology. An inventory of an industrial-based of olive kernel oil production system is also provided in this study. The system boundary was the cradle to the factory gate of the production system. The results indicated that the natural gas consumption was the highest contributor to the most investigated impact categories. The global warming potential of one kg produced oil from olive kernel was calculated to be 0.32 kg CO_2eq. The damage category of resource depletion had the highest negative impacts during the production of olive kernel oil, followed by human health damage category.

Biomass Waste Valorization to Generate Modified Biochar to Recover Phosphorus from Animal Manure Wastewater.

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One of the reality before us today is the increasingly exhausted of phosphorus (P) resource. Animal manure, produced from livestock and poultry production, contains large amount of P. The treatment of P recovery from animal manure is regarding as a promising technical for food security. Recently, numbers methods to treat waste agricultural biomass have been considered. Amongst, pyrolysis to generate biochar has attracted attention. Biochar, has a rich surface chemistry, interesting nanostructures, abundant oxygen-containing functional groups, and a large porous structure, regarded as a potential sorbent. Due to the limitation of P-solubilization and selectivity recovery processes caused by the existing of organic phosphorus, sparingly soluble P, and many other kinds of substances, we have conducted a series of explorations on phosphorus solubilization and selectivity adsorption. For P solubilization, organic phosphorus and sparingly soluble P can be decomposed, dissolved, and released under thermal conversion (ultrasound, hydrothermal process, microwaves digestion). Coupling degradation and oxidation process, such as microwaves digestion and NaOH (or H_2O_2-HCl), ultrasound/H_2O_2, and hydrothermal assisted process have been developed. For P fixation, cation loaded biochar, such as magnesium modified corn biochar, ferric oxide hydrate modified biochar, calcium modified biochar, can be synthesized to enhance P adsorption selectivity. The adsorption isotherm, adsorption kinetics, thermodynamics have been investigated. The P saturated adsorbed modified biochar could continually release P in soil environment and its fertilizer property has been analysis.

High Quality Biochar Preparation, Upgrading and Application.

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Biochar has received increasing attention due to its unique feature such as high carbon content and cation exchange capacity, large specific surface area and stable structure, which can be prepared from various organic waste feedstock, such as agricultural wastes and municipal sewage sludge. This report summarized the preparation, characterization, modification, and especially environmental application of biochar. This report establishes the mapping relationship between the adsorption characteristics of biochar prepared by 6 types of bulk agricultural wastes and typical pollutants and obtains the key control factors during the best preparation process. In addition, using biomass macromolecular pyrolysis gas as carbon source and template method to prepare porous hydrogen storage porous carbon materials was put forward in order to achieve high value utilization of biomass macromolecular pyrolysis gas before condensation and reduce coke to improve liquid quality. Furthermore, this report proposes a new activated carbon modification method in oxygen-helium plasma system, explores the effect of modification process on activated carbon, establishes a low temperature plasma activated carbon regeneration method in oxygen-helium-water vapor system, and specifies the characteristics of regeneration and recycling method in different systems.

Eliminating Supplemental Non-Renewable Natural Gas in Biogas Fired Power Generation.

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Municipal Sanitation Districts blow air into activated sludge aeration units. Biogas is produced with anaerobic digestion processes, typically at 65% methane and the balance of the dry composition primarily being Carbon Dioxide. The resultant biogas must be supplemented with at least a 10% natural gas feed to raise the heating value for a stable firing. The power for the use of air in the aeration unit and the use of non-renewable natural gas to supplement the heating value for biogas combustion are significant municipal sanitation process operating costs, and take away from sustainability. The goal is to maximize sustainability by minimizing power consumption and by firing with 100% renewable biogas, which will as well minimize operating costs. This is achieved by using the patent pending Black Swan Wig Membrane as manufactured by Generon for direct capture of carbon dioxide which also produces an enriched stream of oxygen up to 45%. This oxygen enriched stream can replace the aeration stream to the activated sludge aeration unit and considerably reduce the power consumption of the aeration blower by 60%. This oxygen enriched stream can also be fed into the combustion air inlet of the biogas fired power generation unit and eliminate the need for any supplemental natural gas firing, without modification to the power generation unit. The oxygen enrichment raises the firing temperature of a 100% biogas feed to a level equivalent to a natural gas fired unit. A side benefit is that the flue gas is a higher concentration of CO2, and thus a more capturable/ usable exhaust from the stack. A Black Swan Membrane Air Enrichment (MAE) with a 5MW Refinery Cogeneration Unit Process pilot uses concentrated CO2 (up to 50%) in the stack gas from the power generation unit for crop carbon enrichment. The CO2 is dispersed to the crops at 1000 ppm to produce enhanced yield in agricultural products (up to 140% for almonds) and additional other biomass via biosequestration, with the added benefit of saving up to 40% in the water utilization efficiency. Proposed pilot and demonstration unit is funded by the California Department of Food and Agriculture and hopefully a pending grant application with the California Energy Commission.

Effectively Pretreating Spiramycin from Antibiotic Production Wastewater through Hydrolyzing Its Functional Groups Using Solid Superacid TiO_2/so_4.

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Breaking down the functional groups of antibiotics are more efficient than destroying the whole molecule in antibiotic production wastewater (APW) pretreatment before further biotreatment. Two sulfonate group-bearing solid superacids (TiO_2/SO_4), SSA1 and SSA2 were synthesized, characterized, and evaluated for spiramycin hydrolysis in APW. The hydrolysis efficiencies followed an order of SSA2>SSA1>TiO_2≈pH=3>control. And the efficiencies increased with rising temperature from 25 °C to 65 °C. The kinetics followed a first-order model and SSA2 outperformed its counterpart. The performances were positively correlated with both the total acidity determined by n-butylamine titration and the strength of acid sites measured by NH_3-temperature-programmed desorption (TPD). The residual solution for SSA2 presented the least antibacterial potency and anaerobic inhibition among all treatments. The hydrolyzed product was identified as the m/z 699.4321 fragment using UPLC-Q/TOF-MS, which was formed after losing a functional mycarose moiety from the parent molecular. The solid superacids were effective in selectively eliminating 433 mg/L of spiramycin and the antibacterial potencies of the spiramycin production wastewater, which contained very high concentrations of COD. This hydrolytic method avoids using and handling hazardous and corrosive mineral acids on site. It is attractive as a selective catalytic pretreatment method to cleave antibiotics' functional groups and to reduce its inhibitory effects before sequential biotreatments.

KEYNOTE SPEECH-SESSION 4

Pharmaceutical Sorption to Iron Oxides.

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Up to 70% of pharmaceuticals imbibed by humans have been shown to exit the body unchanged and still reactive. These pharmaceuticals and their metabolites can then enter the environment after leaving a wastewater treatment facility via aqueous effluent or are leached from sewage biosolids applied to agricultural fields. Once pharmaceuticals reach freshwater systems they have been shown to be detrimental to downstream ecosystems. While the application of biosolids to agricultural fields is essential in sustainable farming practices, especially with ever increasing urbanization, it is important to ensure this does not lead to environmental contamination.

We use Fourier transform infrared (FTIR) spectroscopy and high performance liquid chromatography (HPLC) coupled with mass spectroscopy (MS) to examine the behaviour of the pharmaceutical Ciprofloxacin (CIPRO), which has been identified from biosolid runoff, at the iron oxide (goethite) mineral-water interface. We found that sorption was pH dependent, with maximum sorption between pH 7-10. After 24h more than 50% of the CIPRO was oxidized, with part of the molecule remaining on the goethite surface and part being remobilized into solution. Two breakdown products were observed and tracked as a function of pH. It is important that we understand not only how mobile pharmaceuticals are in environmental systems, but also how mobile the breakdown products are, with the goal to understand their toxicity.

Metal-Organic Framework Adsorbents for Industrially Important and Challenging Separations.

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Hybrid nanoporous materials have recently gained great attention due to their interesting properties. Among them, metal-organic framework (MOF) is a new type of crystalline nanoporous materials, which can have significantly high surface areas (~7,300 m^2/g) and tailorable functionalities and pore sizes by the combinations of various inorganic and organic building blocks. Due to these attractive features, MOFs have been extensively studied as potential materials for various industrial applications such as adsorptive gas storage, adsorptive and membrane separations, heterogeneous catalysis, and sensing. The separations of CO_2/N_2, N_2/CH_4, C_3H_6/C_3H_8, CO/CO_2 and xylene isomer mixtures are industrially important and challenging issues. Since adsorption is considered an energy- and cost-effective separation technology, we need to develop high performing adsorbents for these separations. This talk will introduce the recent studies on hybrid nanoporous materials, mainly focusing on MOFs for these adsorptive separations. Material syntheses and characterizations, various adsorption analyses, and molecular simulations have been combined to develop hybrid nanoporous materials for various separations and to unveiled molecular-level adsorption mechanism in nanoporous materials.

Porphyrin-Based Metal-Organic Frameworks As Low-Temperature NO_2 Adsorbent.

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Nitrogen dioxide (NO_2) is a criteria air pollutant that bring huge damage to the environment and people's health, contributing to the formation of photochemical smog, fine particulate matter ($PM_{2.5}$), acid rain, as well as many human diseases. The development of effective techniques to mitigate NO_2 emission is therefore urgent and sought-after. Although the selective catalytic reduction (SCR) exhibits high-efficiency in NO_2 conversion at high temperatures (250-600 ^oC) and has been widely used in industry, it does not work for the abatement of ambient NO_2 emission. Gas adsorption by solid adsorbents is a promising approach for NO_2 capture at mild conditions. As NO_2 is a highly reactive, oxidizing, and corrosive gas, it's challenging to develop the adsorbents that simultaneously show high NO_2 capacity, high selectivity, and good regenerability in real cases. In this work, we successfully developed one type of porphyrin-based metal-organic frameworks (Al-PMOF) as low-temperature NO_2 adsorbent. The NO_2 capture ability was tuned by changing the atom-isolated transition metals (TMs) in porphyrin ring. The NO_2 breakthrough experiments indicated the Al-PMOF with inserted nickel (Al-PMOF(Ni)) showed the highest NO_2 adsorption capacity of 2.30 mmol/g (1000 ppm NO_2/Helium) at room temperature. *In situ*-DRIFTS and synchrotron X-ray diffraction experiments were conducted to reveal the adsorption mechanism. NO_2 would partially transform into N_2O_4 upon adsorption and both molecules could interact with Al-node via hydrogen bonding and inserted TMs via π-backbonding. The potential of Al-PMOF(Ni) as efficient adsorbent for ambient NO_2 abatement would provide a new avenue to mitigate NO_2 emission.

The Effect of Flue Gas Recirculation on Nox Emission from Char Combustion.

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An incineration process is the most dominant method among waste treatments in Japan. A stoker furnace incinerator has been widely used for the waste incineration. In the stoker furnace incinerator, waste products can be sufficiently stirred and burned completely with long residence time in combustion zone. Low air ratio and high temperature incineration tend to be applied to many current stoker furnace incinerators to reduce the loss of sensible heat in flue gas and then to raise temperature in boilers for the steam turbine. Nowadays, waste incineration plats should be electric power plant with high energy conversion efficiencies, too. Meanwhile, high temperatures in the furnace results in the increase in the amount of NOx, one of typical air pollutants. In particular, it is difficult to control NOx production in char combustion zone in the stoker furnace. EGR (Exhaust Gas Recirculation) is commonly used to reduce NOx emissions in combustion process, since it can constrain thermal NOx generations. However, the effect of EGR on the control of fuel NOx generation in waste combustion is still not clear. Therefore, objective in this research is to evaluate the NOx generation mechanisms in char combustion of waste incineration process.

RDF (Refuse Derived Fuel), made of municipal waste, was used as a simulated waste sample in this study. RDF char was prepared by an electric heater prior to the combustion experiments. In N_2 atmosphere, a RDF pellet in a platinum basket was heated at 1173K for 10 minutes and then cooled down. The RDF char sample in a basket was hanged by the wire from the electric balance and promptly placed into a reactor tube equipped with electric heater, which had been heated into a given temperature in advance. Then, the isothermal combustion of RDF char could be achieved in this experimental procedure. The temperature was set to be 1023K, 1123K, and 1173K. The atmosphere in the reactor tube was prepared by introducing several cylinder gases, such as N_2, O_2 and CO_2. Steam was also mixed to the atmosphere gas to simulate EGR (Exhaust Gas Recirculation) conditions. Steam was heated at 473K by preheated system before mixing to other gases. Five gas compositions were examined in this study, those were 21vol%O_2, 7vol%O_2, 7vol%O_2+15%volH_2O, 7vol%O_2+15%volCO_2, and 7vol%O_2+15%volH_2O+15%volCO_2. N_2 was a balance gas in all cases above. During combustion experiments, the decrease in mass of RDF char was continuously measured by the electronic balance to investigate transient combustion behaviors of RDF char. At the same time, the flue gas was analyzed downstream by continuous gas analyzer, such as HORIBA PG-250 (NOx, CO, CO_2, O_2, SO_2) and N_2O meter.

The effect of gas compositions on RDF char combustion and NOx emissions were examined at constant temperature of 1123K. The combustion rate of RDF char in 21vol%O_2 was much faster than that in 7%vol%O_2. Combustion rates in 7vol%O_2+15%volH_2O and 7vol%O_2+15%volCO_2 were a little faster than that in 7%vol%O_2 only, showing that H_2O and CO_2 were not inert but working as oxidizing agents on RDF char. Total NOx emissions, integrated with time, were almost the same between 7vol%O_2 and 7vol%O_2+15%volCO_2 atmospheres. However, total NOx emission in 7vol%O_2+15%volH_2O was much larger than those in 7vol%O_2 and 7vol%O_2+15%volCO_2 atmospheres without steam. In contrast, CO emission in 7vol%O_2+15%volH_2O was less than 10 ppm throughout the char combustion reaction , while CO emissions in atmospheres without steam had peaks higher than 100ppm. In general, CO has a reduction effect of NO, providing local reduction region near solid fuels even in combustion reactors. On the other hand, experimental results indicated that the addition of steam to the atmosphere prevented CO from reducing NO as a result of water-shift reaction ($CO+H_2O \rightarrow CO_2 + H_2$). Unfortunately, H_2 emissions were too small (less than limit of detection in gas analyzers used in this study) to verify this consideration.

The effect of temperature on NOx emissions were examined in 21%vol%O_2. Total NOx emission at 1023K was larger than those at 1123K and 1173K. It is well-known that thermal NOx generation increases with temperature in combustion zone, while the amount of fuel NOx discharged from char combustion does not depend on temperature. Instead, gas phase reaction between CO and NO becomes faster at higher temperature. Then, total NOx emission became smaller at higher temperature under the same gas composition in this study. This consideration was supported by the fact that CO emission was also smaller at higher temperature. In other words, more CO was consumed by the reaction for NO reduction at higher temperature.

Techno-Economic Feasibility of Distributed Waste-to-Hydrogen Systems to Support Green Transport in Glasgow.

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Significant greenhouse gas and pollutant emissions from fossil-fuelled transport call for alternative green transport fuels like hydrogen. Biomass waste is a low carbon source for hydrogen production via various thermochemical and biochemical technologies. As a result, distributed Waste to hydrogen (WtH) systems are a potential solution to tackle the twin challenges of sustainable waste management and transport. In this work, a novel concept of distributed WtH systems based on gasification/fermentation to support hydrogen fuel cell buses in Glasgow was proposed. The system configurations of WtH systems were identified for the different technology routes, based on hydrogen production process modelling that includes the choice of biomass waste feedstock, hydrogen production reactors, and upstream and downstream system components. In the process modelling, the impacts of operating conditions on the hydrogen production were evaluated to develop the optimal process parameters based on maximum hydrogen yields. A cost-benefit analysis was conducted to evaluate the economic feasibility of the systems, based on the accumulation of a systematic database including direct cost data on construction, maintenance, operations, materials, transport and storage, along with indirect cost data comprising environmental impacts and externalities, cost of pollution, carbon taxes and subsidies. Sensitivity analysis was conducted to identify the most significant factors determining the profitability of distributed WtH systems supporting hydrogen fuel cell buses in Glasgow.

Thermal Conversion of Carbonaceous Waste for Carbon Nanotube Production.

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Thermo-chemical conversion of carbonaceous waste for carbon nanotube production

Ye Shui Zhang

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Thermo-chemical conversion of carbonaceous wastes such as tyres, plastics, biomass and crude glycerol is a promising technology compared to traditional waste treatment options (e.g. incineration and landfill). The process promotes the sustainable management of carbonaceous waste and realize the potential value of these wastes. Carbon nanotubes (CNTs) is one of the most extensively investigated and high-value materials due to their electrical, mechanical and physical properties. Producing CNTs from waste materials could solve the issues of waste management and simultaneously bring down the cost of CNT production. This talk covers the most abundant waste carbonaceous materials (waste tyres and plastics) which have great potential to be the alternative feedstocks for CNT production. Pure model compounds investigation could assist the study of CNTs growth mechanism from waste feedstock. Following with the study of fine structural change of single catalyst particle through the degradation process by using advanced Nano X-ray computed tomography. Finally, a novel GCM microbalance as an in-situ sensor for monitoring coke formation in nanogram resolution is introduced in the high temperature thermo-chemical conversion process.

TECHNICAL SESSION 1

Phytoavailability and Plant Uptake of Microplastic-Bound Chromium.

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The unconstrained release of microplastics through direct discharge and the degradation of larger plastic materials that are attached with toxic metal(loid)s may create a widespread ecological risk via the application of biosolids into soils. The objectives of the present research are to assess the phytoavailability and plant uptake of microplastic-bound chromium (Cr) in soil, mimicking the scenario of microplastic contamination via biosolid application to soil. Polyethylene microplastics were adsorbed with hexavalent chromium ($Cr_2O_7^{2-}$; 2 mg/g) and used for laboratory incubation and pot experiments with 0.5% (w/w) microplastic application rate under Bushita beans (*Vigna unguiculata*) growth. Prior to the experiments, the soil and microplastics were characterized for electrical conductivity (EC), pH, cation exchange capacity (CEC) and total Cr concentration. After 53 days, the soils from the incubation and pot experiments were tested for phytoavailable Cr using 0.01 M $CaCl_2$ extraction, toxicity characteristic leaching procedure (TCLP) and total Cr using acid digestion of the soil and plant (root, shoot and pod) samples. The experimental soil demonstrated pH = 6.76, EC = 34.2 ds/m, and CEC = 3.88 $cmol_c$/kg. The $CaCl_2$-extractable Cr in the soil after the incubation and plant growth experiments was 190.2±1.17 µg/g 60±0.12 µg/g, respectively. An average 380 µg/g leachable Cr was observed in the TCLP test in the pot experiment. The total Cr concentrations in the root, shoot and pod of the bean plant were 81.4±0.34, 27.6±0.5, and 8.8±0.5 µg/g, respectively, whereas the control treatment resulted in considerably low Cr concentrations in the plant parts (16±3.6, 11±0.78, and 1.3±0.12 µg/g, respectively). Translocation factor was calculated as 0.34 depicting the limited risk of Cr due to uptake in *Vigna unguiculata* from microplastic-bound Cr contaminated soil, at least in the short term.

Unseen Career for the Entry of Microplastics into the Soil: Compost.

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Application of urban compost in agricultural lands intensifies soil fertility, furthermore, compost can be a source of microplastics that are not eliminated during the composting process in urban areas. Current researches focused on aquatic, and marine environments, and comparatively the knowledge lacks about sources and pathways of microplastics in the terrestrial environment. This study was focused on the potential of urban compost as an entry route for microplastics into the soil. Compost samples from obtained from three sites Karadiyana, Kalutara, and Muthurajawela municipal solid waste composting facilities, and density separation via NaCl was used for the extraction process. Three main steps are involved in sample processing; density separation, sieving, and visual sorting of microplastics. Size, color, and shape identified using visual observation, and identification of polymer type carried out using Flourier Transform Infrared Spectroscopy (FTIR). We used 1 mm, 500 µm, and 250 µm sieves, the availability of microplastics in small sieves were observed using a microscopic image processing. Results of the study obtained that majority of microplastics were identified as polyethylene (PE), and polypropylene (PP) with some Polystyrene (PS) foams. Fragments attained from large debris seem to be the prominent type of microplastics, and the size range of microplastics was 3 mm -1.5 cm retained on 1 mm sieve. Microplastics abundance was recorded as 40 items per 100 g. Further experiments are

ongoing on analyzing potential toxic elements in the microplastic samples from compost and risk assessment.

Developing Higher Levels of Sustainability with Digitalization.

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Digitalization can deliver changes in process operations that increase sustainability. The 17 sustainability goals outlined by the United Nations provide a guideline for a business to prioritize the goals that are most relevant and impactful to their business, and in most cases, digital solutions will help achieve these goals. Digitalization refers to the revolution of innovative IOT technologies, Cloud Computing, Artificial Intelligence, Networking and Communication solutions. Through a collaboration of experts and combination of these technologies, synergies are created that lower costs of the previous way of delivering outcomes and with the standardization and automation these technologies deliver, quality is increased with waste and re-work is reduced.

As a model of how digitalization for sustainability may be adopted, the Evergreen Water Company is introduced and their operational transformation that resulted in greater levels of sustainability due to their implementation of digital technologies is described. The entire lifecycle and supply chain grows in sustainability; beginning with the raw water intake, the conditioning and treatment of the water, transmission and distribution to the users, collection and treatment of wastewater, storage, and customer service. Through these examples of technologies and the potential benefits that can be delivered, concepts and an approach that helps deliver on sustainability goals is provided for other process industries to consider for their own journey to greater levels of sustainability.

TECHNICAL SESSION 2

GAC-Based Cathodes for Capture and Electrochemical Reduction of Halogenated Contaminants in Water.

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Electrochemical research on contaminant degradation in water and wastewater has primarily focused on oxidation but such systems are inhibited by expensive electrode materials, toxic oxidation byproducts, energy costs, and treatment times. A large portion of contaminant classes on lists of regulatory priorities comprise halogenated compounds (e.g., industrial solvents, pesticides), which are often more amenable to reductive degradation techniques than oxidative ones. In waters contaminated by halogenated organics, electrochemical reduction employing carbon-based electrodes would be a viable alternative to oxidation. Carbon (e.g., GAC) is inexpensive and readily adsorbs most halogenated compounds, enabling rapid (<15 min) sequestration of compounds from water with complete electrolytic destruction occurring over longer time scales while also avoiding oxidation byproducts.

This study assessed degradation rates and products of several environmentally relevant halogenated contaminant classes (e.g., trihalomethanes) during chronoamperometric reductive electrolysis of compounds adsorbed to cathodes made of GAC conductively adhered to carbon cloth. Brominated compounds were easier to degrade than their chlorinated analogues, as were compounds with higher degrees of halogenation. Effect of applied potential and solution pH was also evaluated. To predict dehalogenation rates and products, density functional theory was used to calculate different reaction free energies (e.g., Gibbs free energies of electron affinity, Marcus Theory activation energy of electron transfer) and free energy correlations were developed. Building a predictive framework for electrolytic dehalogenation will identify the broad applicability of simple carbon cathodes for contaminant remediation.

Reductive Electrochemical Activation of Hydrogen Peroxide As an Advanced Oxidation Process to Treat Reverse Osmosis Permeate during Potable Reuse.

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The generation of hydroxyl radical (•OH) via the UV/hydrogen peroxide (H_2O_2) advanced oxidation process (AOP) to treat reverse osmosis permeate (ROP) in potable reuse treatment trains is inefficient, using only 10% of the initial H_2O_2, resulting in high UV fluence and energy requirements. This study evaluated •OH generation by electron transfer from a low-cost stainless steel cathode. In deionized water, the electrochemical system achieved 0.5-log removal of 1,4-dioxane, a performance benchmark for AOPs at potable reuse, within 4 min using only 1.25 mg/L H_2O_2. Maximum 1,4-Dioxane degradation was achieved at a +0.02 V vs. S.H.E. potential. Positively- and negatively-charged compound degradation was comparable to neutral 1,4-dioxane. Thus, degradation occurs by •OH generation from neutral H_2O_2 and electrostatic repulsion of contaminants from the electrode is not problematic. For ROP without chloramines, we achieved 0.5-log removal of 1,4-dioxane in 6.7 min, with 7 mM salts (phosphate buffer) for ionic strength and 2.5 mg/L H_2O_2. For ROP with 1.4 mg/L as Cl_2 chloramines, we achieved 0.5-log removal of 1,4-dioxane in 13.2 min, with 7 mM salts and 4.5 mg/L total H_2O_2 dosed in 3 separate injections in 5 min intervals. Based on lab-scale electrochemical AOP treatment, initial estimates indicate that the cost is comparable to the UV/H_2O_2 AOP. The electrochemical AOP featured lower reagent costs and higher electricity costs, which could be reduced by optimization of the electrochemical design.

Geogenic Contaminants in Shallow Groundwater in the Areas of Endemic Chronic Kidney Disease of Unknown Etiology, Sri Lanka.

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Many hypotheses have been introduced as causatives for the prevailing Chronic Kidney Disease of unknown etiology (CKDu) in Sri Lanka, in which geo-environmental factors has gained wider attention. This study assessed the enrichment of contaminants in groundwater from geogenic sources, which may consider as a risk factor for the emergence of CKDu. Hydrogeochemical investigations were carried out in Girandurukotte, Sri Lanka, a known CKDu hotspot. A total of 46 and 49 groundwater samples were collected in wet and dry seasons accordingly, and analyzed for major constituents and stable isotopes. In most cases, the anions in groundwater varied in the sequence of $HCO_3^- > Cl^- > SO_4^{2-} > F^-$ while cations varied in the order of $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ for both seasons. Majority of the samples were dominated by Ca-Mg-HCO_3 type. Among the studied parameters, 30% of the samples from the wet season and 67% of the dry season exceeded the maximum permissible level for fluoride (0.5 mg/L). Elevated Total Dissolved Solids (TDS) levels reported in the dry season samples than in the wet season which may attributed to dissolution of aquifer minerals and higher rate of evaporation. Other considered major cations, anions, alkalinity, and hardness were under the permissible levels (SLS 614:2013). Stable isotope data in wet season showed a slight deviation from the local meteoric water lines which indicate mixing of surface water in most locations. Data revealed that the higher ion content is mainly associated with geogenic

influence thus a detail study on interaction between groundwater and aquifer material is recommended.

Linking Anaerobic Wastewater Treatment to Non-Potable and Potable Wastewater Reuse.

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Energy efficiency has become a priority for wastewater treatment plants (WWTPs) as they are large consumers of electricity and energy costs are increasing. Aeration, which is required to feed microorganisms that degrade sewage, typically accounts for half of WWTP energy costs. There is new interest in degrading sewage using anaerobic microorganisms, which doesn't require aeration. Anaerobic treatment can lower electricity demand of a WWTP by 0.45 kWh/m3 by eliminating aeration and generating methane that can be transformed into energy. ***For municipal utilities to adopt anaerobic treatment, it's crucial to demonstrate that anaerobically treated wastewater is compatible with WWTP water reuse systems.*** This will allow utilities to realize the energy savings of anaerobic treatment technology without having to forego reuse opportunities. This presentation describes a research project beginning in 2021 that uses pilot-scale equipment at Silicon Valley Clean Water Plant to link anaerobic treatment and reuse. This project will (1) evaluate hydrogen peroxide as a low-cost oxidant to control sulfides generated by anaerobic treatment, (2) compare performance to membrane-aerated biofilm reactor treatment of anaerobic effluent to control sulfides and nitrogen, (3) demonstrate that effluent meets water quality guidelines among 10 states for potable and non-potable reuse (4) evaluate anaerobic effluent fouling potential on RO membranes, and (5) validate superior contaminant removal from anaerobically-treated effluents. The presentation will outline preliminary project data, including kinetics of sulfide oxidation by hydrogen peroxide, the effect of hydrogen peroxide dose on concentrations of reactants, products, and solution absorbance, and the impact of sulfide on UV inactivation.

TECHNICAL SESSION 3

Recycling Humins from Rice Waste Valorisation for Catalyst Synthesis in Biorefinery.

Xinni Xiong
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To develop integrated prototype for the innovative food waste valorisation technology, utilization of the unavoidable by-products from biomass conversion to synthesize functional materials was investigated in this study. Under the microwaving heating at 160 °C in $AlCl_3$ aqueous solution, the starch in rice waste was effectively converted into value-added chemicals (e.g., 5-hydroxymethylfurfural) via hydrolysis, isomerization, and dehydration, simultaneously forming recalcitrant and insoluble humins as by-product via condensation of intermediates during the hydrothermal processes. Thermochemical catalytic systems varying substrate concentrations (0.1, 0.15, 0.2 g/mL) and $AlCl_3$ catalyst loading (10 wt% or 20 wt%) in different duration time (0-40 min) were tested and compared to determine desired conditions. Subsequently, batch production of humins were conducted in the selected conditions, and the solid residues were collected for Al impregnation followed by carbonization at 500 °C to produce humins-derived biochars. The derived solid materials were characterized to indicate the successful synthesis of metal-impregnated carbon materials, including XRD, SEM, BET, Raman, and XPS. These solids are also evaluated as heterogeneous catalysts for glucose isomerization by microwaving heating under different temperatures, holding time and solvents. Fructose yield of 14 Cmol% could be obtained at 160 °C for 20 min in water as green medium. This research proposed a novel practice for recycling by-product from waste valorization to synthesize renewable and sustainable solid catalyst. Knowledge on the controlling parameters to tailor the properties and catalytic activities of synthesized catalysts were discussed. The

approach of catalyst synthesis from humins recycling provides scientific insights to build an integrated biorefinery and boost the circular economy.

Environmental Sustainability Evaluation of Technologies to Recover Phosphorous from Incinerated Waste Streams.

Ario Fahimi
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The annual demand for P based fertilizers is constantly growing of about 3%, inducing to an inefficient use of P particularly in agricultural sector (e.g. eutrophication) and the depletion of phosphate rocks. A promising way to efficiently recover P is to address incinerated waste streams (P rich sources) as potential substitute of phosphate rocks with the possibility to reduce the volume of disposal. We report a simplified and novel approach for sustainability evaluation of new technologies, based on the use of two parameters (i.e. embodied energy and CO_2 footprint) that account for the energy and emissions involved in the formation of a material. A dimensionless index, defined as SUB-RAW index, compares the results about the environmental impact of selected substituting material/process. This method is applied to any scale processes available in literature in the context of P extraction technologies, showing that chemical leaching approaches are the most suitable methods. The approach aims to represent a milestone in the evaluation of strategies to handle with resources depletion and to suggest opportunities for legislative evolution, in support of sustainable alternative to raw materials.

Continuous Flow System for the Heterogeneous Catalytic Production of Advanced Biofuels.

Norman Fraley Jr.
Chemistry, Wake Forest University, Winston Salem, NC

Biojet and biodiesel fuel production using low-quality feedstock is challenged by high concentrations of free fatty acids and water. Extensive cleanup is required to avoid saponification when using traditional base catalysts. Although these challenges may be avoided by using acid catalysts, it has been at the cost of longer reaction times and lower yields. We have developed a continuous flow system designed to incorporate high productivity and completely green chemistry for the creation of advanced biofuels from waste fats and oils. A sulfonated carbon acid catalyst was successfully prepared from hydrothermal carbonization of biomass (HTC). The HTC was converted to catalytically active carbon using a novel, environmentally benign process involving the use of L-cysteine followed by reduction with $NaBH_4$ and oxidation with H_2O_2. The catalytic performance was first confirmed in a batch reaction system before continuous flow studies. The system reliably operates at relatively low temperatures and pressures to produce high quality biofuels from waste containing high concentrations of free fatty acids and water. Catalyst characterization, conversion chemistry, system performance and scale-up insights will be presented.

Enhanced Removal of Antibiotics from Biochar Colloids.

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Ecosphere Resilience Research Center, Faculty of Applied Sciences, University of Sri Jayewardenepura, Nugegoda, Sri Lanka

Biochar has been a center of focus in the recent research on adsorbents in removing emerging contaminants due to its multifunctionality and low production cost, however, needs cost-effective modifications to improve its capacity further. Therefore, the objectives of the research were to examine the performance of high lignin biochar colloids produced from disc milling in ethanol media for the

removal of emerging contaminants such as antibiotics. In this study, ciprofloxacin (CPX), a ubiquitous antibiotic found in the aqueous environments due to its frequent use, was tested against the initial pH, time and adsorbate loading at the pH range of 3-9 by adding 0.001, 0.01 and 0.1 M $NaNO_3$, with an initial ciprofloxacin concentration of 25 mg/L and a biochar dosage of 1 g/L. The average particle size of colloidal biochar was given as ~351 nm whereas the BET surface area was 284.28 m^2/g. Results of the edge experiment indicated that CPX adsorption was pH-dependent and a 15% reduction in adsorption was observed in 0.1 M $NaNO_3$. The maximum adsorption of CPX was observed from pH 4.5 to 6 where zwitterionic form of CPX is prominent. Kinetic experimental data demonstrated a rapid adsorption of CPX in the first 20 minutes, which could be due to the presence of abundant and available active sites on the biochar surface subsequently, the adsorption equilibrium (25.34 ± 0.2 mg/g) was reached. Moreover, the adsorption process primarily followed pseudo-second-order kinetics suggesting chemisorption mechanism. Further experiments are planned on the potential use of biochar colloids in real-scale application via mimicking CPX in synthetic hydrolyzed human urine.

Characterization of Phosphate Solubilizing Bacteria Isolated from Municipal Solid Waste Dumping Site Soils.

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Phosphate solubilizing bacteria (PSB) is one of the feasible and eco-friendly strategies to upliftment the quality of the soil. In the present work, four Phosphate solubilizing bacteria (PSB) were isolated and characterized from municipal solid waste (MSW) dumping site soils. Furthermore, molecular characterization by 16s RNA was shown that two *Bacillus sp.* and two *Enterobacter sp.* were identified from all four isolated strains. The results showed that the strains P1, P2, P3 and P4 were found to solubilize insoluble phosphorous $Ca_3(PO_4)$ and produce soluble phosphorus in Pikovskaya (PVK) media. The range of solubilized phosphorus is 46 to 277.66 mg L^{-1}. The solubilisation of phosphorus has been associated with reduced pH (7.22 to 3.32), produced organic acid (e.g. gluconic acid malonic acid, citric acid and acetic acid) and acid phosphatase activity in the medium. Among the isolated strains, the P4 strain had the highest phosphate solubilization efficiency. The P solubilization results demonstrated that it is positively associated with pH, acid phosphatase activity, and organic acid. Additionally, it also revealed that the acidification of the growing medium might be the primary strategy for the solubilizing phosphate from inorganic phosphate.

Guiding Environmental Sustainability of Emerging Waste-Derived Sophorolipid Production By Adopting a Dynamic Life Cycle Assessment (dLCA) Approach.

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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 one such produced microbial glycolipid biosurfactants, representing the largest market share of the 27 billion USD global surfactant market. Though SL production is based on renewable feedstocks challenges concerning the production of electricity, enzymes, and materials that are primarily fossil based, still exist. From a scale-up perspective, it is imperative to quantify the environmental impacts associated with the SL production pathway and inform improvements at the research and development (R&D) stage, to facilitate commercial exploitation of these new generation biosurfactants. LCA is considered a powerful tool to evaluate environmental sustainability, its application of emerging technologies is different and is challenged with problems like data scarcity and rapid changes in the technology itself. This study adopts a dynamic LCA (dLCA) framework consisting of two traversals that emphasizes iterative evaluations and collaborative efforts with the experimentalists to tackle these problems. The dLCA framework is used to analyze SL production from organic waste streams, identify hotspots, derive recommendations to reduce environmental impacts at lab scale, to avoid unintended consequences while scaling up. LCA in the first traversal identified food waste as the most suitable feedstock. After accounting for experimental results with food waste as feedstock, two separation technologies were evaluated in the second traversal to find out that fed batch fermentation integrated with *in-situ* separation resulted in lesser environmental impacts compared to conventional separation technique. Results obtained from each traversal will inform the experimentalists to optimize those processes, resultant data sets can be iteratively used in subsequent traversals to account for the technological changes and mitigate the impacts before scaling up.

TECHNICAL SESSION 4

Machine Learning-Based Prediction of Immobilization Efficiency of Potentially Toxic Elements in Biochar Amended Soils.

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Biochar application to contaminated soils is one of the most promising strategies for both waste reuse and soil remediation since it plays a major role in green and sustainable remediation. Machine learning (ML), as a data-driven approach, can further aid us to understand this process by connecting all the important factors to the remediation target. In this study, ML algorithms were employed to predict the immobilization efficiency of potentially toxic elements (PTEs) in biochar amended soil, based on a set of input features which included biochar, soil, and PTE properties. The results suggested that the random forest (RF) algorithm could predict PTE immobilization efficiency of biochar based on the above-mentioned characteristics with a high degree of accuracy (training R^2=0.96, training RMSE=6.55 and test R^2=0.92, test RMSE=9.32). A simplified ML model with reduced features was further devised based on the results of ML-based feature engineering, and analysis was performed to understand the significance of each of the input features on the immobilization of PTE on biochar amended soil. The results revealed that biochar application rate was the most significant feature, followed by the N % in the biochar, with both having positive correlations on PTE immobilization. The soil electrical conductivity and pH were the third and fourth most important features, indicating the importance of soil properties in PTE immobilization. Interestingly, and in contrast to related studies, the surface area of biochar and the pyrolysis temperature were not determined as the most significant features by the model, thus presenting new insights on understanding the effect of biochar characteristics and soil properties for PTE immobilization in contaminated soils. This study was supported by the National Research Foundation of Korea (NRF) (Germany-Korea Partnership Program (GEnKO Program) 2018–2020).

Keywords: Biochar; machine learning; heavy-metal immobilization; potentially toxic element; soil remediation

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A NOVEL Approach to Investigate Bromine Content in E-Waste Plastic By Short Wave Infrared Spectroscopy.

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Brominated Flame Retardants (BFRs) are toxic for the environment and harmful for human health and animals. Those chemical substances are mainly used in plastics for its property to increase fire resistance and delay/avoid flames, especially in Electrical and Electronic Equipment (EEE). In the last decades, have been introduced different prohibitions on production and utilization of some families of BFRs. For these reasons, is of utter importance to develop sustainable correct actions of recycling. Nowadays, Plastics containing BFRs are sorted by dense medium, however plastics containing other kind of additives are lost in underflow by using these traditional methods. Thus, the necessity of using a technology, which is low cost, effective, reliable, sustainable and with a low environmental impact. The aim of this study was to test whether SWIR (Short Wave InfraRed) spectroscopy can be used as a tool for testing the bromine concentration plastics coming from an e-waste stream of CRT (cathode-ray tube) monitors and televisions. In order to achieve this goal, X-Ray Fluorescence (XRF) analysis was performed on plastic scraps and used as reference method. An ASD FieldSpec® 4 Standard-Res portable spectroradiometer working in VIS-SWIR was used for collecting spectra on samples. Chemometric methods were adopted for setting up models able to discriminate bromine content. More in detail, Principal Component Analysis (PCA) was used as exploratory tool. While, Partial Least Squares (PLS) and Locally Weighted Regression (LWR) – based on PLS regressions were used as multivariate regression models for testing the ability of the spectra to predict bromine content.

Environmental Impacts of Upscaled Mixed Cation Perovskite Precursors for Emerging Lead Halide Perovskite Solar Cells.

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Efficiencies of lead halide perovskite photovoltaics (LHP PVs) reached a record of 25.2% just 10 years after their inception, positioning them to compete with current PV technologies developed over decades. Combined with their low fabrication costs, earth-abundant materials, and superior optoelectronic performance, LHP PV's are on track for near-future commercialization. Key challenges exist today to improve the module operational lifetime, upscale manufacturing, and derisk the presence of toxic lead. Devices fabricated with a mixed cation perovskite absorber layer such as cesium/ methylammonium/formamidinium ($Cs_xMA_yFA_{1-x-y}PbI_3$) show longer operational stability and higher efficiency than the most-studied $MAPbI_3$. Earlier life cycle assessment (LCA) literature based on lab scale analysis reported an outsized environmental impact for FA, raising concerns over commercializing high-performing compositions. In this talk, we will present a comprehensive LCA study that uses updated data sources, process scale-up concepts, and sensitivity analysis to build ex ante commercial-scale life cycle inventory models for perovskite precursors that can inform industrial manufacturing choices with more transparent and robust environmental analysis. We have found that the impacts between

Cs/FA/MA across climate change, cumulative energy demand, and human toxicity categories are all similar to each other. Process contribution analysis reveals that reducing solvent usage and solvent recovery may reduce impacts. However, the impacts for precursors, including lead iodide, are already 1,000 times less than those of other module components like solar glass or flexible substrates. Therefore, selection of perovskite composition can be based on PV efficiency and operational stability, without additional constraints of environmental impact.

Gap Analysis of Current Discarded Solar Photovoltaic Panels Management between Germany and Thailand.

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To deal with global warming situations, renewable energy plays a key role to solve the problem. Energy from solar power is the most reliable and cost-effective of clean technology. The installed capacity of solar photovoltaic (PV) panel has been dramatically increased annually. This also leads to the sharp increase of discarded solar panels. In Thailand, the estimated number of discarded solar PV panels will be accumulated to 105,285 tons by 2037. Good end of life (EoL) management plans and strategies are required to deal with solar PV module waste in the future, which was the main objective of this work. Germany, which is well known regarding to EoL management of solar PV module and the recycling technology, was selected as the role model and identified the successful key factor. Gap analysis was applied to compare the EoL PV management system between Germany and Thailand based on a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis. The results showed that the key factors to fulfill the gap were specific policies for solar modules waste management, added up tax for recycling system, advance technology for high recovery yield for precious materials, and downstream industries for recycled materials. Nonetheless, the common weaknesses of Germany and Thailand were uncertainty of solar PV panels waste projection, insufficient solar panels to supply recycling plant, and unclearly procedure to handle hazardous substances from recycling process. These issues required attentions in the future study to develop a sustainable EoL solar PV modules management in Thailand context.

New Porous Materials Derived from Industrial By-Products for Nanoparticles Capture.

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Particulate matter (PM) is the air pollutant which has the most severe impact on health. Currently, around 90% of the population of European cities for which PM data exist is exposed to levels exceeding WHO air quality guidelines levels. To improve air quality in cities, the challenge is to develop an innovative material solution that can reduce the concentration of PM in the air. The aim of this work is the evaluation of hybrid porous materials, named SUNSPACE realized with silica fume and bottom ash (as raw materials), compared to cement and leaf for PM entrapment. The great advantages of these porous materials are not limited to the improvement of urban air quality but include also the reuse of waste that occurs in their synthesis. Experimental tests on particles entrapment were conducted, for the first time, by using a nanoparticles generator. TiO_2 suspension, with a size of 300 nm and a concentration of 3 g/L, was used to simulate the dispersion of nanoparticles. To compare the quantity of TiO_2 adsorbed by each specimen, both the exposed and the pristine samples were digested and then analyzed by Total X-Ray Fluorescence (TXRF). The results show a high adsorption capacity of SUNSPACE realized with bottom ash (3526 ± 30 mg/kg). The main advantage of this porous material, in comparison

to the corresponding SUNSPACE realized with silica fume is its light color, that overcome the aesthetic limits of SUNSPACE (that has a dark grey color), making more suitable its application on the buildings' facades.

The Multiple Intelligence of the Intelligent Building.

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Human intelligence was born in nature, but the building intelligence was built with design. Since the intelligence of buildings are thought to consist of Building Automation (BA), Communication Automation (CA), Office Automation (OA), the buildings were highly bonded with the energy issues. Unfortunately, the content drives the intelligent building into the uncertain loop of increasing the use of energy while people thought that they were saving the current expending in energy but no guaranty for low energy. Therefore, the intelligent building will be a new impact for the energy issue. This study used the multiple intelligence theory, proposed by the psychologist Prof. Howard Gardner, intended to developed a system to classify the intelligence of the building for its different functions and requirements. Prof. Gardner proposed the multiple intelligence theory for people to understand more about the human intelligence. As to the intelligence of building, designed by human, the theory should be applicable when the building was treated as the intelligent thing. The automation works makes most of the intelligence in the building need energy to operate, only when buildings owning its appropriate intelligence, the energy will be limited in the minimum. The result of this study can provide an extra vision for the intelligence of building in the sustainable development.

Biochar Mediated Changes in Soil Contaminated with Metal Halide Perovskite Solar Cell Waste.

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Metal-halide perovskite solar cells have emerged as frontier materials in the solar photovoltaic technology. However, toxic elements inside solar cells can be exposed to the environment resulting in potential risk to surrounding ecosystems through soil and groundwater pollution. The objective of this study was to evaluate the Pb dynamics in soil contaminated with metal halide perovskite solar cells and the effect of biochar on mobility and bioavailability of Pb. Silty loam soil was treated with 300 mg/kg of Pb^{2+} in the form of solar cell powder (SCP) or perovskite solution (PS) and incubated one month. Biochar produced using rice husk at two different pyrolysis temperatures, 550 °C (RHB 550) or 700 °C (RHB 700) was added to the treated soil after one month and incubated for another one month with four

replications. Soil samples were collected before and after addition of biochar and analyzed for pH, electrical conductivity, exchangeable bases, cation exchange capacity and ammonium acetate extractable Pb^{2+} contents. After two months, SCP application has significantly increased soil pH (10.13 ± 0.01) compared to soil before treatment application (8.25± 0.01). However, there was no change in soil pH in PS applied soil (8.26 ± 0.02). Even though, SCP application has reduced Pb^{2+} compared to PS, Pb^{2+} content in SCP applied soil increased over the time possibly due to continuous release. RH 700 has significantly reduced the Pb availability in both SCP and PS applied soil suggesting potential of RH 700 on Pb immobilization in soil. In addition, synchrotron-based X-ray absorption fine structure (XAFS) spectroscopy will be used to elucidate the speciation of Pb in soils and sequential extraction will be carried out to assess the geochemical fractions in soils. The changes in the soil microbial community due to contamination of soil by solar cell waste will be assessed through next generation pyrosequencing.
This study was supported by the National Research Foundation of Korea (NRF) (Germany-Korea Partnership Program (GEnKO Program) 2018–2020).

Keywords: Black carbon, Electronic waste, Life on Land, Soil pollution, Waste valorization

SHORT TALK AND POSTER SESSION

Characterization of a New Activated Carbon Along Loading-Regeneration Cycles for Indoor Air Treatment.

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Adults spend, on average, 21 h/day in indoor environments where they may be exposed to polluted air. Volatile organic compounds (VOCs) are a class of prominent pollutants usually emitted from paints, aerosol sprays and building materials, which may cause critical health problems even at low concentrations (<100 ppm) [1]. Hence, VOCs elimination is mandatory to improve indoor air quality, which may be accomplished by adsorption using activated carbon. It is a promising treatment technology as it combines cost-effectiveness and flexible operation with high capacity, selective and low-cost materials.

Herein, it is characterized a new activated carbon to remove acetaldehyde (model VOC) from air under fixed-bed operation. The system behavior is analyzed performing adsorption-desorption experiments, from which breakthrough curves, adsorption capacity (q_e) and regeneration efficiency (η) are determined. From the 1st to the 3rd adsorption cycle, q_e varies from 0.58-0.73 to 0.34-0.41 mmol/g, and η is always > 56 %. The maximum capacity taken from isotherm is 0.95 mmol/g. Decreasing the regeneration temperature from 180 to 80 ºC does not affect results significantly. Therefore, this activated carbon is a promising material for indoor air purification since reduces the energetic costs and its regeneration is much safer for a domestic equipment.

[1] J.M. Kim, J.H. Kim, C.Y. Lee, D.W. Jerng, H.S. Ahn, J. Hazard. Mater. 344 (2018) 458-465.

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Catalytic Redox Treatment of Fluconazole Using Pd-Rh Bimetallic Catalysts.

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Fluconazole is a fluorinated organic compound used as an antifungal medicine and it is considered to be one of emerging fluorinated pharmaceutical contaminants in the environment. In this study, the efficacies of catalytic degradation of fluconazole using noble metal catalysts were investigated and compared using three different reactions: reduction using H_2 as reductant, oxidation via catalyst-activated peroxymonosulfate (PMS), and sequential reduction and oxidation reactions. Fluconazole and degradation products were analysed using Liquid Chromatography Mass Spectrometry (LC-MS). Multiple heterogeneous mono- and bimetallic catalysts (i.e., Rh, Pd, Pt, Rh-Pd, Rh-Pt, and Pd-Pt) were investigated for reductive and oxidative degradation of fluconazole, and only Rh-Pd bimetallic catalyst could degrade fluconazole via both reductive and oxidative pathways. Among different support materials (α-Al_2O_3, β-Al_2O_3, SiO_2, TiO_2-rutile (<5 µm), TiO_2-rutile (<100 nm), TiO_2-anatase), TiO_2-rutile (<100 nm) showed the highest activity for both oxidation and reduction. The oxidation pathways were mainly driven by sulfate radical reactions, including hydroxylation, demethylation, dehydration, and ring opening, while defluorination and hydrogenation were the dominant reductive degradation pathways.

Under sequential reduction/oxidation reactions, defluorinated intermediates of fluconazole generated during reduction were effectively eliminated during the subsequent oxidation. It was demonstrated that combined reduction/oxidation process using Rh-Pd bimetallic catalyst can minimize the formation of various fluorinated intermediates, preventing unwanted byproduct formation during treatment of fluorinated pharmaceuticals in water.

Designing a Novel Electrode for Alkaline Water Electrolysis Using Biomass-Derived Material.

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Hydrogen can be a good solution to utilizing renewable energy and reducing the use of fossil fuel. The great merits on alkaline electrolyzer regarding maturity, large capacity, and cost-effective features have drawn much attention as one of the possible energy storage systems connected to the renewable energy sources. Both improvements of kinetic efficiency and mitigation of electrode degradation under high current operation conditions would increase hydrogen production density, and thus improve the economics of alkaline water electrolysis. Here we report a study of the biomass-derived electrode for alkaline water electrolysis. Biochar is a pyrolyzed biomass at high temperature under less or no oxygen condition. It can be utilized from biomass waste, and is carbon-negative unlike the usual fossil-fuel-based carbon material such as graphite. Due to the economic feature and the eco-friendliness, biochar was selected as a carbon source in preparing electro-catalyst for hydrogen evolution reaction. Several types of biochar were chosen as the carbon source of Mo_2C electro-catalyst. The mixture of reductant Mg powder and biochar impregnated with $(NH_4)_2Mo_7O_{24}\cdot 4H_2O$ solution was milled at 300 rpm in a planetary ball mill. The resulting powder was made into a catalyst ink and was tested on a rotating disk electrode in 1 M KOH electrolyte. When magnesio-ball-milled, samples showed different XRD peaks showing different phases of molybdenum carbide, depending on the type of biochar. Also, even within the same phase, molybdenum carbide with higher crystallinity showed better performance than the other. The best performance reported among the tested samples is 0.576 V_{RHE} at 100 mA/cm^2 which is only 0.124 V bigger than the commercial Pt/C catalyst at the same current density.

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Development of Aptamer That Recognize PFOA and Its Application for Detecting Levels in Water.

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Per- and polyufluoroalkyl substances (PFAS) are comprised of various length of carbon chain where the fluorine atoms bind partially or fully to the carbon atoms. Due to their hydrophobic, lipophobic, and heat and chemically resistant characteristics, PFAS have been used in manufacturing water, soil, stain, and oil resistant coated leather, carpet, and cookware, and even fire-fighting foam. Owing to their persistent and recalcitrant characteristics in natural and engineered environmental systems, PFAS are widely recognized as one of emerging contaminants. Perfluorooctanoate (PFOA), one of the primary PFAS members, is ubiquitous in many water sources, especially in drinking water. While numerous studies are available on PFOA treatment, sensor-based monitoring technologies for PFOA and other

PFAS remains in the early stage. In this study, we focus on developing aptamer-based sensor that can selectively bind to on PFOA. The aptamer is isolated via capture-SELEX technique, a systematic evolution of ligands by exponential enrichment. The selected aptamer showed binding affinity for PFOA with K_D= 5.4 µM. Furthermore, the detection of PFOA using the selected aptamer in wastewater conditions was also tested. Our results suggest that aptamer-based sensor can be a promising technology to monitor PFOA and other PFAS in water.

Immobilization of Pb in Contaminated Soil with Standard Biochars.

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The Pb immobilization efficiency and release of soil nutrients were evaluated in contaminated soil amended with standard biochar. Biochar has been well known as a sustainable adsorbent for heavy metal immobilization or a competitive fertilizer in soils. This study adopted standard biochar which was produced from UKBRC (UK Biochar Research Centre). It is a set of biochar pyrolyzed under well controlled units and provided to biochar research groups worldwide, providing the standardized reference of biochar to researchers. Ten kinds of Standard biochar that derived from five kinds of feedstocks and each pyrolyzed at 550℃ and 700℃ were applied to the microcosm experiment. The microcosm was composed of 100 g of Pb contaminated soil with 2.5% (w w−1) biochar treatments in 70% of water holding capacity and incubated for 21 days. The available Pb was analyzed to examine the immobilization efficiency. Most of the Standard biochar treatments performed Pb immobilization with different ranges. Especially, OSR 700 (oilseed rape straw at 700℃) and RH 700 (rice husk at 700℃) showed a significant decrease of available Pb content. The soil samples were analyzed for pH, electric conductivity (EC), total nitrogen, organic matter contents, exchangeable cations. As a result, except SWP 700 (Softwood pellet at 700℃) biochar treated soils, soil pH increased from 6.0 to 7.0 and EC also increased from 0.0805 dS/m to 0.2707 dS/m. The largest increase of pH and EC was found with OSR 700 treatment. Correspondingly, OSR 700 treated soil showed the high content of exchangeable cations including the greatest concentration of K^+. The result of total nitrogen was varied among the standard biochars, while OSR 550 (oilseed rape straw at 550℃) treated soil showed a significant increase of nitrogen. This study suggests that OSR biochar is the most efficient biochar on Pb immobilization and fertilization. This work was carried out with the support of "Cooperative Research Program for Agriculture Science and Technology Development", Rural Development Administration, Republic of Korea.

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