2019 E2S2-CREATE and AIChE® Waste Management Conference

11-13 MARCH 2019 | CREATE TOWER NUS | SINGAPORE

CO-ORGANIZED BY

AIChE
The Global Home of Chemical Engineers

institute for sustainability
An AIChE Technological Community

E2S2 CREATE
Energy and Environmental Sustainability Solutions for Megacities

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WELCOME ADDRESS

Dear Colleagues:

On behalf of the organizing committee (E2S2-CREATE), we would like to invite you participate in the 2019 E2S2-CREATE AND AICHE WASTE MANAGEMENT CONFERENCE. This conference aims to provide a platform for technical and scientific professionals from industries, academia, research, government organizations and researchers working in diverse fields of waste management to exchange knowledge as well as to keep abreast of the emerging state-of-the-art technologies.

We are inviting accomplished speakers from the academia and industries, and organize oral presentations in the topics such as “Recycling Behavior and Waste Sorting”, “Food waste and anaerobic digestion technology”, “Gasification technology”, “Conversion of waste to resource”, “System and industrial ecology”, “Waste handling technology and circular economy”, “Environmental technology for waste management”, and “Solar thermal treatment of organic solid waste”. More information about the conference regarding presentation instruction, conference shuttle bus service timetable and technical tour timetable can also be found at the following conference website:
http://waste.chbe.nus.edu.sg/index.html

The final conference program book is available at the following AIChE conference website:
https://www.aiche.org/ifs/conferences/e2s2-create-and-aiche-waste-management-conference/2019.

Thank you very much for your consideration and we look forward to seeing you in Singapore soon!

Conference Chair

Chi-Hwa Wang
Professor, Department of Chemical and Biomolecular Engineering
National University of Singapore
http://cheed.nus.edu.sg/stf/chewch/index.htm

Program Overview

2019 E2S2-CREATE and AIChE Waste Management Conference Schedule

All sections, breaks, lunches and events take place in CREATE Tower 2nd Floor, unless otherwise

Monday, March 11, 2019			
15:00-18:00	Conference Registration and Setup of Posters Lab Tours and Introduction of CREATE E2S2		15:00-18:00
18:20-19:00	Conference Registration (cont'd), Rochester Park Avenue Hotel		18:20-19:00
19:00-21:00	Scientific Board Meeting and Networking Dinner (by invite)		19:00-21:00
Tuesday, March 12, 2019			
9:00-12:45	Opening Ceremony and Keynote Speeches		9:00-12:45
12:45-13:45	Buffet Lunch		12:45-13:45
13:45-15:55	Section A, Keynote and Invited Speeches		13:45-15:55
15:55-16:20	Coffee break and Poster Section		15:55-16:20
16:20-18:20	Section A, Keynote and Invited Speeches	Section B, Oral Presentations, 15th Floor	16:20-18:20
18:20-20:45	Welcome Dinner (NUS Guild House), Assembly on 2nd Floor		18:20-20:45
Wednesday, March 13, 2019			
08:30-10:50	Section C, Keynote, Invited and Oral Presentations	Section D, Oral Presentations, 15th Floor	08:30-10:45
10:50-11:05	Coffee Break and Poster Section		10:45-11:05
11:05-12:35	Section C, Keynote, Invited and Oral Presentations	Section D, Oral Presentations, 15th Floor	11:05-12:35
12:35-13:35	Buffet Lunch		12:35-13:35
13:45-15:30	Section E, Oral Presentations	Technical Tour, Assembly at 13:35 PM on 2nd Floor	13:35-17:30
15:30-15:45	Coffee Break and Poster Section		
End of Conference			

CONFERENCE ORGANIZERS

Conference Chair

Chi-Hwa Wang, *National University of Singapore, Singapore*

Conference Co-Chairs

Yen Wah Tong, *National University of Singapore, Singapore*
Yong Sik Ok, *Korea University, South Korea*
Jeffrey Seay, *University of Kentucky, United States*
Xiao Liu**,** *Shanghai Jiao Tong University, China*
Adil Dhalla, *Nanyang Technological University, Singapore*

Organizing Committee

Yinghong Peng, *Shanghai Jiao Tong University, China (Committee Chair)*
Xiaotao Bi, *The University of British Columbia, Canada*
Yanjun Dai, *Shanghai Jiao Tong University, China*
Tianshu Ge, *Shanghai Jiao Tong University, China*
Shih-Hsin Ho, *Harbin Institute of Technology, China*
Deyi Hou, *Tsinghua University, China*
Duu-Jong Lee, *National Taiwan University, Taiwan*
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Yiu Fai Tsang, *The Education University of Hong Kong, Hong Kong*
Ruzhu Wang, *Shanghai Jiao Tong University, China*
Xiaonan Wang, *National University of Singapore*
Siming You, *University of Glasgow, United Kingdom*

Organizers

The 2019 E2S2-CREATE and AIChE Waste Management Conference is co-organized by the AIChE Institute for Sustainability and CREATE.

TECHNICAL PROGRAM

Monday, March 11, 2019		
15:00-18:00, Conference Registration and Setup of Posters, CREATE Tower 2nd Floor		
15:00-18:00	Registration at CREATE Tower Level 2 Foyer	
	Setup of All Poster Boards / Posters	
15:00-18:00, Lab Tours and Introduction of CREATE E2S2, CREATE Tower 2nd Floor (Open to All)		
Lab Tour Chair: Xiaonan Wang / Augustine Quek		
15:00-15:45	Food waste and anaerobic digestion technology workshop and lab tours.	
	(Co-Chairs: Junwei Lim and Jonathan Lee)	
15:45-16:30	Biomass and municipal solid waste gasification workshop and lab tours.	
	(Co-Chairs: Xian Li and Ye Shen)	
Rapid-Fire Talk Chair: Yen Wah Tong / Chi-Hwa Wang		
16:30-18:00	5-minute Rapid-Fire Talks by CREATE E2S2 Researchers to showcase various research projects in E2S2 CREATE Program	
18:00-18:20	Shuttle Bus from CREATE Tower to Rochester Park Avenue Hotel	
18:20-19:00, Conference Registration, Rochester Park Avenue Hotel		
19:00-21:00	Scientific Board Meeting. Networking dinner for keynote speakers, and invited speakers. (Assembly at 18:45 pm at lobby of Rochester Park Avenue Hotel)	
Tuesday, March 12, 2019		
9:00 -12:45, Opening Ceremony and Keynote Speeches, CREATE Tower 2nd Floor		
Chair 1: Chi-Hwa Wang / Yen Wah Tong		
09:00-9:30	Opening Ceremony	
Chair 2: Yen Wah Tong / Chi-Hwa Wang		
09:30-10:05	Keynote Talk: Closing the Waste Loop: The Role of Research and Development in Singapore's Waste Management	Patrick Pang, National Environment Agency (NEA), Singapore
10:05-10:40	Keynote Talk: Circular Economy Waste to Resources Management Minimising Environmental Footprints	Jiří Jaromír Klemeš, Brno University of Technology, Czech Republic
10:40-11:00	Coffee break and conference photo	
Chair 3: Yen Wah Tong / Yong Sik Ok / Jeffrey Seay		
11:00-11:35	Keynote Talk: Biofuels and Biorefineries for Energy and Environmental Sustainability	Ashok Pandey, CSIR-Center for Innovation and Translational Research, CSIR-Indian Institute of Technology Research; Center for Energy and Environmental Sustainability, India
11:35-12:10	Keynote Talk: Environmental Sustainability in World's Fastest Growing Regions: Challenges and Opportunities for Water and Waste Management	Shane Snyder, Nanyang Technological University, Singapore
12:10-12:45	Keynote Talk: TBA	Yongguan Zhu, Chinese Academy of Science (CAS), China
12:45 - 13:45, Buffet Lunch, CREATE Tower 2nd Floor		
13:45 - 18:20, Section A, Keynote and Invited Speeches, CREATE Tower 2nd Floor		
Chair 4: Yen Wah Tong / Xiao Liu / Ashok Pandey		
13:45-14:20	Keynote Talk: Data, Machine Learning and Decision-Making	Jie Lu, University of Technology, Sydney, Australia
14:20-14:55	Keynote Talk: Microwave-Assisted Catalytic Pyrolysis of Biomass	Xiaotao Bi, The University of British Columbia, Canada

14:55-15:55	Meet the Editors Session (Chaired by Yong Sik Ok)	
15:55-16:20	Coffee break and Poster Section	
Chair 5: Jiri Klemes / Yanjun Dai / Shane Snyder		
16:20-16:40	Invited Talk: Co-Chair Research Highlights on Waste Plastic	Jeffrey Seay, University of Kentucky, USA
16:40-17:00	Invited Talk: Versatile Use of CO2 in the Thermo-Chemical Process	Eilhann Kwon, Sejong University, Korea, Republic of (South)
17:00-17:20	Invited Talk: Green and Sustainable Remediation Using Nature Based Solutions with Biological Waste Derived Materials	Deyi Hou, Tsinghua University, China
17:20-17:40	Invited Talk: Biomass Pyrolysis for Gas Fuel, Liquid Chemicals and Solid Carbon-Materials Polygeneration	Haiping Yang, Huazhong University of Science and Technology, China
17:40-18:00	Invited Talk: Solar Thermochemical Technology for Processing Carbonaceous Materials	Wojciech Lipinski, The Australian National University, Australia
18:00-18:20	Invited Talk: Energy Recovery from Food Waste Gasification Process Using Stirling Engine with Heat Harvesting	Yanjun Dai, Shanghai Jiaotong University, China
16:20 - 18:35, Section B, Oral Presentations, CREATE Tower 15th Floor		
Chair 6: Adil Minoo Dhalla / Wojciech Lipinski		
16:20-16:35	Phytoremediation Plant	Pranjal Mathur, HKUST AIChE Student Chapter, Hong Kong
16:35-16:50	Catalytic Microwave Pyrolysis of Plastic Waste Using Metallic Biochar Derived from Oil Palm Waste: Production of Hydrogen, Gaseous Hydrocarbons and Energy Efficiency	Su Shiung Lam, Universiti Malaysia Terengganu, Henan Agricultural University, University of Cambridge, Malaysia
16:50-17:05	Optimal Maintenance Scheduling for a Waste-to-Energy Combined Heat and Power Plant Under Uncertainty	Chenlian Hu, Shanghai Jiao Tong University, University of Technology, Sydney, China
17:05-17:20	Upcycling of Mixed Plastic Waste to Oil and Multi-Walled Carbon Nanotubes: Techno-Economic Feasibility and Environmental Impacts	Ashiq Ahamed, Nanyang Technological University, Abo Akademi University, Singapore
17:20-17:35	Effects of Production Temperature on Suitability of Environmental Applications of Rice Husk Biochars	Zhengtao Shen, University of Alberta, Canada
17:35-17:50	Life Cycle Assessment of Different Strategies to Overcome Ammonia Inhibition in Anaerobic Digestion Process	Hailin Tian, National University of Singapore, Singapore
17:50-18:05	Conceptual Design of Ethylene Oxide Production Process with Integrated Conversion of Waste CO2 Stream	Magda H. Barecka, Lodz University of Technology, Poland
18:05-18:20	Sustainable Recycling of Spent Asymmetric-Capacitance Power Batteries	Ming Wang, shandong university of technology, China
18:45-20:45, Welcome Dinner (NUS Guild House), Assembly at 18:45 pm at Level 2, CREATE Tower		
Wednesday, March 13, 2019		
08:30 - 12:35, Section C, Keynote and Invited Speeches, Oral Presentations, CREATE Tower 2nd Floor		
Chair 7: Xiao Liu / Chi-Hwa Wang		
08:30-09:00	Applied Energy UNILAB EB2W Presentation	
09:00-09:35	Keynote Talk: Measuring China's Circular Economy	Yong Geng, Shanghai Jiao Tong University, China
09.35-10.00	Invited Talk: Valorization of Food Waste into Platform Chemicals	Daniel C.W. Tsang, Hong Kong Polytechnic Univ., Hong Kong

10.00-10:25	Invited Talk: Continuous Thermal Conversion of Waste Lignin and Application of Lignin Derived Biochar for the Production of Valuable Compounds	Young-Kwon Park, University of Seoul, Korea, Republic of (South)
10:25-10:50	Invited Talk: TBA	Tsang Yiu Fai, The Education University of Hong Kong, Hong Kong
10:50-11:05	Coffee break	
Chair 8: Daniel C.W. Tsang/Eilhann E. Kwon		
11:05-11:20	Integration of Biomass into District Energy Systems with Methanol Production Based on a MINLP Optimization Methodology	Yingru Zhao, Xiamen University, China
11:20-11:35	Utilization of Waste Materials to Enhance the Composite Behavior between Cementitious Mortar and 3D-Printed Polymer Reinforcements Designed to be Applied for Construction 3D-Printing of Cementitious Materials	Alexander Lin, National University of Singapore, University of California, Berkeley, Singapore
11:35-11:50	Using Aquatic Plants and Plant Material for a Sustainable Water Purification Creating Low Impact Development Systems	Stephan Pflugmacher Lima, University of Helsinki, Finland
11:50-12:05	The Prediction and Optimization of Biochar Yield Based on the Feedstock Characteristics and Pyrolysis Parameters Using Machine Learning	Xiaonan Wang, National University of Singapore, Singapore
12:05-12:20	Generation and Combustion Emissions of Trash to Tank Fuel Derived from Plastic Waste	Chandni Joshi, University of Kentucky College of Engineering, USA
12:20-12:35	Promoting Food Waste Recycling in the Commercial and Industrial Sector By Extending the Theory of Planned Behaviour: a Hong Kong Case Study	Tiffany M.W. Mak, The Hong Kong Polytechnic University, Hong Kong
08:30 - 12:35, Section D, Oral Presentation, CREATE Tower 15th Floor		
Chair 9: Deyi Hou		
08:30-08:45	An Anaerobic Digestion Waste-to-Energy System for Food Waste Treatment and Fertilizer Production	Jingxin Zhang, Shanghai Jiao Tong University, China
08:45-09:00	Preparation of Nanocarbon from Bioenergy Waste Derived Biochar through Mechanized Grinding for the Removal of Pharmaceuticals from Aqueous Media	Sammani Ramanayaka, Ecosphere Resilience Research Center, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka
09:00-09:15	Comparison of Different Start-up Strategies for Thermophilic Anaerobic Digestion: Process Stability and Microbial Community Structure Shifts	Jun Wei Lim, NUS, Singapore
09:15-09:30	Technical and Economic Aspects of Hot Syngas Purification for Power Generation from Gasification of Municipal Solid Waste	Wei Ping Chan, Nanyang Technological University, Singapore
09:30-09:45	A Data-Driven Two-Stage Resource Allocation Model for Sewage Networks Against Failures	Jing Jiang, Shanghai Jiao Tong university, China
09:45-10:00	Clay-Biochar Nanocomposite As a Media for the Removal of Oxytetracycline Antibiotic from Water	Meththika Vithanage, Ecosphere Resilience Research Center, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka
10:15-10:30	Green Preparation of Fluorescent Carbon Dots from Durian Shell Waste for Highly Sensitive Detection of Fe3+ Ions	Supuli Jayaweera, Nanyang Technological University, Singapore

10:30-10:45	Making Use of Wasted Coconut Water through Freeze Concentration	Daisy Badilla, Philippine Nuclear Research Institute, Philippines
10:45-11:05	Coffee break	
Chair 10: Young-Kwon Park		
11:05-11:20	Pinch Analysis and Emission Intensity for Waste Management Planning: EU 28	Yee Van Fan, Brno University of Technology, Czech Republic
11:20-11:35	The Application of Machine Learning for Modeling the Adsorption of Heavy Metals on Biochars with Different Origins	Xinzhe Zhu, National University of Singapore, Singapore
11:35-11:50	Residential Waste Dumping Behaviors for Waste Sorting and Relevant Managerial Insights	Peng Jiang, Shanghai Jiao Tong University, China
11:50-12:05	Microplastics Bound Transport of Antibiotics in Aquatic Environment	Thilakshani Atugoda, University of Peradeniya, Sri Lanka
12:05-12:20	Three-Stage Anaerobic Co-Digestion of Food Waste and Waste Activated Sludge: Identifying Bacterial and Methanogenic Archaeal Communities and Their Correlations with Performance Parameters	Le Zhang, National University of Singapore, Singapore
12:20-12:35	Behavior of Recycled Aggregate Reinforced Concrete Columns Under Uniaxial Loading	Syed M. Shamaim Ali, Exponent Engineers (Pvt). Ltd, Exponent Engineers (Pvt).Ltd, Pakistan
12:35 - 13:35, Lunch, CREATE Tower 2nd Floor		
13:35 - 17:30, Technical Tour, Assembly at 13:35 PM at CREATE Tower 2nd Floor		
13:45 - 15:45, Section E, Oral Presentations, CREATE Tower 2nd Floor		
Chair 11: Tsang Yiu Fai		
13:45-14:00	Biomass Based Hydrogen Production through Thermochemical Processes: A Review and Future Prospects	Daniel C.W. Tsang, Hong Kong Polytechnic Univ., Hong Kong
14:00-14:15	Life-Cycle Assessment and Optimization Framework for Sustainable Urban Farming Systems	Lanyu Li, National University of Singapore, Singapore
14:15-14:30	Market Potential of Biomethane in South Korea	Woong Kim, Kyungpook National University, Korea, Republic of (South)
14:30-14:45	Preparation of a Novel Composite Using Chitosan, Laterite and Iron Oxide Nanoparticles and Its Efficacy in Removing Methylene Blue Dye and Arsenic from Water	Md. Nurus Sakib, University of Dhaka, Bangladesh
14:45-15:00	Batch and Fixed Bed Column Based Optimization of Municipal Solid Waste Biochar Application for Volatile Organic Compound Removal Form Landfill Leachate	Yohan Jayawardhana, National Institute of Fundamental Studies, Sri Lanka
15:00-15:15	Environmental Impacts from Energy Use in Solar Photovoltaics Manufacturing	Augustine Quek, NUS, Singapore
15:15-15:30	King Coconut Husk Derived Biochar through Hydrothermal Activation Process for the Removal of Cadmium (II) and Copper (II) from Aqueous Media	Heshan Galagedara, National Institute of Fundamental Studies, Sri Lanka
15:30-15:45	Coffee break	

End of Conference

POSTER TITLES

Poster #	Presenting Author	Title
552152	Chenlian Hu, Shanghai Jiao Tong University, University of Technology, Sydney, China	Robust Trading Strategies for a Waste-to-Energy Combined Heat and Power Plant in a Day-Ahead Electricity Market
552156	Francis Tan, Petrochemical Corporation of Singapore (Private) Limited, Singapore	Case Study - Demonstration Plant of Water Recycling of Treated Industrial Wastewater Using Microfiltration/Reverse Osmosis and Activated Carbon Filter for Process Use in a Petrochemical Plant, Singapore
552222	Le Zhang, National University of Singapore, Singapore	Mesophilic Versus Thermophilic Anaerobic Digestion of Soybean Curd Residue for Methane Production: Characterizing Bacterial and Methanogen Communities and Their Relationship with Organic Loading Rates
552287	Min-Jeong Kim, Korea University, South Korea	Preparation of Waste Coffee Ground-Based Microporous Carbons for CO2 Capture
553190	Min-Jeong Kim, Korea University, South Korea	Efficient Mg-Doped Porous Carbon Derived from Petroleum Coke for Removing Heavy Metal Ions from Wastewater
553210	Ki-Joon Jeon, Inha University, South Korea	Development of MoS2/Graphene on Carbon Cloth Electrode for Simultaneous Wastewater Treatment and Hydrogen Production Using Water Splitting
553814	Kaifeng Yu, Shanghai Jiao Tong University, China	High-Throughput Profiling of Antibiotic Resistant Genes in a Novel Tridimensional Eco-Biological WWTP with High Discharge Standards for Reuse
553863	Young Kwon Park, University of Seoul, Sunchon National University, South Korea	Application of Liquid Phase Plasma in Photocatalytic Hydrogen Production from Wastewaters Containing Organic Pollutants
554309	Li-Hua Xu, Ajou University, South Korea	Investigation of Phosphorus Removal in Sewage Sludge Solid Fuel Using Citric and Formic Acid
554451	Hocheol Song, Sejoung University, South Korea	Thermochemical Conversion of Polyvinyl Chloride (PVC) in the Presence of Fe_3O_4 and CO_2 for Syngas Production

Keynote Speaker Biographies

Xiaotao Bi

Professor, Chemical and Biological Engineering, The University of British Columbia, Canada

Dr. Xiaotao (Tony) Bi is a professor in the Department of Chemical and Biological Engineering at the University of British Columbia, and is a Fellow of Canadian Academy of Engineering. He has been an associate director of the Clean Energy Research Centre (www.cerc.ubc.ca), director of China-Canada Bioenergy Centre (c-cbc.center), and manager of the Fluidization Research Centre (www.frc.engineering.ubc.ca/). His current clean energy research has been focused on development of fluidized bed reactors for biomass gasification, torrefaction, and catalytic pyrolysis, life cycle analysis and integrated assessments of bioenergy systems. He has published 350+ peer-reviewed papers, being cited 12200 times with an H-Index of 54. He was the recipient of a UBC Killam Senior Research Fellowship (2011), AIChE Particle Technology Forum Lectureship Award (2012), and Teaching Excellence Award of UBC Chemical and Biological Engineering Department (2014).

Yong Geng

Professor and Dean, School of Environmental Science and Engineering, Shanghai Jiao Tong University, China

Dr. Yong Geng is a distinguished Professor on Circular Economy and Industrial Ecology and also dean at the School of Environmental Science and Engineering, Shanghai Jiao Tong University, China. His main research field covers industrial ecology, environment management, climate change, carbon emission accounting and sustainable development. He has published over 250 peer-reviewed papers in international journals such as Science, Nature, Environmental Science & Technology, etc. In 2013, he received the National Science Fund for Distinguished Young Scholars from the Natural Science Foundation of China (NSFC). He is a Cheung Kong Scholar Chair Professor of Ministry of Education. He is also serving in various organizations and scientific communities, such as a Leading Author in IPCC AR-5 and AR-6, reviewers for many international journals, experts in UN organizations (UNEP, UNIDO, UNU, UNCRD), and consultants for Chinese local governments.

Jiří Jaromír Klemeš

Head of Sustainable Process Integration Laboratory (SPIL), NETME Centre, Brno University of Technology, Czech Republic

Dr. Hab Jiří Jaromír Klemeš is the Head of "Sustainable Process Integration Laboratory – SPIL", NETME Centre, Faculty of Mechanical Engineering, Brno University of Technology - VUT Brno, Czech Republic and Emeritus Professor at "Centre for Process Systems Engineering and Sustainability", Pázmány Péter Catholic University, Budapest, Hungary. He was previously the Project Director, Senior Project Officer and Hon Reader at Department of Process Integration at UMIST, The University of Manchester and the University of Edinburgh, UK. Founder and a long-term Head of the Centre for Process Integration and Intensification – CPI2, University of Pannonia, Veszprém, Hungary. He was warded by the EC with Marie Curie Chair of Excellence (EXC). He has a track record of managing and coordinating 93 major EC, NATO and UK Know-How projects. His research funding has attracted over 29 M€.

Dr. Klemeš is the Co-Editor-in-Chief of Journal of Cleaner Production and Chemical Engineering Transactions, Subject Editor of Energy and Emeritus Executive Editor of Applied Thermal Engineering. He is the founder and President for 22 years of PRES (Process Integration for Energy Saving and Pollution Reduction) conferences. A seven years Chairperson of CAPE Working Party of EFCE (European Federation of Chemical Engineering), a member of WP on Process Intensification and of the EFCE Sustainability platform. He has been awarded by the Web of Science and Publons a Highly Cited Researcher, Top Peer Reviewerand Top Handling Editor. He has authored and

co-authored close to 500 papers, has an h-index in Google Scholar of 52 and in Scopus without self-reference 47. His Publons profile (a branch of Web of Science) shows 1,150 reviews for 82 scientific journals and 3,170 Editors Merits for 18 Editorial boards. A number of books published by Dr. Klemeš in Elsevier, De Gruyter, Woodhead, McGraw-Hill, Ashgate Publishing Cambridge, Springer, WILEY-VCH, and Taylor & Francis. He has also been invited as a lecturer at 46 universities world-wide, distinguished visiting professor at multiple universities, Doctor Honoris Causa and Honorary Dotor of Engineering at universities in Europe and Asia. Dr. Klemeš has further been awarded with “Honorary Membership of Czech Society of Chemical Engineering", "European Federation of Chemical Engineering (EFCE) Life-Time Achievements Award" and "Pro Universitaire Pannonica" Gold Medal.

Jie Lu

IEEE Fellow, Centre for Artificial Intelligence; Faculty of Engineering and Information Technology, University of Technology Sydney (UTS), Australia

Distinguished Professor Jie Lu is a Fellow of IEEE and Fellow of IFSA, an internationally renowned scientist in the areas of computational intelligence, specifically in decision support systems, fuzzy transfer learning, concept drift, and recommender systems. She is the Director of Centre for Artificial Intelligence (CAI) and the Associate Dean in Research Excellence in the Faculty of Engineering and Information Technology at University of Technology Sydney (UTS). She has published six research books and over 400 papers in Artificial Intelligence, IEEE transactions on Fuzzy Systems and other refereed journals and conference proceedings. She serves as Editor-In-Chief for Knowledge-Based Systems (Elsevier) and Editor-In-Chief for International Journal on Computational Intelligence Systems (Atlantis), has delivered 25 keynote speeches at international conferences, and has chaired 15 international conferences. Lu was/is a finalist of the Australian Eureka Prize for Advanced Data Science 2017/2018. She has received Computer Journal Wilkes Award" (2018) and other national and international awards.

Ashok Pandey

Distinguished Scientist, Centre for Innovation and Translational Research, CSIR-Indian Institute of Toxicology Research; Executive Director, Centre for Energy and Environmental Sustainability, India

Professor Ashok Pandey is currently the Distinguished Scientist at the Centre for Innovation and Translational Research, CSIR-Indian Institute of Toxicology Research, Lucknow, India and Executive Director (Honorary) at the Centre for Energy and Environmental Sustainability – India. Formerly, he was Eminent Scientist at the Center of Innovative and Applied Bioprocessing, Mohali and Chief Scientist & Head of Biotechnology Division and Centre for Biofuels at CSIR’s National Institute for Interdisciplinary Science and Technology, Trivandrum. His major research and technological development interests are industrial & environmental biotechnology and energy biosciences, focusing on biomass to biofuels & chemicals, waste to wealth & energy, industrial enzymes, etc. Professor Pandey is Adjunct/Visiting Professor/Scientist in universities in France, Brazil, Canada, China, South Africa, and Switzerland and also in several universities several in India. He has ~ 1300 publications/communications, which include 16 patents, 65 books, ~ 660 papers and book chapters, etc with h index of 92 and > 37,000 citations (Goggle scholar). He has transferred several technologies to industries and has done industrial consultancy for about a dozen projects for Indian/international industries.

Professor Pandey is the recipient of many national and international awards and honours, which include Highest Cited Researcher (Top 1% among 4000 in the world; Top 10 among India), Clarivate Analytics, Web of Science (2018); Life-Time Achievement Award from the Biotech Research Society, India (2018); Life-Time Achievement Award from Venus International Research Awards (2018); Most Outstanding Researcher Award from Career360 (2018); Life-Time Achievement Award from the International Society for Energy, Environment and Sustainability (2017); Academician of European Academy of Sciences and Arts, Germany (2015); Honorary Doctorate degree

from Univesite Blaise Pascal, France (2007); Thomson Scientific India Citation Laureate Award, USA (2006); UNESCO Professor (2000); Raman Research Fellowship Award, CSIR (1995); GBF, Germany and CNRS, France Fellowships (1992) and Young Scientist Award (1989), etc. He is Fellow of various academies, which include Royal Society of Biology, UK (2016); International Society for Energy, Environment and Sustainability (2016); National Academy of Sciences, India (2012); Association of Microbiologists of India (2008), International Organization of Biotechnology and Bioengineering (2007) and the Biotech Research Society, India (2005).
Professor Pandey is Founder President of the Biotech Research Society, India; Founder & International Coordinator of International Forum on Industrial Bioprocesses, France, Chairman of the International Society for Energy, Environment & Sustainability, Editor-in-chief of Bioresource Technology, Honorary Executive Advisor of Journal of Water Sustainability, and Journal of Energy and Environmental Sustainability, Subject Editor of Proceedings of National Academy of Sciences, India, and editorial board member of several international and Indian journals.

Patrick Pang

Chief Technology Officer and Director of the Environmental Technology Department, National Environment Agency (NEA), Singapore

Mr. Patrick Pang is Chief Technology Officer (CTO) of the National Environment Agency (NEA) of Singapore. He heads the Technology & Systems Integration Division (TSID) of the Joint Operations & Technology Group, which incorporates NEA's Environment Technology Department (ETD). He leads ETD in the strategic management of NEA's overall research and development (R&D) plans and project portfolio, which entails operations-technology visioning, technology master-planning, project pipe-lining and providing oversight of fund allocation. TSID is also responsible for providing oversight to the development and implementation of technology within NEA, to enhance operational effectiveness. As CTO, he is also to provide strategic, integrative leadership to the development of new technologies, innovation and technology adoption in the industry. Patrick has been seconded to NEA from the Government Technology Agency of Singapore (GovTech). His last posting was Director, Digital Economy at the National Research Foundation, where he set up the Digital Economy Research Directorate and coordinated the overall development of the Services & Digital Economy R&D agenda for Singapore, under the current five-year Research, Innovation & Enterprise 2020 (RIE2020) plan.

Shane Snyder

Professor, Nanyang Technological University (NTU), Singapore

Dr. Shane Snyder is a Professor of Civil & Environmental Engineering and is the Executive Director of the Nanyang Environment & Water Research Institute (NEWRI) at Nanyang Technological University (NTU) in Singapore. He joined NTU after serving as a Professor of Chemical & Environmental Engineering and the co-Director of the Water & Energy Sustainable Technology (WEST) Center at the University of Arizona, USA. For over 20 years, Dr. Snyder's research has focused on the identification, fate, and health relevance of emerging water pollutants. Dr. Snyder and his teams have published over 200 manuscripts and book chapters on emerging contaminant analysis, treatment, and toxicology. He currently serves as an editor-in-chief for the international journal Chemosphere. Dr. Snyder has been invited to brief the Congress of the United States on three occasions on emerging issues in water quality. He is a Fellow of the International Water Association and a member of the World Health Organization's Drinking Water Advisory Panel. He has served on several US EPA expert panels and is currently a member of the EPA's Science Advisory Board drinking water committee and the US EPA's Board of Scientific Counselors Sustainable Water committee. He was a member of the US National Academy of Science's National Research Council Committee on Water Reuse and currently serves on the WHO's guiding committee on development of potable reuse guidelines. Dr. Snyder has also worked as a Visiting Professor at the National University of Singapore (2011-2017).

Yongguan Zhu

Co-Editor-in-Chief, Environment International; Chinese Academy of Scince (CAS), Beijing, China

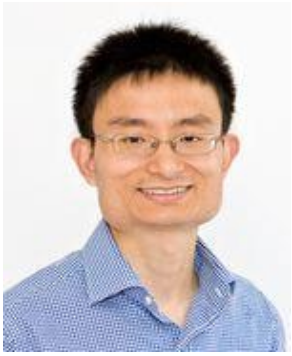
Dr. Yongguan (Y-G) Zhu, professor of Biogeochemistry and Environmental Biology, is the Director General of the Institute of Urban Environment, Chinese Academy of Sciences (CAS). He has been working on the biogeochemistry of nutrients, metals and emerging pollutants (such as antibiotics and antibiotic resistance genes). Professor Zhu is a leader in taking multi-scale and multi-disciplinary approaches to soil and environmental problems. Before returning to China in 2002, he was working as a research fellow (Supported by the Royal Society London), the Queen's University of Belfast, UK (1994-1995); and a postdoctoral fellow in The University of Adelaide (1998-2002), Australia. He obtained his BSc from Zhejiang Agricultural University in 1989, and MSc from CAS in 1992, and then a PhD in environmental biology from Imperial College, London in 1998. Dr Zhu is currently the co-editor-in-chief of Environmental Technology & Innovation (Elsevier), associate editor of Environment International (Elsevier), and editorial members for a few other international journals. He is a scientific committee member for the ICSU program on Human Health and Wellbeing in Changing Urban Environment, and served for nine years as a member of Standing Advisory Group for Nuclear Application, International Atomic Energy Agency (2004-2012). Professor Zhu is the recipient of many international and Chinese merit awards, among them including TWAS Science Award 2013, National Natural Science Award 2009; Professor Zhu has published over 200 papers in international journals, and these publications have attracted over 10,000 citations (Web of Science) with an H-index of 58. He was selected as a Web of Science Highly Cited Researcher (2016); an elected Fellow, American Associate for the Advancement of Science (AAAS).

Invited Speaker Biographies

Yanjun Dai

Department of Power and Energy Engineering, Shanghai Jiao Tong University, China

Dr. Dai Yanjun (Y.J.Dai) is a full professor in the School of Mechanical engineering, Shanghai Jiao Tong University(SJTU), P. R. China, Head of Department of power and energy engineering, SJTU, and the Vice director of engineering research center of solar energy, Ministry of Education, China. He has been the research associate in the Department of Mechanical engineering in the University of Hong Kong (2001), visiting professor in North Dokota state university, USA (2009). Principal investigator (PI) for E2S2 project of CREATE program, sponsored by NRF, Singapore (2012-2017). His research interests involve solar heating and cooling, solar buildings, desiccant dehumidification and moisture control in built environment, et al. To date, he has published 4 books or book chapters, over 100 international journal papers, and obtained 20 patents in the aforementioned areas. He has been the principal investigators for projects of NSFC, National High-tech programs, etc. He has received several awards at national level, such as National Innovation Award (II), National Natural Science Award (II) etc. He is now the Subject Editor of , the member of International Society of Solar Energy (ISES). He has served the guest editor of for Special issue SET2010, SET2011.



Deyi Hou

Associate Professor and Assistant Dean, School of Environment, Tsinghua University, China

Dr. Hou is the associate Editor, Science of the Total Enviornment (Impact Factor: 4.610); Editorial Board Member, Remediation Journal; Guest Editor, Chemosphere (Impact Factor: 4.208); Guest Editor, International Journal of Environmental Research and Public Health (Sediment and Environmental Pollution) (Impact Factor: 2.145); Invited Reviewer for nearly 40 academic journals including EST, JHM, JCP, STOTEN, etc; Sustainable Remediation Forum (SURF), Member; American Geophysical Union (AGU), Member/Annual Conference Session Chair; ASTM International, Member/Working Group Member; and Higher Education Academy, Associate Fellow.

Eilhann E. Kwon

Professor, Sejong Univerrsity, South Korea

Dr. Kwon completed his Ph.D. in the Department of Earth and Environmental Engineering (Interdisciplinary department between chemical and environmental engineering) at Columbia University in the City of New York, USA in 2008. Immediately following, Prof. Kwon was appointed as Associated Research Scientist at the Earth Engineering Center of the Earth Institute at Columbia University. Afterwards, Prof. Kwon returned to South Korea and worked at the Research Institute of Industrial Science and Technology (RIST) from 2010 to 2013. In 2013, Prof. Kwon joined as a faculty member in the Department of Environment and Energy at Sejong University. His research interests are

focused on combustion, catalysis, fuel processing, bioenergy, and air pollution controls. To date, Prof. Kwon has published more than 190 articles in peer-reviewed international SCI journals.

Wojciech Lipinski

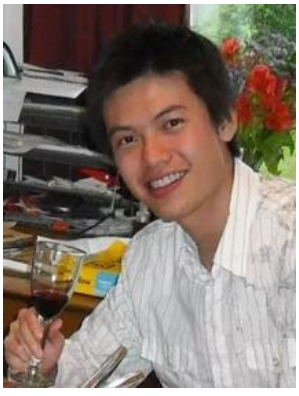
Professor and Leader of Australian National University (ANU) Solar Thermal Group, ANU, Australia

Wojciech Lipiński is Professor and Leader of the Solar Thermal Group at the Australian National University. His research interests are in thermal, chemical and optical sciences, with applications in energy, materials and environmental engineering. His core research program encompasses transport phenomena, in particular radiative transfer, chemically reacting flows, and high-temperature solar thermal processing.

Young-Kwon Park

Professor, School of Environmental Engineering, The University of Seoul, South Korea

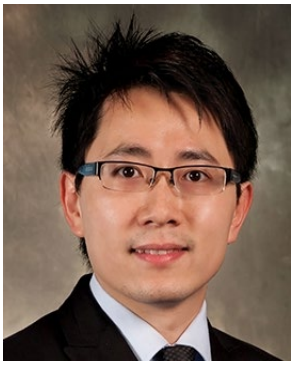
Dr. Young-Kwon Park received his B.S., M.S., and Ph.D. from the Chemical Engineering of Korea Advanced Institute of Science and Technology in 1992, 1994, and 1999, respectively. Then Prof. Park worked at Industrial Technology Institute of Hyundai Heavy Industries as a senior researcher. Since 2002, Prof. Park has been employed as a Professor in the School of Environmental Engineering of The University of Seoul, Korea. His current research interests include nanoparticle preparation, environmental catalysis, pyrolysis/gasification of wastes and catalytic process for renewable energy. Prof. Park has published more than 300 journal articles. Prof. Park has served as deputy editor of Korean Journal of Chemical Engineering (SCIE listed) and editor of Applied Chemistry for Engineering (ESCI listed). Currently, he is also serving as the chairman of the division of Energy & Environment of the Korea Institute of Chemical Engineers.



Daniel C.W. Tsang

Associate Professor, Programme Leader (EOSH), Department of Civil and Environmental Engineering, Hong Kong Polytechnic University, Hong Kong

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.



Yiu Fai Tsang

Associate Professor, The Education University of Hong Kong, Hong Kong

Dr. Yiu Fai Tsang is an Associate Professor in the Department of Science and Environmental Studies at The Education University of Hong Kong (EdUHK). He received his BEng and PhD in Environmental Engineering from The Hong Kong Polytechnic University (PolyU). Prior to joining EdUHK, he was a Visiting Scholar in the Department of Agricultural and Biological Engineering at the University of Illinois at Urbana-Champaign (UIUC) and a Research Fellow in the Department of Civil and Environmental Engineering at PolyU. Currently, he is the Editor-in-Chief of Energy & Environment (SAGE), Subject Editor of Process Safety and Environmental Protection (Elsevier), Associate Editor of Water Science and Technology (IWA), and Editorial Board Member of Chemical Engineering Journal (Elsevier). He has served as the Managing/Lead Guest Editor of six special issues in renowned SCI-listed journals. He also received the President's Award for Outstanding Performance in Research (Research Excellent Award) from EdUHK in 2017/18.

Haiping Yang

Professor, State Key Laboratory of Coal Combustion, Huazhong University of Science and Technology, China

Dr. Yang is a professor in State Key Laboratory of Coal Combustion (SKLCC) at Huazhong University of Science and Technology, China. Her research interests are focused on Biomass pyrolysis/gasification for H2 enriched gas fuel, liquid bio oil and carbon contained materials and chemicals. She also working on the fundamental mechanism exploration of biomass thermochemical conversion process. So far she has published over 100 SCI papers, and 5 were cited in ESI, and the highest SCI cite for 1 paper is over 2000. Now she owns Newton Advanced Fellowships (UK, 2018) and the Chinese Most Cited Researchers (Elsevier, 2014-2018). She gained the National Science Fund for Excellent Young Scholars program in 2016 (China).

Opening Ceremony and Keynote Speeches

Keynote Talk: Closing the Waste Loop: The Role of Research and Development in Singapore's Waste Management.

Patrick Pang
National Environment Agency (NEA), Singapore

This presentation will lay out the current waste management landscape in Singapore, focusing on the challenges, which many other cities are facing or would soon face. These will set the context for how the National Environment Agency, along with our partner agencies, are setting about research and development, as well as testbedding and demonstrations, to address these challenges.

Keynote Talk: Circular Economy Waste to Resources Management Minimising Environmental Footprints.

Jiří Jaromír Klemeš *and Yee Van Fan*
SPIL, NETME Centre, Faculty of Mechanical Engineering, Brno University of Technology, Brno, Czech Republic

Sustainable management considers the efficient resources utilisation and environmental issues for long term gain, benefiting current and future generation. The management practices look beyond the short-term profit. This study aims to review the recent sustainable management strategies and methodologies given focus on environmental components involved in circular economy. The focus is given on the waste/nutrient, water and energy (including renewables) management. The strategies can be generally divided into three major groups: a) Maximise the utilisation of waste as secondary resources b) Minimise the resources used and improve the process efficiency c) GHG and Smog/Haze emission minimisation/mitigation/capture. Circular economy, industrial symbiosis, recycling and Process Integration concepts are the examples of maximising the utilisation of waste. It is mainly by reusing, recovering, sharing (mapping the supply and demand) or even better covering the 6R practice (reduce, reuse, recycle, recover, redesign and remanufacture). The improvement of the process efficiency focuses on upgrading and integrating the technical process by identifying the bottlenecks. GHG minimisation/mitigation/capture for reprocessing is a downstream solution for the released emissions. Several technologies for GHG reprocessing and biochar application are introduced to the circular management system. The GHG capture and storage are more linear and broken economy rather than reuse and circular economy. Environmental impact quantification methods being widely introduced have been environmental footprints. From more than a hundred of developed footprints several of them been analysed: Carbon/GHG Footprint, Nitrogen and Water Footprints, also Virtual Footprints related world-waste trade. The limitation and the need for an extended approach that complements environmental, financial and even societal considerations (e.g. sustainability index) has been also highlighted. This overview is pointing out two important issues in footprint quantification for future research: (i) Afterlife footprints demanding further attention and (ii) Lifespan issues need to be considered.

Keynote Talk: Biofuels and Biorefineries for Energy and Environmental Sustainability.

Ashok Pandey
CSIR-Center for Innovation and Translational Research, CSIR-Indian Institute of Technology Research, Lucknow, India; Center for Energy and Environmental Sustainability, Lucknow, India

Waste-to-energy concept has gained much momentum in recent years as on one hand, it offers unique opportunity to handle and dispose solid wastes (municipal waste as well as agro-industrial wastes), and simultaneously provides alternative sources of renewable energy. Solid waste treatment and management is a major issue worldwide. Several countries lack proper basic waste management infrastructure and awareness. Thus, waste-to-energy could be an attractive solution for resource recovery, which eventually offers potential benefits when works on principles of biorefinery. A biorefinery is a facility that integrates biomass conversion processes and equipment to produce bio-products, including biofuels and chemicals. It is analogous to today's petroleum refinery. By producing several products, a biorefinery takes the advantages of various components present in the biomass and their intermediates, therefore maximizing the value derived from the biomass feedstock. They also help in complete or near-complete utilization of the feedstock and reduction in solid, liquid or gaseous wastes.
Lignocellulosic biomass-based research has extensively progressed for the production of value-added products and biofuels. Potential application of such biomasses for the production of liquid and gaseous biofuels and other products on principle of biorefineries has gained more attention for possibilities of bioethanol, biobutanol, biodiesel and other high-value chemicals production, coupled with industrial wastewater treatment. Two major pathways for these include thermo-chemical conversion and biochemical conversion. However, process integration is key for the techno-economic success.
The lecture will discuss the issues and perspectives, with specific to Indian scenario.

Keynote Talk: Environmental Sustainability in World's Fastest Growing Regions: Challenges and Opportunities for Water and Waste Management.

Shane Snyder
Civil & Environmental Engineering, Nanyang Environment & Water Research Institute (NEWRI), Nanyang Technological University, Singapore

Clean and reliable water is critical for sustainable economic development and for protecting human and ecological health. Water is also highly susceptible to impacts of climate change and environmental pollution. Rapid urbanization is taxing natural resources, including water supplies. Before the industrial revolution, cities housed less than 10% of human population. Today, approximately half of the world's population lives in cities, with half of these cities having populations greater than one million people. By 2050, an addition 2.5 billion people are expected to live in cities. Cities produce nearly 70% of greenhouse gas emissions and have a commensure amount of energy consumption. At the same time, highly urbanized areas are increasingly struggling with management of waste generated within these densely populated regions. For instance, synthetic chemicals were not part of the human experience until the late 19th century with the accidental discovery of the synthetic dye, mauve. Today, more than 65 million chemicals are commercially available, many of which enter the environment both knowingly and unknowingly. From a drinking water exposure standpoint, not only are the chemicals themselves a potential risk, but also the innumerable transformation products formed during water treatment processes. Fortunately, technological advances in water purification, waste treatment, and analytical characterization are providing sustainable solutions for protecting the public health and the environment. This presentation will discuss the history and evolution of water and waste treatment technologies with a view for the future opportunities for global sustainability.

Keynote Talk: TBA.
Yongguan Zhu
Co-Editor-in-Chief, Environment International; Chinese Academy of Scince (CAS), Beijing, China

TBA

Section A – Keynote and Invited Speeches

Keynote Talk: Data, Machine Learning and Decision-Making.
Jie Lu
Centre for Artificial Intelligence, University of Technology, Sydney, Sydney, Australia

The talk will present how machine learning can innovatively and effectively learn from big data to support data-driven decision-making in uncertain and dynamic situations. A set of new fuzzy transfer learning theories, methodologies and algorithms are proposed that transfer knowledge learnt in one or more source domains to target domains by building latent space and mapping functions to overcome tremendous uncertainties in data, learning processes and decision outputs (classification and regression). Another set of concept drift theories, methodologies and algorithms are developed to handle ever-changing dynamic data stream environments with unpredictable stream pattern drifts by effectively and accurately detecting concept drift in an explanatory way, indicating when, where and how concept drift occurs and reacting accordingly. These new developments enable smart learning and therefore enhance data-driven prediction, recommendation and decision support systems in uncertain and dynamic environments.

Keynote Talk: Microwave-Assisted Catalytic Pyrolysis of Biomass.
*Badr Mohammad**, Xiaotao Bi,** Naoko Ellis, Chang Soo Kim*
Clean Energy Research Centre, The University of British Columbia, Vancouver, Canada

Biomass residues are low-carbon renewable energy sources and have the potential to replace fossil fuels to reduce greenhouse gas emissions. Thermochemical pathways such as gasification and pyrolysis have been applied to convert biomass into drop-in biofuels, but still face both technical and economic challenges. Among the technical challenges is the poor quality of intermediates, e.g. bio-oil, for upgrading. Novel methods have been explored to improve the quality of intermediates, such as catalytic pyrolysis, plasma/microwave heating. In this study, we evaluated K3PO4, clinoptilolite, bentonite and their combinations as potential additives for enhancing microwave absorption, catalyzing pyrolysis of biomass and improving bio-oil and biochar qualities, in a thermogravimetric analysis (TGA) and a microwave reactor.
K3PO4, clinoptilolite and bentonite all showed good catalytic activities in microwave-assisted pyrolysis, resulting in reduced acidity, viscosity and water content of bio-oil product and catalyst loading and combination of different catalysts are controlling parameters on heating rate and product quality. Biochar produced from K3PO4, clinoptilolite and bentonite with biomass showed good performance in reducing toxicity and uptake of heavy metals than biochars produced biomass only. All the results demonstrated that catalytic microwave-assisted pyrolysis could be one potential approach for tailoring biochar quality to improve soil physiochemical properties. High microwave absorption, high water and nutrient affinity, desirable plant nutrients and high catalytic performance are the four key features of an effective additive for microwave-assisted biomass pyrolysis for making high quality bio-oil and biochars.

Co-Chair Research Highlights on Waste Plastic.

Jeffrey Seay
Chemical and Materials Engineering, University of Kentucky, Lexington, KY

Municipal solid waste accumulation is a major challenge for governmental municipalities, particularly in developing countries, where population growth, urbanization, capital and infrastructure constraints, poor regulation and waste management education challenge the way waste is collected, recycled and disposed. In particular plastic accumulation further poses a threat due to its persistence in the ecosystem when improperly disposed of. This can lead to serious health and environmental consequences when waste plastic is dumped on open plots of land, in the streets or in waterways. Furthermore, plastic accumulation in the world's oceans is a critical sustainability issue. According to some estimates, the mass of waste plastic will outweigh fish by 2050. Unfortunately, much of the plastic that enters the oceans comes from regions where infrastructure limitations are major roadblocks to effective waste management strategies. Finding solutions to address this issue that are environmentally benign, socially acceptable and economically viable will be a critical sustainability challenge. This contribution will present potential strategies and research highlights for addressing this pressing global issue.

Invited Talk: Versatile Use of CO_2 in the Thermo-Chemical Process.

Eilhann Kwon
Department of Environment and Energy, Sejong University, Seoul, Korea, Republic of (South)

Valorization of biomass and municipal solid waste (MSW) via a pyrolytic platform was investigated. In an effort to establish the more sustainable pyrolysis platform for biomass and MSW, this study particularly employed carbon dioxide (CO_2) as reactive gas medium. Thus, this study laid great emphasis on mechanistic understanding of CO_2 during the thermolysis of biomass and MSW. A series of the TGA tests signified that the mechanistic roles of CO_2could be exerted by the homogeneous reactions between volatile organic carbons (VOCs) evolved from the thermolysis of carbonaceous materials (*i.e.,*biomass and MSW) and CO_2. Also, lab-scale pyrolysis of biomass and MSW demonstrated that the homogeneous reactions (between VOCs and CO_2) played a pivotal role for shifting the carbon distribution from pyrolytic oil to pyrolysis gas. Such phenomena were initiated at ≥ 550 ˚C. Meanwhile, CO_2also suppressed dehydrogenation of VOCs. Such genuine mechanistic role of CO_2resulted in the compositional modification of pyrolytic oil by restricting the formation of benzene derivatives including polycyclic aromatic hydrocarbons (PAHs).

Invited Talk: Green and Sustainable Remediation Using Nature Based Solutions with Biological Waste Derived Materials.

Deyi Hou
School of Environment, Tsinghua University, Beijing, China

Land contamination at many thousands of sites around the world pose a severe hazard to public health. Traditional physical and chemical remediation solutions will often require high energy with secondary pollution emission, high resource input and waste production, and can result in loss of soil functionality. Therefore, the 'Green and Sustainable Remediation' (GSR) concept has been put forward to facilitate prudent holistic land remediation decision making. The emphasis of GSR is placed on maximizing net environmental benefit, rather than health risk assessment alone. This provides a framework where the recycling of waste materials is afforded greater value than the use of virgin materials, and nature based solutions (NBS) are valued over traditional thermal or chemical based remediation. As such, GSR

provides the incentive to develop and promote new remediation technologies that are aligned well to these values. This departs from the traditional driving forces for developing new remediation technologies, which has been to develop the best available technology in terms of efficiency of reducing the risk of soil contaminants. In the context of NBS, contaminant stabilization may be achieved by reagents that derive from biological waste, such as biochar. Biochar is produced by the combustion of biomass under a limited supply of oxygen in a controlled environment. The main purpose in contaminated land application is to reduce contaminant bioavailability, as well as enhancing soil structure and fertility. Biochar has the potential be widely used as a low-cost in situ stabilization agent for the remediation of pollution-degraded land. The growth of GSR in the remediation industry should proceed hand-in-hand with the development of new nature based solutions like biochar.

Invited Talk: Biomass Pyrolysis for Gas Fuel, Liquid Chemicals and Solid Carbon-Materials Polygeneration.

Haiping Yang[1] *and Hanping Chen*[2]
(1)State Key Laboratory of Coal Combustion, Huazhong University of Science and Technology, Wuhan, China, (2)Department of New Energy Science and Engineering, Huazhong University of Science and Technology, Wuhan, China

As the only carbon contained renewable energy resources, the utilization of biomass is the key for the problem between energy and environment. Pyrolysis can convert biomass to gas fuel, liquid oil and solid char efficiently, it can convert biomass to high quality fuel, and is one of the main route for biomass utilization. However, as biomass type is diversity, and pyrolysis is very complex and quickly, the development of biomass pyrolysis is still very slow. In this study, the mechanism of hemicelluloses, cellulose and lignin pyrolysis was revealed. We set up a model to simulate biomass pyrolysis process based on biomass components. Technology of polygeneration based on biomass pyrolysis was put forward with target product controlling theory, and the operation experiment on the pilot and commercial size had also finished. The volume content of combustible composition in bio-gas would be above 70 vol %, especially, the volume content of CH4 would be above 22 vol %, while the LHV of gas would up to 15 MJ/Nm3. It is a good quality gaseous fuel for user. At the same time, a higher performance on the adsorption and combustion was obtained for the solid char product while the liquid oil was enriched more light weight composition such as phenols and acetic acid. The technology economic and environmental analysis shown that this technology has a good economy and environment performance compared with other biomass conversion technology. A further upgrading of the pyrolytic products and the application of these products were carried out. For example, after nitrogen doping, the char product was converted to a good electrode material with the specific capacitance ~180 F/g. It will be expected as a better biomass conversion technology to enhance the utilization level of abundant biomass resources in China.

Invited Talk: Solar Thermochemical Technology for Processing Carbonaceous Materials.

Wojciech Lipinski[1]*, John Pye*[1]*, Mahesh Venkataraman*[1]*, and Gilles Maag*[2]
(1)Research School of Electrical, Energy and Materials Engineering, The Australian National University, Canberra, ACT, Australia, (2)Universidade de São Paulo, São Paulo, Brazil

A review of the state of the art in solar thermal processing of carbonaceous materials is presented. Pertinent studies in process thermodynamics, chemical kinetics, and solar reactor design and modelling are surveyed, and discussed in the context of solar thermal waste processing.

Invited Talk: Energy Recovery from Food Waste Gasification Process Using Stirling Engine with Heat Harvesting.

***Jialing Chen*[1]*, Yanjun Dai*[2]*, Xian Li*[3]*, and Chi-Hwa WANG*[4]
(1)School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai, China, (2)School of Mechanical Engineering, Shanghai Jiaotong University, Shanghai, China, (3)NUS Environmental Research Institute, National University of Singapore, Singapore, (4)Department of Chemical and Biomolecular Engineering, National University of Singapore, Singapore

The high cost of food waste treatment by the traditional method and the hygiene problems caused by the accumulation make the reduction and energy regeneration of food waste locally necessary. In this paper, a combined gasification and CHP unit using Stirling engine system is modeled and evaluated. The process is aimed to treat the food waste from canteen in the campus of Shanghai Jiao Tong University. After pretreatment, the water content of food waste from the canteens at SJTU is less than 17%. By establishing a steady-state chemical reaction equilibrium model, the characteristics and yield of syngas from food waste through gasification process are analyzed. The results show that CO accounts for about 26.9% and H2 accounts for about 30.3% in syngas, and the low heating value is 6.674 MJ/m3. The syngas is fed to a Stirling engine for power generation. The Stirling engine has low requirements of feedstock and is suitable for distributed waste to energy systems. The electricity efficiency and the whole energy efficiency of the Stirling engine is about 27% and 77%. By handling with food waste 1175kg/d during peak days, the system can generate electricity 1594 kW·h/d and output heat in the form of hot water 2953 kW·h/d.

Section B – Oral Presentations

Phytoremediation Plant.

Pranjal Mathur*, Ayman Hoque, Kishore Kandasamy, and Sricharan Poyyamozhi*
Chemical and Biological Engineering, HKUST AIChE Student Chapter, Kowloon, Hong Kong

An increasing world's population has started to put a greater burden on our fresh water resources of which the majority is used to satisfy humanities agricultural needs while increasing amounts of sewage from an exponentially urbanizing society goes unrecycled. Current sewage treatment methods are inefficient when it comes to agricultural purposes as they strip the water of phosphates and nitrates, crucial compounds for plant growth. We propose the use of phytoremediation, the process of chemically purifying water using plants, as the process of choice to purify wastewater. This method removes all chemical compounds while retaining phosphates and nitrates. We have designed an easily scalable low-cost structure that would purify sewage by running it through multiple levels of the water hyacinth plant. A continuous process, the resulting affluent would remove toxins such as heavy metals and reduce BOD and COD to levels suitable for agriculture while retaining phosphates and nitrates optimal for plant growth. This structure requires very little oversight and maintenance. This promises a low-cost method of producing nutrient rich water in rural areas and places suffering from drought while freeing up fresh water resources to satisfy humanity's needs.

Catalytic Microwave Pyrolysis of Plastic Waste Using Metallic Biochar Derived from Oil Palm Waste: Production of Hydrogen, Gaseous Hydrocarbons and Energy Efficiency.

Su Shiung Lam
Pyrolysis Technology Research Group, School of Ocean Engineering, Universiti Malaysia Terengganu, Kuala Nerus, Malaysia; School of Forestry, Henan Agricultural University, Zhengzhou, China; Department of Chemical Engineering and Biotechnology, University of Cambridge, Cambridge, United Kingdom

Microwave pyrolysis was performed on plastic waste pre-mixed with metallic biochar synthesized from similar pyrolysis technique. The metallic biochar, possessing a highly porous structure with high surface area (410 m^2/g), acted initially as 'adsorbent' by providing many active sites for metals, metal oxides, and plastic waste to be attached onto. The biochar then acted as microwave absorbent, which absorbed microwave radiation and heated up to high temperature (650 °C) in a short time, observed to generate arcing and sparks intermittently, and in turn transformed into high temperature hot spots and acted as catalyst that promoted the pyrolysis cracking of plastic waste. This pyrolysis approach provided a fast heating rate (50 °C/min) and short process time (35 min) to generate higher yields of light C_5-C_{10} hydrocarbons (up to 75 wt%), H_2 and CO gases (up to 40 vol%) in the pyrolysis products. The pyrolysis-gas (up to 35 wt%) were dominated by up to 70 vol% of C_1-C_6 hydrocarbons and 40 vol% of H_2 and CO, showing great promise for use as gaseous fuel or to be upgraded to produce more hydrogen as second-generation fuel. Up to 65 wt% yield of liquid oil was also obtained, detected to have high energy content (49 MJ/kg), C_{13}–C_{24} hydrocarbons within the hydrocarbon range of diesel fuel, and promising green features for use as a potentially 'cleaner' fuel with low oxygen and nitrogen content, and free of sulphur. Energy balance analysis showed that this catalytic pyrolysis approach is potentially energy efficient to produce fuel products at a positive energy ratio of 8 (energy content of fuel products/electrical energy supplied for microwave heating) and a net energy output of about 160 MJ/h; this is supported by the high heating rate and short process time recorded by this approach, hence the lower power and energy consumption.

Optimal Maintenance Scheduling for a Waste-to-Energy Combined Heat and Power Plant Under Uncertainty.

Chenlian Hu[1,2]*, Xiao Liu*[1]*, and Jie Lu*[2]
(1)Department of Industrial Engineering & Management, Shanghai Jiao Tong University, Shanghai, China, (2)Centre for Artificial Intelligence, University of Technology, Sydney, Australia

Waste management and energy crisis are two compelling challenges worldwide due to the population growth, economic development, and rising living standards in both developed and developing countries. Waste-to-energy (WtE) technologies, which turn waste into energy, provide elegant and effective solutions to these challenges. Because of the high overall thermal efficiency, modern WtE plants are often combined heat and power (CHP) producers which generate power and heat simultaneously. WtE CHP plants are often integrated into a district heating network and they also sell electricity on commercial terms. To ensure the continuous operation of WtE CHP plants, preventive maintenance scheduling is a significantly important task for plant operators. This paper studies the optimal preventive maintenance scheduling strategy for a WtE CHP plant which exports heat to a district heating network and sells electricity in a deregulated electricity market. Since the maintenance scheduling strategy has to be determined months before the actual actions, many key parameters are uncertain or partly predictable at the time of planning the maintenance. These parameters include future electricity prices, district heating demand, and the amount of waste delivered to the plant. To address the problem, we develop a two-stage robust optimization model considering different types of uncertainty. We also design a solution procedure based on the column-and-constraint generation method to solve the model. To illustrate the effectiveness of the proposed model and the solution procedure, a case study is performed based on real-world data. Moreover, a sensitivity analysis is conducted to investigate the impacts of different types of uncertainty on the optimal maintenance scheduling strategies for the WtE CHP plant.

Upcycling of Mixed Plastic Waste to Oil and Multi-Walled Carbon Nanotubes: Techno-Economic Feasibility and Environmental Impacts.

Ashiq Ahamed[1,2]*, Andrei Veksha*[1]*, Ke Yin*[3]*, Piyarat Weerachanchai*[1]*, Apostolos Giannis*[1,4]*, and Grzegorz*

Lisak[1,5]
(1)Residues and Resource Reclamation Centre, Nanyang Environment and Water Research Institute, Nanyang Technological University, Singapore, Singapore, (2)Faculty of Science and Engineering, Abo Akademi University, Abo, Finland, (3)Department of Environmental Engineering, Nanjing Forestry University, Jiangsu, China, (4)School of Environmental Engineering, Technical University of Crete, Chania, Greece, (5)School of Civil and Environmental Engineering, Nanyang Technological University, Singapore

Large amounts of mixed plastic waste are generated worldwide, including in Singapore. The available technologies, such as mechanical sorting, chemical treatment and pyrolysis of mixed plastics to fuels have low economic benefits. Owing to low profitability, the recycling rates for mixed plastic waste are low. One of the possible solutions is the conversion of mixed plastics into carbon nanotubes (CNTs) that have high value (> 80 USD/kg) and thus, create an additional stream of revenue for pyrolysis plant operators encouraging waste recycling. The objectives of this study were to investigate the techno-economic feasibility and environmental impacts of the integrated process that upcycles mixed plastic waste with high PET content (11.8 and 27.5 wt.% of PET) into oil and CNTs. In the proposed process, mixed plastics were initially pyrolyzed and the produced vapours were subjected to catalytic treatment to improve oil quality. After oil condensation, the remaining non-condensable pyrolysis gases were used for CNTs synthesis. Cost-benefit analysis indicated 3-10 times more revenue for the plant operators with the addition of CNTs synthesis unit. The life cycle assessment (LCA) study indicated that fossil depletion and climate change potentials for the feedstock with 27.5 wt.% PET are 30% and 73% higher, respectively, compared to the feedstock with 11.8 wt.% PET. Integration of CNTs synthesis with the pyrolysis process showed significant improvements in the climate change, fossil depletion, eco-toxicity and acidification potentials yielding positive effects on the environment. Overall, the pyrolysis process integrated with CNTs synthesis showed environmental benefits while incineration resulted in net negative impacts.

Effects of Production Temperature on Suitability of Environmental Applications of Rice Husk Biochars.

***Zhengtao Shen[1]**, Deyi Hou[2], and Daniel Alessi[1]*
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The environmental application of biochar in soil or water treatment depends on the surface chemistry of biochar and its interaction mechanisms with heavy metals. In this study, rice husk biochars were produced at 300, 500, and 700 °C (RH300, RH500, and RH700). The surface chemistry of these rice husk biochars and their interaction mechanisms with lead (Pb) were investigated. The surface area (from 0.632 to 193.149 m^2/g) and pH (from 7.13 to 9.80) of the rice husk biochars significantly increased as production temperature rose from 300 to 700 °C, while the number of functional groups (e.g., carboxyl) decreased. The maximum adsorption capacity (Q_{max}) values for Pb are in the order of RH300<RH500<RH700 (14.1, 21.7, and 26.7 mg/g respectively). Although RH300 has the smallest Q_{max} value, its exchangeable Pb amount is the largest (2.61 versus 0.223-0.377 mg/g), suggesting RH300 may be suitable for water treatment due to the easy separation of immobilized Pb and better recycling usage. The Pb immobilized on RH500 and RH700 was mainly acidic soluble and generally stable. Hydrocerussite ($Pb_3(CO_3)_2(OH)_2$) is one important form within the acidic soluble fraction. Within the generally stable formation, pyromorphite ($Pb_5(PO_4)_3X$ (X=Cl, F, OH)) is a form for the immobilized Pb on the rice husk biochars, particularly for RH500 and RH700. These findings suggest RH500 and RH700 are of huge potential to be applied in soil remediation to immobilize Pb and reduce its environmental risks.

Life Cycle Assessment of Different Strategies to Overcome Ammonia Inhibition in Anaerobic Digestion Process.

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Anaerobic digestion (AD) is a widely used technology to simultaneously dispose biowaste and recover energy (in the form of CH_4). However, the hydrolysis of urea (e.g. manure-based feedstock) and the degradation of protein and amino acid releases ammonia, which could inhibit the AD process when it is at high levels (> 0.15 g NH_3-N L^{-1}). Thus poor substrate utilization and unstable reactor performance are usually observed when protein-rich feedstock is used. In recent years, different strategies are proposed to overcome the ammonia inhibition problem, aiming to improve the methane yield of the feedstock. For example, bioaugmentation with ammonia tolerant methanogenic consortia, dilution of the substrate with water, addition of absorbing material and air stripping are extensively investigated by a lot of researchers. These methods increase the methane production to a certain level, but they also need extra operations and costs, which cause additional environmental impacts, such as energy and resource consumption. Up to now, few studies can be found discussing about the overall environmental impacts of these proposed methods. Therefore, in order to determine which method to use from the sustainable perspective, it is of great importance to evaluate and compare the environmental impacts of all the methods. In this study, life cycle sustainability assessment (LCSA) methodology is employed to assess these methods with respect to both the life cycle costing and the environmental impacts on different damage categories, such as climate change, human heath, resource, etc. The results derived from this study will be used to identify the weak point of each method and support the strategy choosing to overcome ammonia inhibition in the future.

Conceptual Design of Ethylene Oxide Production Process with Integrated Conversion of Waste CO2 Stream.

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Carbon dioxide (CO2) is widely known to be one of the most redundant gaseous waste streams. The conversion of CO2 into fuels and chemicals is a promising pathway for dealing with waste CO2 and more sustainable chemicals manufacturing. Nevertheless, examples of the process on an industrially relevant scale are still missing. One of the obstacles limiting the process application are additional up & downstream costs related to obtaining pure CO2 and separation of the reaction products. Hence, this paper analyses the case of integration of CO2 electroreduction (CO2RR) into a manufacturing process in which those two key barriers can be omitted: ethylene oxide (EO) production. EO is one of most widely used bulk chemicals and the process variant mostly applied in the industry generates significant amounts of waste CO2 as reaction by-product. The waste CO2 is separated from gas stream and removed to avoid compound build-up, hence the substrate for electroreduction is available at no additional cost. CO2 can be converted into an ethylene-rich stream and recycled back to the EO reactor, which uses ethylene as raw material. Further, no complex separations are required, as other key electroreduction product (CH4) is also used in EO production reactors. Overall, integration of CO2 electroreduction into EO manufacturing enables to reduce waste generation and significantly increase process mass efficiency. To highlight the great potential of such process integration, the conceptual process design is presented and the potential for economic savings is quantified.

Sustainable Recycling of Spent Asymmetric-Capacitance Power Batteries.
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There is a pressing need to recover asymmetric-capacitance nickel-metal hydride power batteries (AC-NiMHs) owing to their large number of applications. However, recycling of these batteries is challenging since it is a long process with low extraction efficiency and high cost. Herein, we demonstrate a sustainable, green, and effective recovery process for rare earth metals while directly preparing $LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$ cathodes from cathode and anode AC-NiMH spent materials. We investigate the effects of a range of parameters (i.e., acid concentration, reaction temperature, and time) on the leaching process. Over 99% of rare earth, Co, Ni, and Mn are leached out during the recovery process, with the leaching kinetics following a shrinking core model with inter-diffusion as the rate-determining step. Rare earths are recovered in the form of high-purity sulfuric acid complex salts, while Ni, Co, and Mn are used to synthetize $LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$ cathodes with good electrochemical properties. This research demonstrates a sustainable process for the recycling of power sources by incorporating the principles of green chemistry.

Section C – Keynote and Oral Presentations

Keynote Talk: Measuring China's Circular Economy.
Yong Geng
School of Environmental Science and Engineering, Shanghai Jiao Tong University, Shanghai, China

China is pioneering a new sustainable development model which has the ability to overcome current environmental and resource management problems, while achieving improvements in resource productivity and eco-efficiency. This model, formally accepted in 2002 and termed the “circular economy”, is understood to mean the realization of a closed-loop of materials flow in the Chinese economic system. Successful implementation of this model is seen as one way China can “leapfrog” the environmental damages typically seen as economies industrialize. This speech introduces an emergy based circular economy indicators, including the objectives, policies and measures, so that the country can ‘leapfrog’ its way from environmentally-damaging development to a more sustainable path. The speech then identifies a series of barriers and challenges to the implementation of the emergy-based indicators In China.

Invited Talk: Valorization of Food Waste into Platform Chemicals.
Daniel C.W. Tsang
Civil and Environmental Engineering, Hong Kong Polytechnic Univ., Hong Kong

Food waste that amounts to over one billion tonnes per year globally is a potential renewable feedstock for biorefineries. Our research focuses on the development of high-throughput catalytic systems to produce value-added platform chemicals, such as hydroxymethylfurfural (HMF) and levulinic acid, from various selected food waste that is rich in starch, cellulose, or sugars. Homogeneous (e.g., SnCl4 and AlCl3) and heterogeneous catalysts (e.g., zeolites) were evaluated, which carry different Brønsted acidity and Lewis acidity for controlling HMF yield and selectivity. These acidities maneuver the kinetics of desirable tandem reactions (hydrolysis of glycosidic bonds, isomerization of glucose, and dehydration of fructose) and side reactions (polymerization and rehydration). In particular, our recent studies highlight biochars functionalized via N-doping, metal impregnation, sulfonation, and acid activation as novel solid catalysts in different important reactions, for achieving sustainable and circular biorefineries. Solvents are also evidenced to play an important role beyond serving as a reaction medium, e.g., the production

of HMF in the presence of acetone is substantially faster than that in dimethyl sulfoxide/H2O and tetrahydrofuran/H2O. Replacing the industrial co-solvent by greener alternatives, i.e., propylene carbonate and γ-valerolactone, can further accelerate the conversion of food waste. The solvent medium interacts with the substrates and catalysts, altering their reactivity during catalysis. In addition to platform chemicals, hydrochar as a potential solid fuel can be co-generated via a demonstrated microwave-assisted hydrothermal treatment of red seaweed. These research efforts elucidate the roles of different parameters in conversion systems and demonstrate a good potential of food waste valorization for the synthesis of bio-based products in real-life applications.

Invited Talk: Continuous Thermal Conversion of Waste Lignin and Application of Lignin Derived Biochar for the Production of Valuable Compounds.

***Young-Kwon Park**, Se Young Park, Jaehun Jeong, and Sumin Ryu*
School of Environmental Engineering, University of Seoul, Seoul, Korea, Republic of (South)

Recently, large amount of waste lignin has been produced from the bioalcohol (ethanol, butanol) synthesis process using lignocelluosic biomass as feed materials. Also, many researches have been performed for the conversion of waste lignin to valuable monomeric phenolics using fast pyrolysis process to increase the economic feasibility of bioalcohol production process. However, lignin is difficult to be converted effectively to liquid fuels because of its complex structure and thermal stability. Especially, melting of lignin and foaming and agglomeration of char during pyrolysis make a continuous lignin pyrolysis process difficult in a conventional fluidized reactor. Therefore, the fo*a*ming and agglomeration of lignin char needs to be minimized by developing a *new reactor*.
In this study, fast pyrolysis of lignin was carried out using a newly developed bench scale rotary kiln reactor. Initially alumina ball was filled in the reactor. Lignin was then fed into the rotary kiln reactor with a feeding rate of 100g/h. Various kinds of lignin such as kraft lignin, organosolv lignin, butanol production waste lignin, and black liquor lignin were tested. By using this new rotary kiln reactor, the agglomeration and foaming of char did not occurr. Also, highly valuable monomeric phenolics were obtained as the main products. Furthermore, lignin-derived biochar with Ni impregnation was applied to the gasification of biomass and was found to produce higher amount of hydrogen gas than commercial Ni/alumina catalyst.
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Invited Talk: TBA

Tsang Yiu Fai
Associate Professor, The Education University of Hong Kong, Hong Kong

TBA

Integration of Biomass into District Energy Systems with Methanol Production Based on a MINLP Optimization Methodology.

*Xiangyan Zhan, Xuyue Zheng, Xingyi Zhu, Jian Lin, and **Yingru Zhao***
College of Energy, Xiamen University, Xiamen, China

The international energy consumption has considerably increased due to the demographic and economic growth in recent decades. In this framework, polygeneration represents an innovative and promising concept. The purpose of this study is to provide a generic modelling and optimization

framework to evaluate the polygeneration systems in urban areas. An integrated biomass-based polygeneration scheme with CCHP (combined cooling, heating and power) system, providing electricity, heating and cooling as well as methanol product, is proposed and evaluated in this work. The potential of integrating the system into a district energy system is also investigated by case study. A mixed-integer nonlinear programming (MINLP) approach has been formulated in GAMS (General Algebraic Modeling System) to address the following issues: a) selection of technologies, types and numbers of equipment to match the energy demand of end users; b) strategic planning and process designing from both economic and environmental perspectives; c) representation of the relationships and trade-offs between the trigeneration and chemical conversion steps; d) operation strategies for the dynamic energy systems with time dependent components and boundary conditions. Moreover, the proposed system is compared to the conventional natural gas based CCHP system as the reference.

Utilization of Waste Materials to Enhance the Composite Behavior between Cementitious Mortar and 3D-Printed Polymer Reinforcements Designed to be Applied for Construction 3D-Printing of Cementitious Materials.

Alexander Lin[1]***, Hayden Taylor***[2]*, Harn Wei Kua*[3]*, Sze Dai Pang*[4]*, Jacky Chung*[5]*, and Chi-Hwa Wang*[6]
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Polymer reinforcement with novel geometry achieved by 3D-printing was proposed as a new reinforcement system for 3D-printed mortar components, which consist of cement, water and silica sands, for buildings and infrastructures. This polymer reinforcement effectively enhanced the ductility of mortar specimens which was casted layer by layer to simulate a mortar 3D-printing process. However, the polymer reinforcement system reduced the mechanical strength of the mortar specimens. Waste materials, biochar and fly ash, were added to mortar not only to reduce the carbon footprint but also to find potential solutions for improving the mechanical behavior of the mortar-polymer composite because these waste materials can potentially densify the mortar-polymer interface which is essential for composite behavior between mortar and polymer. Experimental results showed that using biochar, a waste material made by sawdust, in mortar specimens can reduce the mechanical strength reduction induced by polymer reinforcement compared to the strength reduction observed in the mortar without waste material.

Using Aquatic Plants and Plant Material for a Sustainable Water Purification Creating Low Impact Development Systems.

Stephan Pflugmacher Lima
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Phytoremediation and the use of living plants to clean up soil, air or water from hazardous contaminants is well known as a cost-effective approach to take advantage of the abilities of plants to take up compounds and metabolize them in their tissues. However, the practical use of plants and associated microorganisms can lead to an external metabolization of compounds giving possibilities in generating even more toxic metabolites. Recently we demonstrated the successful use of systems only containing rootless aquatic plants for the remediation of cyanobacterial toxins, as well as veterinary pharmaceuticals such as oxytetracycline and methyltestosterone. These Low Impact Development Systems, we called “Green Liver Systems” in analogy that plant have the same or very similar biotransformation systems like our own human liver. Our research showed that using the natural

functions aquatic macrophytes can provide in taking up and metabolizing various contaminants from water is beneficila to the environment. The Green Liver Concept showed that the metabolites are than stored within the plant in vacuols, apoblasts and also included in cell walls. In order to make Green Liver System multi-functionable and suitable for the removal of microplastics as well, we developed additional filter systems using dead plant material such as coconut fibers, luffa pads, jute fibers, cotton pads derived from used t-shirts having a recycling idea in mind and biochar derived from Finnish spruce trees. Applying microplastics (spherical beads 2-10mm, cylindrical particles (1-5mm) and fleece fibers) on the different plant material showed a retention between 75 % - 96 % (spherical beads), 100 % zylindrical particles and 100 % fleece fibers. The overall performance of the newly developed LID System was tested using Diclofenac in combination with spherical microbeads (microplastics) showing that 85% of the Diclofenac could be removed from the water phase and 99% of the MP as well.

The Prediction and Optimization of Biochar Yield Based on the Feedstock Characteristics and Pyrolysis Parameters Using Machine Learning.

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Lignocellulosic biomass, as one of the most abundant and promising renewable raw materials producing biofuels, have attracted extensive attention for the dual pressures from increasing energy demand and environmental pollution caused by fossil fuel. The feedstock was derived from the living or waste plants such as woody and agricultural residue. Biochar was the solid by-product of biomass conversion, which has been applied in multidisciplinary due to the higher surface area, microporous structures, and containing functional groups. Generally, the functional groups on the biochar surface area decreased and the surface area increased along with the pyrolysis temperature. Biochar with different characteristics could be applied for different fields. For example, the higher surface area and microporous structure was the most important factor for CO2 capture, while the adsorption of biochar for heavy metals was significantly influenced by the functional groups and containing mineral. Accordingly, improving the biochar yield was one of the important research fields based on biomass properties. Machine learning method was used in the study to predict the biochar yield based on the structural and elementary components of biomass, the particle size of biomass and the pyrolysis parameters. The relative contribution of the influencing factors to biochar yield was also estimated. The results demonstrated the influence of pyrolysis temperature was overwhelming for biochar yield. The partial dependence plots were also performed to gain insights into the relationship between biochar yield and each feature or the synergy effect of any two features on the biochar yield, which could guide the selection of pyrolysis parameters based on different biomass properties.

Generation and Combustion Emissions of Trash to Tank Fuel Derived from Plastic Waste.

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Trash to Tank is a concept based on the conversion of waste plastic trash into a liquid fuel, suitable for use in diesel or kerosene fuel applications. This contribution focuses on both an experimental and theoretical analysis of generation and combustion emissions of waste plastic derived fuels, comparing them with petroleum derived diesel fuel. Results of theoretical calculations and experiments to measure the pyrolysis reaction energy, heating value, carbon dioxide emissions and the corresponding total

generation and production emissions will be presented. The waste plastic feedstock utilized in this study include, low density polyethylene, high density polyethylene, polypropylene and polystyrene. Thermal decomposition was conducted via slow pyrolysis at 450°C in a batch reactor for each of these materials. Potential benefits to the global environment from the use of Trash to Tank fuels as replacements for petroleum derived fuels will be further discussed.

Promoting Food Waste Recycling in the Commercial and Industrial Sector By Extending the Theory of Planned Behaviour: a Hong Kong Case Study.

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In recent years, the government and community have focused extensive attention on food waste recycling to achieve sustainable waste management. However, the motivation of stakeholders from the commercial and industrial sector to change recycling behaviour has not received enough attention. This study aimed to identify, prioritise, and quantify the relationships between key latent variables that affect the food waste recycling behaviour of relevant industries in Hong Kong (*i.e.* representatives from the hotel, food and beverages, and property management industries). This study integrated semi-structured interviews and a survey questionnaire on the basis of the Theory of Planned Behaviour, setting it apart from conventional studies on food waste behavioural factors. Qualitative content analysis and quantitative structural equation modelling were performed to analyse the interview and questionnaire responses, followed by correlation analysis to quantify the relationships between variables. The results demonstrate that food waste recycling behaviour is determined by three latent variables—administrative incentives and corporate support, logistics and management incentives, and economic incentives. Administrative incentives and corporate support demonstrate significant effects on recycling behaviour. Moral attitudes show a strong positive correlation with administrative incentives and corporate support. Similarly, there is a significant positive correlation between moral attitudes and logistics and management incentives. Administrative incentives and corporate support is the determining variable for the hotel and food and beverages industries, whereas logistics and management incentives are of the highest concern to property management representatives. These findings can facilitate the development of stakeholder-oriented policy to encourage corporate behavioural change towards food waste recycling for sustainable resource circulation.

Section D – Oral Presentations

An Anaerobic Digestion Waste-to-Energy System for Food Waste Treatment and Fertilizer Production.

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Optimizing mixing time to reduce energy consumption would create a more energy efficient anaerobic digestion (AD) process with higher biogas yield. This study investigates the effect of different mixing strategies on anaerobic digestion of food waste to make the AD waste-to-energy process more energy efficient. Results showed that intermittent mixing is an alternative strategy to continuous mixing or unmixing for high efficient biogas production and energy saving. Through computational fluid dynamics modeling of fluid flow in anaerobic digesters, the mixing time was optimized to 2 mins/hr, at which point the reaction mixture is almost entirely homogeneous. At an organic loading rate of 2.4 g VS_{FW}/L/day, the semi-continuously mixed reactor maintains a higher specific methane yield of 437 ml

CH_4/g VS_{FW} in comparison with the other controls. The energy balance investigated the electricity generated and the net heat output generated, in addition to self-sustaining and meeting the energy requirements of the various AD processes investigated. Based on the analysis, it was found the semi-continuous mixing is more energy efficient and sustainable to generate sufficient biogas output for the energy system to provide a net positive heat and electricity output. The original digestate from this 1000L anaerobic digester, heat treated digestate and chemical fertilizer are used for cultivation of vegetables. The results showed that the interaction between heat treatment and digestate concentration is significant, so the trend-lines for the different types of digestate are different. The treatment with the highest yield was also compared with the control treatment (chemical fertilizer, 15N:15P:15K, 1.2 g per application) using t-test. The yield of the best performing digestate is not significantly different from the control. It means that the performance of digestate is almost same to the use of chemical fertilizer.

Preparation of Nanocarbon from Bioenergy Waste Derived Biochar through Mechanized Grinding for the Removal of Pharmaceuticals from Aqueous Media.

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Biochar has received recent attention as an excellent adsorbent in the removal of emerging contaminants from water. Similarly, high surface area of the nanoparticles increase the adsorption capacity of the material. Therefore the objective of this study is to prepare nanocarbon from bioenergy waste derived biochar through mechanized grinding. Dendro biochar, which is a solid waste from the dendro-power industry was used to prepare nanocarbon for the removal of antibiotic Oxytetracycline (OTC) from aqueous media. Biochar was mixed with ethanol and ball milled for 6 hrs around 5000 rpm with 30 minutes intervals for every 1.5 hrs. Resulted nanocarbon was characterized by using powder x-ray diffraction (PXRD), Fourier transform infrared spectroscopy (FTIR) and Nanoscale Particle Size Analyzer. Adsorption edge experiment was carried out from pH 4 to 9 at a dosage of 1 g/L nanocarbon and antibiotic oxytetracycline was analyzed by using UV/Vis spectrophotometer at the wavelength of 354 nm. The particle size of nanocarbon was in the range of 15 to 414 nm. Adsorption of 17 mg/L of oxytetracycline in 24 hrs was observed at pH 4 from a solution with 25 mg/L of concentration. The PXRD pattern for biochar confirmed the amorphous nature of biochar and a poorly crystalline solid, which further revealed a noticeable reflection at 2q = 24° that shows the presence of SiO_2 in the material. Transmittance spectra for the pristine biochar evidenced the functional groups present in the material. Intense peaks at the fingerprint area is accountable due to the presence of aromatics (1650 cm^{-1}) and the presence of C-H bending at 1000 cm^{-1} which confirmed further the aromaticity in the biochar. Hence the results indicate that the nanocarbon produced by dendro biochar is being promising for the removal of OTC from aqueous media.

Comparison of Different Start-up Strategies for Thermophilic Anaerobic Digestion: Process Stability and Microbial Community Structure Shifts.

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The aim of this study was to compare between step-wise and one-step increase in temperature from mesophilic (35°C) to thermophilic (55°C) for better start-up of thermophilic anaerobic digestion (AD) from a mesophilic digester. The stability of the reactors as well as shifts in microbial community structures were investigated. Stable thermophilic AD (biogas yield of more than 500mL/L/d) was achieved within 10 days from a mesophilic digester treating food waste by adopting the one-step start-up strategy. On the other hand, biogas yield of thermophilic AD with the step-wise start-up strategy dropped to less than 200mL/L/d after the temperature was raised beyond 50°C. After the increase of temperature, thermophilic methanogenic community was established, which was characterised by the colonisation of *Thermotogae*, *Methanosarcina*, *Methanomassiliicoccaceae* and *Methanoculleus*. Results from this study demonstrated that the one-step start-up strategy could allow the rapid establishment of the thermophilic anaerobic microbial community.

Technical and Economic Aspects of Hot Syngas Purification for Power Generation from Gasification of Municipal Solid Waste.

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Gasification is an advanced thermochemical process, which can convert municipal solid waste (MSW) into gaseous fuel (syngas) for utilization in solid oxide fuel cells (SOFCs), gas engines, combined cycle gas turbines (CCGTs) and/or hybrid systems with potentially higher electrical efficiency and lower emission of pollutants. However, this requires the development of cost-efficient syngas purification technologies that are able to remove particulates, tar, HCl, alkali chlorides and sulphur species at high temperatures. The objective of this study was to investigate the technical feasibility and cost benefit analysis of hot syngas treatment using a multi-stage purification process. To achieve these goals, a syngas purification system (5 L/min syngas treatment capacity) was integrated with a lab-scale downdraft gasifier operating on refuse-derived fuel (RDF). RDF pellets were gasified at 850 °C with equivalence air ratio of 0.3 and 25% moisture content to produce syngas with consistent properties. The technical feasibility of the purification process of the raw syngas was evaluated with the focus on the performance of fluidized bed tar reforming (850 °C) and syngas desulfurization (400 °C). Cost effectiveness and energy efficiency of the developed system were analysed using simulated models (ASPEN Plus®). Hot syngas purification is demonstrated to be technically feasible based on the experimental results and economically feasible based on the modeling results.

A Data-Driven Two-Stage Resource Allocation Model for Sewage Networks Against Failures.

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Sewage is a type of waste that is produced by domestic households, industrial and agricultural practices. The management of sewage networks is an important environmental issue, because the failure of network components results in sewage overflow to the ground surface, and thus creates offensive odors or even causes health hazards. In order to prevent such component failures, we address the optimal allocation of the limited resources by developing a data-driven two-stage non-linear programming model. In the first stage, the objective is to minimize the total allocated resources and the expected recovery costs of the network and environment, considering the random behaviors of component failures. In the second stage, the amount of leaked sewage caused by component failures is analyzed

based on the hydraulic simulation model. The collected data is the historical failure data and detected network state for a fixed inspection interval. Driven by the data, the failure rate of network components is updated by the maximum likelihood estimation. Besides, genetic algorithm is proposed to analyze the two-stage model. In order to demonstrate the practical applicability of the proposed model, the case of a sewage network is conducted and some suggestions on the optimal resource allocations are finally provided. Furthermore, we discuss the impacts on the total costs caused by the data-driven updating of failure rate.

Clay-Biochar Nanocomposite As a Media for the Removal of Oxytetracycline Antibiotic from Water.

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Oxytetracycline (OTC) is considered as one of the frequently used antibiotic in human and in the veterinary industries, release into environment and recorded in the wastewaters. Biochar has been received recent attention as a material for removing pharmaceuticals in aqueous media however, still the capacity needs to be increased further. This study investigates OTC sorption from water using nanocomposite derived from municipal solid waste biochar (MSW-BC) and montmorillonite. The adsorbents were characterized using powder X-Ray Diffraction (PXRD), Fourier-Transform Infrared (FTIR) spectroscopy, and Scanning Electron Microscope (SEM) before and after adsorbent treatment with OTC. Batch experiments were conducted to study the mechanisms involved in the adsorption with changing pH and time for 10 mg/L initial concentration of OTC at a pH range of 3.5-10 until 10 hrs. The SEM confirmed the successful binding of montmorillonite (MMT) onto the MSW-BC through a flaky structure along the porous morphology. Encapsulation of MMT onto MSW-BC was exhibited through changes in basal spacing of MMT via PXRD analysis. Results from FTIR spectra indicated the presence of functional groups for both pristine materials and composites that are involved in the adsorption. There was no considerable effect from the acidic pH while the basic pHs reduced OTC adsorption. Adsorption capacity ranged in 4-4.5 mg/g. Adsorption reached equilibrium at 8 hrs. The results indicated that the clay-biochar nano composite can be used for the removal of OTC in aqueous media.

Green Preparation of Fluorescent Carbon Dots from Durian Shell Waste for Highly Sensitive Detection of Fe3+ Ions.

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Carbon dots (CDs) are a novel class of nanomaterials that provide unique optical and electronic properties including tunable photoluminescence, low photobleaching, easy functionalization, aqueous solubility and low toxicity. Production of CDs from cellulose biomass precursors has gained attention over the years due to positive economic and environmental impact. However, the photoluminescence yield of cellulose-based CDs is low in the absence of modification additives. In this study, CDs were produced from Durian shell waste (DSW) in a one-pot process without any modification agents with a mass yield of 13.9% and quantum yield of 6.2%. This was two times higher compared to that of CDs derived from pure cellulose. 90% of the DSW comprised cellulose, hemicellulose and lignin while the remainder consisted of extractives such as carboxylic acids, phenolic compounds, amino acids,

aldehydes and esters. These extractives enhanced the oxygenated functional groups in DSW improving the photoluminescence of CDs. The maximum emission was at 436 nm at an excitation wavelength of 360nm and was stable over a wide range of pH and chloride concentration and was resistant to photobleaching. The particles were well dispersed and quasi-spherical with an average particle diameter of 3.2 nm. X-ray photoelectron spectroscopy (XPS) and Fourier transform infrared (FTIR) spectroscopy confirmed the presence of oxygen and nitrogen functional groups on the surface.
The CDs showed high selectivity towards Fe^{3+} and a linear relationship was developed over a concentration range of 0-20 µM with a detection limit of 128 nM (S/N=3). Three actual water samples (lake water, sea water, tap water) were used to validate the model and the relative recoveries of 98.9 - 108.6% and an RSD of <4.11%.

Making Use of Wasted Coconut Water through Freeze Concentration.
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In its natural form, coconut water spoils easily and causes pollution in rivers and streams where it is being thrown away. Through freeze concentration, the volume is decreased and the coconut water is stabilized making it viable for uses not only as a health drink but also as a short-term intravenous hydration fluid, as a cure for renal disorders, as a laxative and other uses. In this study, coconut water was partially frozen and the ice crystals were separated to produce concentrated coconut water. The objectives of this study are to determine the feasibility of freeze concentration of coconut water and to improve the design of the freeze concentrator. Results showed that large ice crystals produced through slow freezing adsorbed less solute and gave a higher concentration of the coconut water concentrate. Coconut water at lower concentration generally freezes faster and therefore requires a shorter freezing time than those at higher concentrations. Only a difference of 10 Brix or larger gave an appreciable change in the freezing time. The increase in concentration of coconut water through freezing was about 1 Brix for every 200 g of ice crystals removed in a 1 liter sample of partly-frozen coconut water. The desired increase in concentration is largely dependent on the amount of ice crystals removed. Empirical equations were obtained to show the effect of weight of ice crystals on concentration of the coconut water concentrate and of the ice crystals. Freeze concentration is an effective method of concentrating coconut water and produces a useful material. Based on the results of the study, a design of the freeze concentration process and the corresponding equipment was proposed. An improved design has been made after the previous study on the scale up of the initially designed freeze concentrator.

Pinch Analysis and Emission Intensity for Waste Management Planning: EU 28.
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Waste recovery and disposal are one of the biggest management challenges. An adequate waste management design is critical in contributing to the development of a sustainable circular economy. There is a need for a systematic and preferably graphical approach to assessing the emission associated with waste treatment processes followed by strategies for mitigation. This study aims to propose a graphical approach in identifying the appropriate waste management system with lower emissions. The proposed graph-based approach, termed as Extended-Waste Management Pinch Analysis (E-WAMPA) is analogous to the existing WAMPA. It differs from WAMPA by three major points a) Emission intensity of waste management system (Net GHG per capita) is introduced to replace the original y-axis, b) the emission of recycling is not assumed as zero c) The demonstration is based on the defined targets, projection and power grid mix of EU. A generic methodology of E-WAMPA is first presented followed by

EU-28 case study to elucidate the application. The considered waste type is municipal solid waste (MSW) and the assessed emission is GHG. E-WAMPA capable to suggest the strategies to fulfill the targeted waste management system intensity of a region (e.g. zero) while meeting the individual treatment targets (e.g. 10 % reduction of landfill target and 65 % recycling rate). One of the possible strategies is by adjusting the waste management system of Malta by having 50 kt of MSW for recycling, 55 kt to incineration, 219 kt to the landfill instead of 21 kt for recycling and 283 kt to landfill. The strength, limitation and way forward of E-WAMPA has also been discussed.

The Application of Machine Learning for Modeling the Adsorption of Heavy Metals on Biochars with Different Origins.

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Biochar, as the solid by-product of biomass, had been applied in multidisciplinary area such as wastewater treatment due to its microporous structure and abundant surface functional groups. The treatment efficiency of biochar for wastewater was significantly influenced by biochar characteristics and the environmental conditions. However, the diversity of biomass feedstock and uncertainty of produced biochar made the relationship complicated. Machine learning may be preferred to resolve the problem through teaching machine to find, recognize and extract relationships or rules based on statistical data. The adsorption of six heavy metals (lead, cadmium, nickel, arsenic, copper and zinc) on the fifty kinds of biochars were modeled using artificial neural network and random forest in the study, respectively, based on collected 433 datasets of adsorption experiments from the literatures. The regression models were trained and optimized to predict the adsorption efficiency according to biochar characteristics, metal sources, environmental conditions (e.g. temperature and pH in water and wastewater), and the initial concentration ratio of metals to biochars. The RF model showed better accuracy and predictive performance for adsorption efficiency with lower root mean squared error (0.038) and higher regression coefficient (R^2=0.986) than ANN. The initial concentration ratio of metals to biochars was demonstrated as the most significant factor for adsorption efficiency, while the biochar properties was secondary. The CEC and pH_{H2O} of biochars accounted for over half of the contribution of biochar characteristics and the surface area was only accounted for 2.4% of adsorption. The accurate predicted ability of developed model could decrease experiment workload such as predicting the adsorption efficiency according to the biochar characteristics, environmental conditions, and the target metals. Moreover, the relative importance of each variable could provide a right direction for better removing heavy metals in the real water and wastewater.

Residential Waste Dumping Behaviors for Waste Sorting and Relevant Managerial Insights.

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Waste sorting at sources of individual residential areas is a popular strategy worldwide for improving the sustainability of megacities. However, few effects can be produced if the strategy is implemented by relying solely on propaganda and civic awareness. Along with the strategy, mandatory regulations of 'fixed waste dumping sites and fixed dumping time windows' and encouraging bonuses for 'accumulating points in green accounts' have been implemented at pilot residential communities in Shanghai in 2018. Impressive effects regarding waste sorting and recycling have been achieved in these

communities under such measures. In early stages after policy regulations, the general waste dumping behaviors of whole residents are nearly unknown, which poses great challenges for decision-makers to determine appropriate waste dumping time windows and schedule manpower and material resources for daily waste collection operations. Traditional simulation approaches have difficulties for the problem due to the population scale and the complexity of individual behavior. To cope with the problem, we design an analytical framework for residential waste dumping behaviors based on the internet of things and data-mining technologies. In the data-mining component of the framework, waste dumping behaviors are visually illustrated by the probability distributions of dumping time, dumping time interval, dumping amounts and dumping frequency, the time-serial trends of dumping amounts, and the weekly patterns and holiday patterns of dumping amounts. A real case of a pilot residential community in Minhang district of Shanghai is employed to demonstrate the effectiveness of the proposed analytical framework. Based on the study of residential waste dumping behaviors, relevant managerial insights can be effectively offered for decision-makers and practitioners.

Microplastics Bound Transport of Antibiotics in Aquatic Environment.

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Microplastics (MP) are considered as potential transport vectors for organic contaminants and heavy metals in the aquatic environment. The emerging contaminants such as pharmaceuticals may sorb onto MP and may influence by different environmental factors and physicochemical properties of MP. The study investigates the sorption behavior of Ciprofloxacin (CPX) antibiotic on polyethylene microplastics (PEMP) through batch sorption experiments. The effects of ionic strength and dissolved organic matter (DOM) were examined by introducing $NaNO_3$ and Humic acid (HA) in to the medium. Pure PEMP was characterized by FTIR to analyze the physicochemical properties of the adsorbent. Batch sorption experiment results showed that the sorption of CPX with pH had a gradual increase reaching a maximum sorption at pH 6-7 and then decreased which is likely due to the speciation of CPX at different pH. In the presence of 0.001 M and 0.1 M $NaNO_3$ ionic strength, the overall CPX sorption capacity of PEMP decreased as the ionic strength increased. Sorption capacity of CPX by PEMP decreased significantly in the range of 0.5 to 2.5 mg L^{-1} of HA highlighting the influence of DOM in the aquatic environment towards the CPX sorption and mobilization by PEMP. Results of the FTIR spectrum attributing to $-CH_2$ and $-CH_3$ functional groups exhibit non-polar hydrophorbic properties of PEMP indicating that hydrophobic interactions between CPX and PEMP have been prominent around neutral pH. Hence, PEMP could be potential vectors to transport CPX in natural aquatic environment where the sorption mechanism is being influenced primarily by the characteristics of the water system and the properties of the adsorbate.

Three-Stage Anaerobic Co-Digestion of Food Waste and Waste Activated Sludge: Identifying Bacterial and Methanogenic Archaeal Communities and Their Correlations with Performance Parameters.

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Food waste (FW) and waste activated sludge (WAS) are critical global issues currently. To combine the benefits of high-solids anaerobic digestion (AD) and wet AD of FW and WAS to improve digester performance and methane production, a three-stage anaerobic digester was developed in this study. Three-stage anaerobic co-digestion of FW and WAS was conducted while corresponding bacterial and methanogen communities were characterized. Results showed that the average methane yield in the three-stage digester was 13-52% higher than that of one- and two-stage digester. An increase of 12-47% in volatile solids reduction was achieved in the three-stage digester, compared to the controls. Bacterial phyla *Proteobacteria, Firmicutes and Bacteroidetes* dominated in one-, two- and three-stage digester while genera *Pseudomonas*, *Tissierella*, and *Petrimonas* were selectively enriched in the three-stage digester due to functional segregation. Taxonomic analysis identified 8 dominant methanogen genera, of which *Methanosarcina*, *Methanosaeta*, *Methanobacterium* and *Methanolinea* collectively accounted for 80%. With increasing organic loading rate and digester stage number, the dominant methanogenic pathway shifted from hydrogenotrophic pattern to acetoclastic pattern and reached a final synergy of these two. *Methanosarcina* was enriched by 1.5-1.7 times in the three-stage digester, contributed to the enhanced methane production. The three-stage digester is promising to be applied to the industrial biogas plants after scale-up and further optimization.

Behavior of Recycled Aggregate Reinforced Concrete Columns Under Uniaxial Loading.

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The root cause of waste generation is due to rapid expansion in the construction industry, which includes the construction of new buildings and demolition of existing structures. It has drawn the attention towards the limited natural materials for construction specifically aggregates which need to be used wisely to diminish detrimental environmental condition. To counter this problem recycling and reusing of coarse aggregate from waste concrete has been identified as one of the solution. This study focuses on the behavior of reinforced concrete columns made up of recycled aggregate, under uniaxial loading. It determines numerous aspects which may affect the behavior of recycled aggregate concrete; it includes percentage replacement of recycled aggregates (30%, 50%, 70% and 100%) and 28 days curing at a constant w/c of 0.43. Initially, mechanical properties of concrete made up of recycled coarse aggregates were determined along with comparing them with properties of natural coarse aggregates concrete. A slight decrease is observed in all the obtained results. The result shows that with the increase in the percentage of RCA, the load carrying capacity of column also decreases. A pure compression failure was observed in RAC columns. This study provides a basis of using RCA in structural concrete by studying the structural behavior of RC columns and recommends further investigations on the failure mechanism of RC compression and flexural members along with studying its durability characteristics to promote the design of green and sustainable structures leading to environmental sustainability.

Section E – Oral Presentations

Biomass Based Hydrogen Production through Thermochemical Processes: A Review and Future Prospects.

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In the future, hydrogen is recognized as one of the cleanest energy carriers and its production from renewable biomass will be the main source of hydrogen energy. Thermochemical and biological technologies are the two routes for hydrogen production from biomass. Thermochemical hydrogen production is more promising in the near future because of its higher potential in industrialization. Combustion, gasification, and pyrolysis are the three main methods in thermochemical hydrogen production from biomass. Biomass gasification and the reforming of pyrolysis bio-oil for hydrogen production are currently the most studied approaches which have the potential to achieve large-scale production, but the selectivity and rate of hydrogen production are not satisfactory. Recently, the research on supercritical water gasification and bio-oil gasification has also attracted attentions. Nevertheless, the most promising emerging technology is the combined strategy of pyrolysis and in-line catalytic steam reforming, which has been gaining superb attention because of its advantages compared to gasification and bio-oil reforming. The combined strategy is more suitable for large-scale centralized hydrogen production with high conversion and hydrogen yield. This article reviews the above technologies of hydrogen production from biomass, discussing the reactors, operating conditions, and catalysts used in different processes. Various hydrogen production schemes are compared with each other, in which the advantages of step-wise strategy are emphatically introduced.

Life-Cycle Assessment and Optimization Framework for Sustainable Urban Farming Systems.
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With the growing population and continuous urbanization, sustainable and secure food production is increasingly important in future urban development. Various advanced farming systems have been developed. The economic performance and environmental impact are important decision criteria for the deployment of such systems. In order to assess and improve the sustainability of urban farming systems, a holistic decision-support framework combining life cycle assessment and optimization is proposed in this work.
After defining the goal and scope of the life cycle assessment and optimization, the life cycle inventory that contains the data of energy and material flows around the system boundary in different phases of the system life cycle is tabulated as the data input for the assessment and optimization of the farming system. The economic performance and environmental impact are evaluated and modeled using the life cycle assessment approach and serve as two objective functions in the optimization of the farming system. Moreover, constraints in the optimization are required to be formulated based on the local market conditions (e.g. demand and price of products, the price of equipment and utilities, and land availability). Decision variables in the optimization including the design of the farming facility, types and amount of crops to be planted and the operating conditions of the farming system can be determined to maximize the economic benefit and minimize the negative environmental impact.
A case study on the design and assessment of a novel modularized urban leafy-vegetable farming system in Singapore utilizing fertilizer derived from beer residue is carried out as a demonstration of the proposed framework. The result of the case study shows the optimized modular vertical farm is promising to be adopted in the urban area for multiple benefits including green and economical urban vegetable supply, waste valorization, and efficient land utilization.

Market Potential of Biomethane in South Korea.
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This study estimated domestically available energy amount of biomethane including landfill gas (LFG) as a transportation fuel by 2035. The amount of available energy that could be supplied was predicted through four stages of 'theoretical-', 'geographical-', 'technical-' and 'market potential' by considering geographical, technical, economic conditions, etc. Energy efficiency and added value of biomethane are largely influenced by the site conditions and the neighboring infrastructures. So, how much of the natural gas used in transportation could be substituted with biomethane was examined by setting limits to the amount of organic wastes generated within urban areas. As a result, the market potential of biomethane including landfill gas was approximately 331 x 10^6 Nm^3/yr, corresponding to 25% of the natural gas supply for transportation, which could be replaced by biomethane. Assuming that 2% of natural gas for transportation is replaced by biomethane, it corresponds to 29 x 10^6 Nm^3/yr (approximately 9% of market potential of biomethane). However, RFS annual mixing rate may be increased upon introduction and the growth rate of the natural gas supply for transport would be higher than that of market potential of biomethane calculated in this study. Therefore, it is vital to ensure a stable supply of biomethane, to improve efficiency in technical development and management, and to lay out specific quality requirements for promoting the use of biomethane as a transportation fuel for efficient implementation of RFS policy.

Preparation of a Novel Composite Using Chitosan, Laterite and Iron Oxide Nanoparticles and Its Efficacy in Removing Methylene Blue Dye and Arsenic from Water.

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Bio-materials are abundant and are finding new avenues of applications. In this research, chitosan, iron oxide nano-particles and laterite clay composite was prepared using sodium-polyphosphate as the cross linker. The reasons of using chitosan are that it is easily available in our country, often used as adsorbents and is biodegradable. Iron oxide nano particles were used to recover the composite. Furthermore, they are often used for the adsorption of arsenic. Laterites are common in Bangladesh and is cheap. Hence, the composite compositions were chosen with a view to preparing them in large scale cost effectively. Composites with different compositions of the three ingredients were prepared and their pore volume and methylene blue (MB) adsorption capacity was compared and the study shows that 1:1:1 composition provides the best suitable adsorption. Removal of MB using this composite shows that with the increase of pH the removal increases and showed maximum adsorption capacity (Q) of 13 mg/g and for arsenic the pH dependency follows the opposite trend of MB and Q value is 0.291 mg/g. Both cases shows that the adsorption is following Langmuir Isotherm model and chemi-sorption is the rate determining step. Studying the nature of the composite tells us that it can be a good anti-microbial agent as well. Finally this non-toxic composite harbors potential in the fields of application of different branches of environmental and pharmaceutical science.

Batch and Fixed Bed Column Based Optimization of Municipal Solid Waste Biochar Application for Volatile Organic Compound Removal Form Landfill Leachate.

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Municipal solid waste biochar (MSW-BC) for the removal of volatile organic compounds (VOCs) from aqueous media was investigated in this study. Batch result supported fixed bed column study was conducted for optimization of site specific permeable reactive barrier. The characteristics of MSW-BC were evaluated under different categories, surface properties, proximates, and elemental. Batch studies for BTEX conducted in different ranger of sorbent dosages (1-10 g/L), pH conditions (3, 5, 7, 9), time intervals (0.5- 24 h) and final sorbate concentrations (10- 600 µg/L). The batch based column experiments conducted for VOCs like toluene and m-xylene. Different quantity from MSW-BC (1, 0.25 %) was utilized into the column and different inlet concentration of Toluene (1000, 4000 µg/L) Xylene (4000 µg/L) was tested for optimization. According to the MSW-BC characteristics, organic sorption favor due to high carbonized structure of sorbent increasing hydrophobicity depicted by proximate analysis of lower polarity index [(O+N)/C] (0.26). Elemental characteristics of lower bioavailable metal environment ideal for field application of MSW-BC. Maximum adsorption of the Isotherm study reveals higher capacity for all VOCs (400 – 700 µg/g). The model fittings of all isotherms well suited with Langmuir and further Fruendlich fitting describe both chemical and physical adsorption. In fixed bed column system, relatively low r^2 values (r^2 = 0.8833, 0.8808) indicated the less applicability of Adams-Bohart model. Hence, both sorbates obey the Thomas model and could explain the Langmuir kinetics adsorption by MSW-BC in a fixed bed system. Hence, it can be concluded that MSW-BC is efficient in the removal of VOCs in batch as well as fixed bed sorption systems simultaneously minimizing the waste acumination in the environment.

Environmental Impacts from Energy Use in Solar Photovoltaics Manufacturing.
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Solar energy have been considered as a clean, renewable and non-pollutive source of energy. However, the environmental impacts of solar energy are usually not considered and not well understood. Crystalline solar photovoltaic (PV) panels are the most popular form of solar energy in use currently. A cradle to gate life cycle assessment (LCA) was done for mono and polycrystalline solar photovoltaic (PV) panels. The raw materials, electricity and other inputs were considered in nine impact categories, up to the manufacturing stage. Results showed that energy input had the greatest environmental impacts among all inputs. Of all possible sources of energy input, coal use had the highest environmental impact. Increasing the proportion of renewable energy use in the manufacturing of PVs reduced the impacts across all categories. This implies that as more PVs are manufactured for use in the coming years, more carbon emissions will be expected, generating a carbon debt, unless a corresponding increase in renewable energy is use in manufacturing. This is also true for other environmental impacts, such as acidification, aquatic, terrestrial and human toxicities. However, certain processes in PV manufacturing, such as silicon ore refining has no known renewable energy substitute. The limits on the use of renewable energy in solar PVs manufacturing would limit the environmental benefits of using PVs and negatively affect decarbonization efforts.

King Coconut Husk Derived Biochar through Hydrothermal Activation Process for the Removal of Cadmium (II) and Copper (II) from Aqueous Media.
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This research was conducted to study the removal of the most prevalent heavy metal ions cadmium (II) and copper (II) by adsorption on King coconut (Red Dwarf coconut, *cocos nucifera.* var) husk biochar.

Raw king coconut biochar (RKH) and steam activated King coconut biochar (AKHC) were prepared and analysed for physical properties, surface properties, elemental composition and functional properties to identify the sorbent suitability. The efficiency of adsorption of heavy metal ions [cadmium (II) and copper (II)] on biochar were studied with batch sorption experiments. Adsorption capacities of RKH and AKHC for cadmium (II) and copper (II) at different pH, initial metal concentrations, ionic strengths and contact times between adsorbent and adsorbate were measured. Scanning electron microscopy reveals the existence of a better and highly porous structure in AKHC than that of RKH, that could be a result of the volatilization by steam process. EDX analysis indicates a carbonized structure for both adsorbents. Further, it was observed that the adsorption of Cd and Cu ions by AKHC could be increased with increasing pH and decreased with ionic strength. Supported point of zero charge pH_{pzc} (5.8, 6.9) can be used to explain the effect of pH on the higher adsorption process at higher pH. The maximum adsorption capacities of Cd and Cu of AKHC were 22.24, 34.24 mg g^{-1}, respectively, and they were considerably lower for RKH with 17.22, 21.25 mg g^{-1}. With well-fitting of Freundlich isotherm, it revealed the heterogeneous properties of the surfaces and favourable adsorption process. The kinetics fittings of pseudo second order were accommodated towards chemisorption process for both Cu and Cd. The higher sorption ability expressed by AKHC and RKH, prepared in this study, show their potential sorbent activity for environmental remediation application.

Poster Presentations

#552152: Robust Trading Strategies for a Waste-to-Energy Combined Heat and Power Plant in a Day-Ahead Electricity Market.

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Waste-to-energy (WtE) technology has been used all over the world as it can solve the dilemma of waste management, energy demand, and global warming. Many modern WtE plants are built and operated in a combined heat and power (CHP) mode due to the high overall energy efficiency. This paper studies robust trading strategies for a WtE CHP plant which sells electricity in a day-ahead electricity market and exports heat to a district heating network. Owing to the requirements of the day-ahead electricity market, plant operators must determine the trading strategy one day before real delivery of electricity. However, many key problem parameters including electricity prices, heat demand, and the amount of waste delivered to the plant are uncertain at the day-ahead stage. To derive robust electricity trading strategies for the WtE CHP plant under different types of uncertainty, a two-stage robust optimization model is developed and a solution procedure based on the column-and-constraint generation method is designed. A case study is also performed to illustrate the effectiveness of the robust model and the solution procedure.

#552156: Case Study - Demonstration Plant of Water Recycling of Treated Industrial Wastewater Using Microfiltration/Reverse Osmosis and Activated Carbon Filter for Process Use in a Petrochemical Plant, Singapore.

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Membrane processes employing pre-treatment with micro-filtration (MF) with reverse osmosis (RO) have been proven to be reliable and economical in Industrial Water Recycling facilities. This has resulted in the conversion of existing Conventional Activated Sludge (CAS) process for treated industrial wastewater recovery for process use.

The aim of this paper is to demonstrate a phased approach of carrying out technological and economic assessment of an alternative approach of applying membrane technology, for water recycling of treated industrial waste water for process use. It has been installed at downstream of the existing CAS at a wastewater treatment plant in the Singapore Petrochemical Complex.
Due to the variability of industrial effluents, this demonstration plant was developed following a rigorous Phase 1 – Pilot Plant with different configuration of pre-treatment membrane (MF/UF) and material selection with RO. Actual treated wastewater effluent was used for the wide range of investigation, particularly on the susceptibility of membranes fouling and formulation of cleaning solutions for membrane flux recovery. The Phase 2 demonstration plant was then designed and constructed, followed by trial runs with enhanced cleaning regimes for fouling control, to validate critical parameters such as allowable flux for a pressurized pre-treatment membrane units and RO permeate quality. The permeate is then passed through an activated carbon filter, to remove any residual organics and free chlorine as the feed water to ion-exchange pure water process unit to produce boiler feed water (BFW) to generate high pressure steam.

#552222: Mesophilic Versus Thermophilic Anaerobic Digestion of Soybean Curd Residue for Methane Production: Characterizing Bacterial and Methanogen Communities and Their Relationship with Organic Loading Rates.

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How to economically and effectively treat huge amount of soybean curd residue (SCR) is a current major challenge to the soybean products processing plants throughout the world due to the fact that the uncontrolled disposal of SCR is liable to cause adverse environmental impacts and threaten the public health. To find the optimal operation parameters for anaerobic digestion of SCR, mesophilic (35^0C) versus thermophilic (55^0C) anaerobic digestion (AD) of SCR for methane production were contrastively investigated for 95 days with an increasing organic loading rate (OLR) from 0.55 to 4.96 gVS/L. Anaerobic digestion performance of SCR indicated that the maximum available OLR was 3.3 gVS/L for both mesophilic and thermophilic AD. Thermophilic AD provided a higher methane yield and volatile solids removal than that of mesophilic AD. The first dominant volatile fatty acid was identified as acetic acid. In addition, an in-depth understanding of the microbial compositions, diversity/similarity, and relations between digester performance, biodiversity and environmental parameters at the genome level was obtained by pyrosequencing technique and bioinformatics analysis, which would help to optimize microbial productivity and maximize the methane yield in the anaerobic digestion process of the SCR.

#552287: Preparation of Waste Coffee Ground-Based Microporous Carbons for CO_2 Capture.

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As the amount of CO_2 in the atmosphere increases, global warming deepens and climate change problems are occurring. Therefore, CO_2 capture and storage (CCS) technology is considered one of the ways to reduce the amount of emitted CO_2. In particular, more than 80% of the total cost of CCS technology is accounted by the capturing stage, therefore efficient CO_2 capturing technology is essential. Absorption, adsorption, and membrane separation are mainly used in post-combustion capture technology. Among them, the adsorption has advantages of low energy consumption and easy regeneration. However, its performance is lower than that of the conventional absorption technology. Thus, it is required to develop efficient adsorbents. Among various materials used as an adsorbent, activated carbon is advantageous in that it is easy to synthesize, cost competitive, and easily controlled

in pore size. In this study, waste coffee grounds were used as a carbon precursor and porous carbon materials were synthesized by using K_2CO_3 as an activating agent. Based on the discarded coffee grounds in daily life, high value-added microporous carbon was produced by the simple synthesis method. The changes of surface area and CO_2 adsorption performance were analyzed with the activation temperature and time and the correlations between the variables were investigated.

#553190: Efficient Mg-Doped Porous Carbon Derived from Petroleum Coke for Removing Heavy Metal Ions from Wastewater.

*Xiangzhou Yuan, **Min-Jeong Kim**, and Ki Bong Lee*
Department of Chemical & Biological Engineering, Korea University, Seoul, Korea, Republic of (South)

Water pollution caused by addition of heavy metal ions resulting from the industrial activities is increasing tremendously and becomes one of the top hottest environmental issues in the entire world. This research focuses on developing an effective adsorption process for treatment of heavy metals-contaminated wastewater. Mg-doped porous carbon was prepared by impregnating Mg onto KOH-activated petroleum coke at a mass ratio of 2, after conducting the KOH activation at 450 °C. The removal of Cd(II), Pb(II), Cu(II), and Ni(II) by the prepared Mg-doped porous carbon was studied depending on initial concentration, pH, contact time, adsorbent dosage and temperature dependent. The removal performance and the selectivity sequence of four mixed heavy metal ions in aqueous solution were also investigated for applying to real industrial wastewater. The adsorption parameters for removing different heavy metal ions were determined using both isotherm and kinetic models. A mechanism for treatment of four mixed heavy metal ions was also investigated. The Mg-doped porous carbon derived from petroleum coke is cost-effective and efficient, and therefore it can be an alternative, practical and promising material for the treatment of wastewater.

#553210: Development of MoS_2/Graphene on Carbon Cloth Electrode for Simultaneous Wastewater Treatment and Hydrogen Production Using Water Splitting.

***Ki-Joon Jeon**[1] and Young-Kwon Park[2]*
(1)Department of Environmental Engineering, Inha University, Incheon, Korea, Republic of (South), (2)School of Environmental Engineering, University of Seoul, Seoul, Korea, Republic of (South)

In recent year, there has been increasing interest in finding solution for the efficient removal of organic contaminants in wastewater and hydrogen production as an alternative energy. In this study, we developed an electrode which is capable of treating organic compounds in wastewater and generating hydrogen by water splitting at the same time. Carbon cloth (CC) is used as an electrode substrate to overcome cost issue of noble metal electrode substrate and catalysts. To overcome limitations of CC such as low conductivity and low active site, the high electrical conductivity of graphene and the large amount of active sites of MoS_2 were synthesized on CC substrate via chemical vapor deposition method. As the result, MoS_2/graphene-CC electrode showed better hydrogen evolution performance than bare-CC and MoS_2-CC. Moreover, we confirmed that the organic compound in artificial wastewater electrolyte was decomposed after electrochemical reactions. We expected to use MoS_2/graphene-CC electrode for wastewater treatment and hydrogen evolution by electrolysis.

#553814: High-Throughput Profiling of Antibiotic Resistant Genes in a Novel Tridimensional Eco-Biological WWTP with High Discharge Standards for Reuse.

***Kaifeng Yu**[1], Yihan Chen[1], Bo Zhang[1], Karina Yew-Hoong Gin[2], Yiliang He[1], Peng Li[1], and Yuansheng Huang[1]*
(1)Shanghai Jiao Tong University, Shanghai, China, (2)Civil and Environmental Engineering, National University of Singapore, Singapore

Antibiotic resistome is a raising concern around the world, especially considering reclaimed wastewater. In this study, a novel tridimensional eco-biological wastewater treatment plant (TEB-WWTP) with high discharge standard (CODcr < 20 mg/L, ammonia < 1 mg/L, TP < 0.2 mg/L, third sort of *Environmental quality standards for surface water in China*) for reuse was selected. The bioreactors were characterized by adding internal bio-modules and planting various macrophytes which were fixed by stainless steel cages with additional bio-ceramsites on the top of bioreactors to purify odor gas. WWTPs are considered as hotspots of antibiotic resistant genes (ARGs). High-throughput qPCR (HT-qPCR) was applied here to profile ARGs in the TEB-WWTP and receiving stream. A total of 228 ARG subtypes were detected in the TEB-WWTP system which exhibited good performance for the removal of ARGs with the number, relative abundance and absolute abundance of ARGs largely decreased in the final effluent. Surprisingly, we found that the number and relative abundance of ARGs in the rhizosphere of three macrophytes (*Canna indica, Cyperus alternifolius* and *Musa basjoo*) were lower than that of biological reactor effluent. Aquatic plants probably play an important role in the inhibition of ARGs dissemination. Most of ARGs have significant correlations ($p < 0.001$) with total abundance of mobile genetic elements (MGEs), suggesting that horizontal gene transfer was the main mechanism for ARGs propagation. More attention should be paid to excess sludge with high relative abundance of ARGs for further dispose or farmland application. The final effluent was discharged to a stream for ecological reuse. The number and relative abundance of ARGs in the sediment of downstream were much higher than that of upstream, indicating that the risk of ARGs can't be overlooked when considering wastewater reuse.

#553863: Application of Liquid Phase Plasma in Photocatalytic Hydrogen Production from Wastewaters Containing Organic Pollutants.

Young Kwon Park**, Kyong-Hwan Chung, and **Sang-Chul Jung
Environmental Engineering, University of Seoul, Seoul, Korea, Republic of (South)

The hazardous wastes and toxic water pollutants have brought out serious environmental problems associated with attracted much attention. In the various physical, chemical and biological techniques for treatment of wastewaters, heterogeneous photocatalysis has been considered as an effective alternative for water remediation. Photocatalytic water splitting is effective for converting water to hydrogen as a clean and renewable energy. It has been also applied on deconposition of organic materias in wastewater. The development of high photosensitive catalysts has been studied under UV and visible light illumination. Although a range of light sources have been employed in photocatalysis, few studies have examined photocatalysis for hydrogen generation using liquid phase plasma by irradiation into water directly.

Photocatalytic decomposion using liquid phase plasma was assesd to produce hydrogen and to remove polluant from wastewater containing organic materials. Characteristics of liquid phase plasma irradiation were examined in the photocatalytic water splitting for hydrogen evolution on modified TiO_2 photocatalysts. Optical emission spectra were characterized with variation of plasma discharging parameters of the liquid phase plasma. Pathway of photocatalytic reaction for hydrogen evolution was also evaluated with degradation of organic pollutants.

The hydrogen was generated in the photodecomposition of water through the liquid phase plasma irradiation without photocatalysts. The active species generated by the liquid phase plasma irradiation brought out the hydrogen evolution regardless of the photocatalysts. The rate of hydrogen evolution depended on the parameters of liquid phase plasma discharging. The hydrogen evolution was significantly enhanced by irradiation of liquid phase plasma from the wastewater. The organic pollutant assisted to improve the hydrogen production with adding of hydrogen by its decomposition.

#554309: Investigation of Phosphorus Removal in Sewage Sludge Solid Fuel Using Citric and Formic Acid.

Li-Hua Xu
Energy Systems Research, Ajou university, Suwon, Korea, Republic of (South)

The amount of sewage sludge continues to increase with expansion of the sewage treatment plant. However, ocean dumping of sewage sludge has been prohibited with the London Protocol for the Prevention of Marine Pollution. Therefore, it is an important issue to treatment of sewage sludge on the ground site. The hydrothermal carbonization technology is one of the attractive solutions to convert the sewage sludge into solid fuel. It can decrease sewage sludge and can produce alternative energy. Unlike coal, the sewage sludge solid fuel contains large quantities of phosphorus. The phosphorus is commonly known as a substance that significantly impacts fouling and slagging. Fouling and slagging is a factor that lowers energy efficiency. Therefore, it is important to remove phosphorus for reducing fouling and increasing energy efficiency. In this experiment, the sewage sludge solid fuel, which was produced from Incheon city, S.Korea, was used. Citric acid and formic acid was used to dissolve phosphorus in water. Sewage sludge solid fuel mixed in citric and formic solution and stirred for 24hours. In order to investigate phosphorus removal by citric and formic acid, phosphorus-dissolved solution was analyzed by Ion Chromatography. As a result, phosphorus removal efficiency of citric acid is higher than formic acid. In order to investigate fouling property of sewage sludge solid fuel with phosphorus removed, muffle furnace experiment and agglomeration test was conducted.

#554451: Thermochemical Conversion of Polyvinyl Chloride (PVC) in the Presence of Fe_3O_4 and CO_2 for Syngas Production.

Hocheol Song*[1]*, *Dong-Wan Cho*[2]*, Gihoon Kwon*[1]
(1)Sejong University, Seoul, Korea, Republic of (South) (2)Korea Institute of Geoscience and Mineral Resources, Daejeon, Korea, Republic of (South)

Thermochemical energy recovery (*i.e.*, syngas production) from waste plastic valorization is more challenging compared to the recovery from biomass due to the relatively high stability of plastic. Thermal degradation of polyvinyl chloride (PVC) assisted by Fe_3O_4 was carried out to investigate the feasibility of using Fe_3O_4 to facilitate enhanced syngas production (H_2 and CO). The enhanced generation of H_2 and CO from thermolysis of PVC/Fe_3O_4 was more obvious in CO_2 atmosphere than N_2 atmosphere. In the presence of Fe_3O_4, the generation of CO from PVC thermolysis began at 560 °C, which was different from the CO generation from powdered activated carbon (PAC) thermolysis that initiated at the temperature over 720 °C. This substantial production of CO was attributed to redox reaction between Fe_3O_4 and CO_2. A small amount of Fe_3O_4 (Fe_3O_4/PVC = 0.01) was able to trigger a CO_2-looping gasification, increasing CO production in the temperature of 560-720 °C (up to 7.1 mole% at 680 °C). On the other hand, further addition of Fe_3O_4 at a ratio of 0.5 enhanced the concentration level of CO, particularly in the latter half of thermolysis (up to 4.5 mole % at 900 °C). Good adsorption capability of biochar from PVC/Fe_3O_4thermolysis was also demonstrated to achieve over 77% removal efficiency of methylene blue.

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Please check the Technical Program for your scheduled presentation time - speaking slots are 15 minutes (including Q&A) for selected speakers, and 35 for Keynote and 25 minutes for Invited speakers (please check the schedule). Presentations should be in PowerPoint format (any aspect ratio) and should be uploaded to the projection computer at least 15 minutes prior to the start of your session. You may email your presentation to lucya@aiche.org ahead of time and bring it on a flash drive as a backup.

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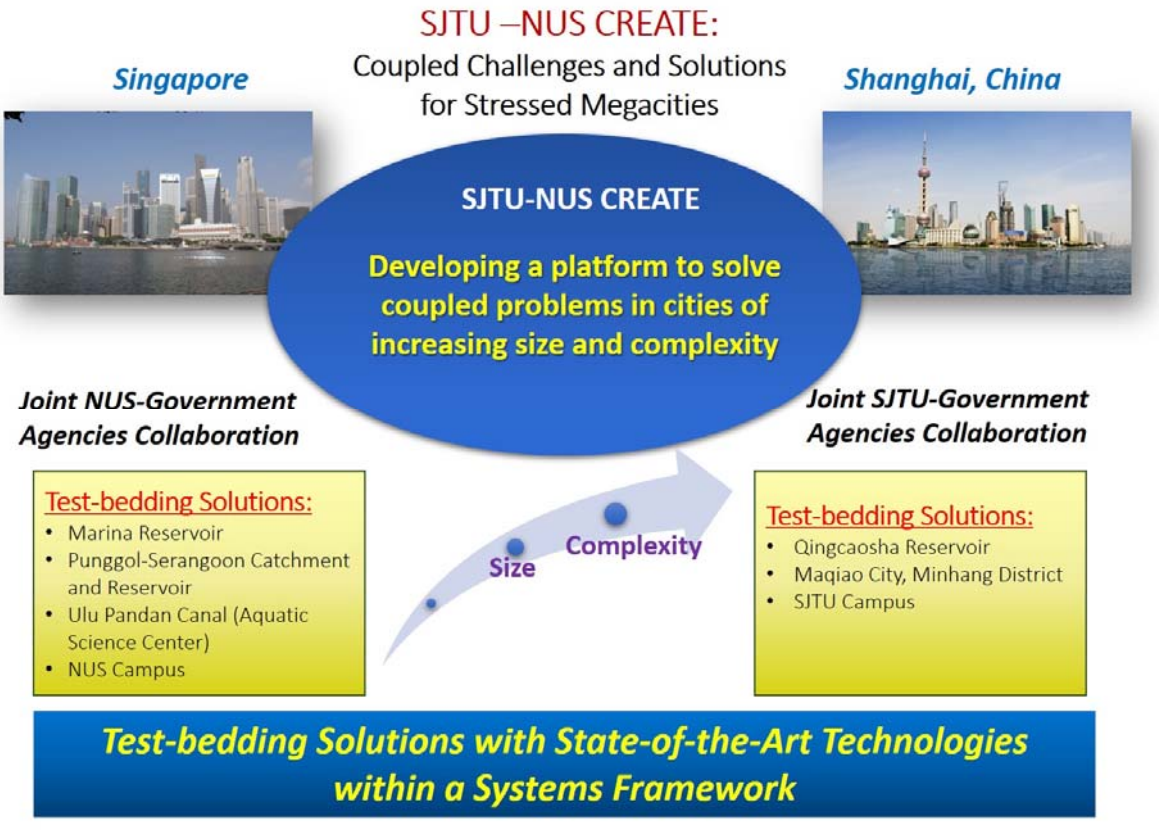
E2S2-CREATE is a successful joint collaborative programme between **Shanghai Jiao Tong University (SJTU)** and **National University of Singapore (NUS)** under the Campus for Research Excellence and Technological Enterprise (CREATE) framework. The programme has completed its **Phase I** and is now in **Phase II**.

In Phase I, we have developed a number of sustainable solutions for coupled problems in the field of waste management and emerging contaminants for Singapore, and other stressed megacities in Asia and around the world. The results also help in strategic policy making and near real-time environmental monitoring and response.

In Phase II, we continue to understand and model for policy formulation and technology development, while reaching down from the city-wide model and developing deeper into the implementations at solving specific urban megacity challenges.

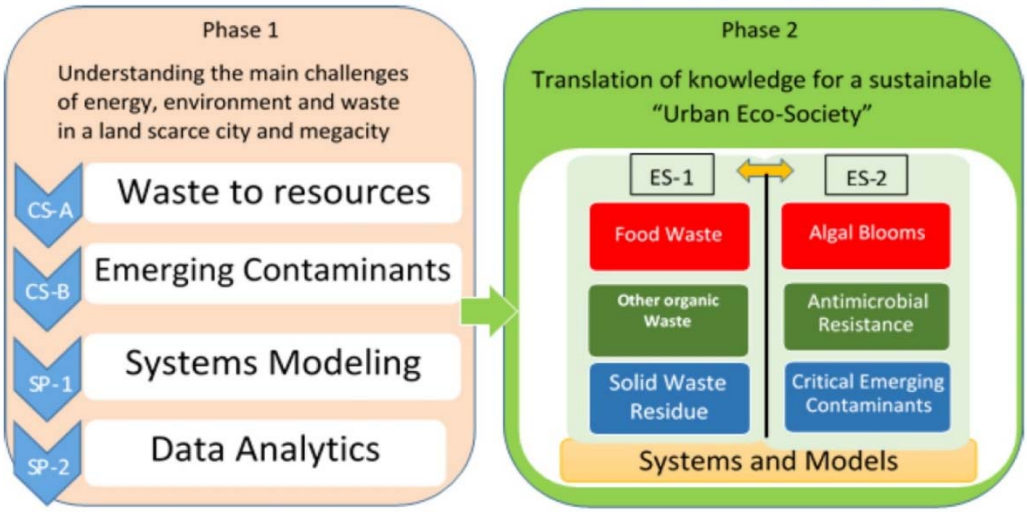


E2S2-CREATE Phase II

Theme

Phase II intends to find Eco-Solutions (abbreviate as ES) to ***Sustainable Urban EcoCity*** from these aspects:

- construction of zero-emission waste loop in megacities;
- detection and management of algal blooms and anti-microbial resistances.



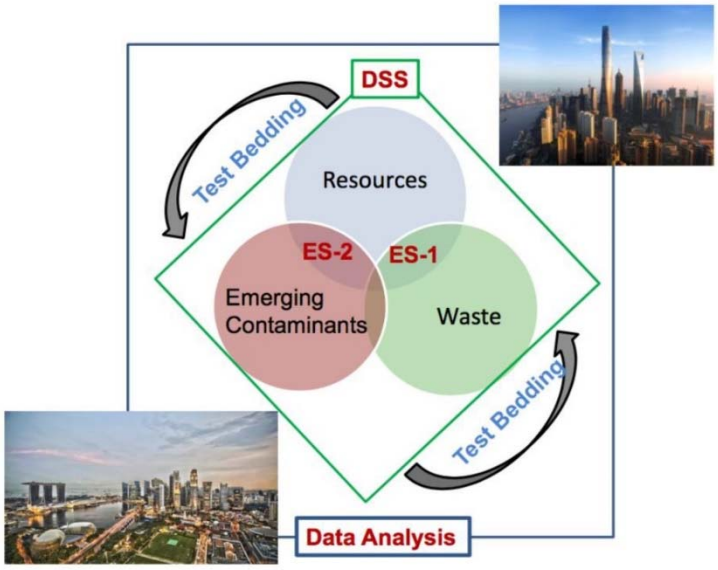
Projects

<u>ES-1: Waste-to-Resource: Eco-Energy System towards Environmental Sustainability</u>

- Food waste
- Gasification
- Decision support system
  - Life cycle assessment
  - Urban metabolism analysis

<u>ES-2: Detection, Assessment and Modelling of Emerging Contaminants in the Urban Environment</u>

- Algal blooms
- Antimicrobial resistance



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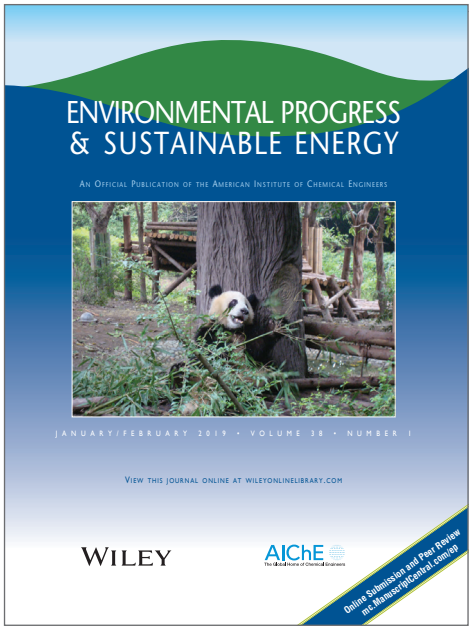

ENVIRONMENTAL PROGRESS & SUSTAINABLE ENERGY

Virtual Issue on Waste Management

Edited by

Martin A. Abraham
(Youngstown State of University)

Jeffrey Seay
(University of Kentucky)

Despite the attention given to sustainability and green engineering, there remains significant interest in improving technologies for waste management. EP&SE's Virtual Issue on Waste Management brings together some of the recently published papers that highlight the breadth of techniques that are now used in waste management. We have focused on four areas of waste treatment that represent technologies frequently included within the remediation/treatment section of the journal: adsorption, bio-based processes, catalytic methods, and systems reports. These advances provide new or improved technologies for the elimination of waste, and are beginning to evaluate how these wastes can be upgraded into useful products, an ongoing and important area of technology development.

A sampling of highlighted articles:

- Preparation of Hybrid Porous Carbon Using Black Liquor Lignin Impregnated with Steelmaking Slag and its Performance in SO_2 Removal (Yong Sun et. al)
- Recovery of energy and simultaneous treatment of dewatered sludge using membrane-less microbial fuel cell (M.Z.M. Muaz et. al)
- Heterogeneous photocatalytic decolorization and degradation of structurally related textile reactive dyes in aqueous suspension of ZnO nanotube (Saurabh K. Patel et. al)
- Characterization and evaluation of poplar and pine wood in twin biotrickling filters treating a mixture of NH_3, H_2S, butyric acid, and ethylmercaptan (Jeronimo Hernandez et. al)

Access the Virtual Issue
tinyurl.com/EPVirtualIssue

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- Industry and Energy Sector CCUS Projects
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- Economic Analysis and Modeling
- Laboratory Investigations
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- Energy-Water Nexus
- Business and Financial Approaches
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