This workshop gathers professionals in various disciplines, from all over the world, to support the formulation of an efficient sustainable management agenda for plastics and microplastics, as well as the global remediation of soil, land and groundwater.

SESSION TOPICS

- Plastics/microplastic in aquatic ecosystems: marine and freshwater bodies
- Plastics/microplastic in terrestrial ecosystems
- Plastics/microplastic and food security, food safety and human health
- Social and economic impacts of plastics and microplastic in the environments
- Policy implications for plastics and microplastic in the environments

CONFERENCE CHAIRS

Yong Sik Ok, **Chair**
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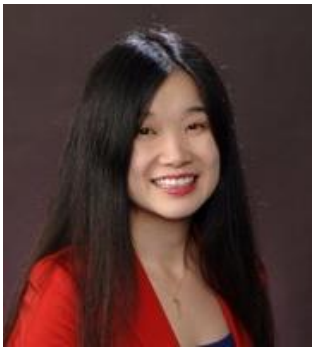


Xiaonan Wang, **Co-Chair**
National University of Singapore, Singapore

Sustainable Waste Management Workshop

January 7-9, 2020| CREATE Tower NUS, Singapore

Plenary Talk: Youn-Joo An, Konkuk University, Republic of Korea

Title: Ecotoxicity of Microplastics in Aquatic Ecosystem




- Plastic wastes, and microplastic pollution in aquatic ecosystems is currently gaining considerable attention worldwide
- These pollutants have potentially adverse impacts on human health, owing to the food chain transfer and substantial reliance on nutrients derived from seafood
- The adverse effects of microplastics on physical, biochemical, and nutritional aspects of the major species in aquatic ecosystems were evaluated
- The results provide insights into the problem of microplastic pollution of the water environment and focus attention on the food chain transfer, which has direct implications on human health.

Invited talk: Wei Zhang, Zhengzhou University, China

Title: The Mechanism of PE Microplastics Carrying Cr(VI) Ions in the Water Environment




- Microplastics can adsorb various contaminants from soil and water environments
- The pH would influence the adsorption capability of pollutants
- The attachment performance of Cr(VI) by Polyethylene (PE) would be promoted by sodium dodecyl benzene sulfonate (SDBS) addition for the pH of less than 6
- The attachment performance would be decreased when the pH was more than 6, for the SDBS would compete with CrO_4^{2-} for occupying the adsorption sites of PE
- This research would provide a basis for investigating the influence of pH on adsorption performance of heavy metal by PE to simulate the surface attachment model of those three kinds of pollutants

Invited talk: Dingding Yao, National University Singapore, Singapore

Title: Thermal-Chemical Recycling of Waste Plastics for Valuable Products




- At present, nearly 908,600 tons of waste plastics are disposed in Singapore according to a NEA report. Plastic waste represented a huge waste of hydrogen and carbon resources, and has been a great challenge for the sustainable development
- Thermal-chemical recycling of waste plastics is a promising way to reduce waste with simultaneously conserving natural resources
- In this work, waste plastic waste was thermally vaporized (pyrolysis) firstly followed by a catalytic reforming/upgrading process, where hydrocarbon-containing compounds being converted to desired valuable products
- As catalyst was very important for this process, experiments were performed into the influence of the catalyst where a series of different Ni or Fe modified catalysts were compared in relation to hydrogen yield and carbon nanomaterials production
- A deep investigation on microstructure and crystalline phase of spent catalyst and products was also conducted for better understanding of the growth of carbon nanomaterials from pyrolysis-catalysis of plastic

Speaker: Xuhong Lu, Nanyang Technological University, Singapore

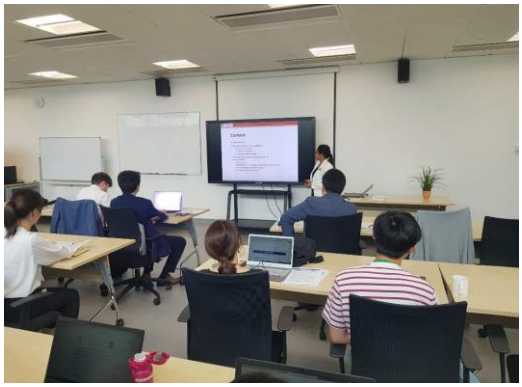
Title: Compare Visual and Spectroscopic Identification of Microplastics in Municipal Solid Waste Samples

- Exposure of plastics to sunlight ultraviolet (UV) radiation, moisture intrusion, elevated temperature, mechanical stress, and stained by organic solvent and corrosive liquid initiate and accelerate the weathering and fragmentation processes of waste plastics
- However, the detection methods and available measurements on MPs occurrences in landfills are lacking
- In this study, MPs in environmental solid samples were separated and characterized by density-based extraction and followed by selective fluorescent staining using Nile Red
- The particles were confirmed by Fourier-Transform Infrared Spectroscopy (FT-IR)
- The best concentration of Nile Red is 10 μg/L, the microscopic fluorescent images can be further analyzed by software
- There is no significant difference between the visual and spectroscopic results of the MPs
- The composition of MPs in different waste fractions of solid waste samples were detected

Speaker: Kumuduni Niroshika Palansooriya, Korea University, Korea

Title: Characteristics of Particulate Plastics in Terrestrial Ecosystems.

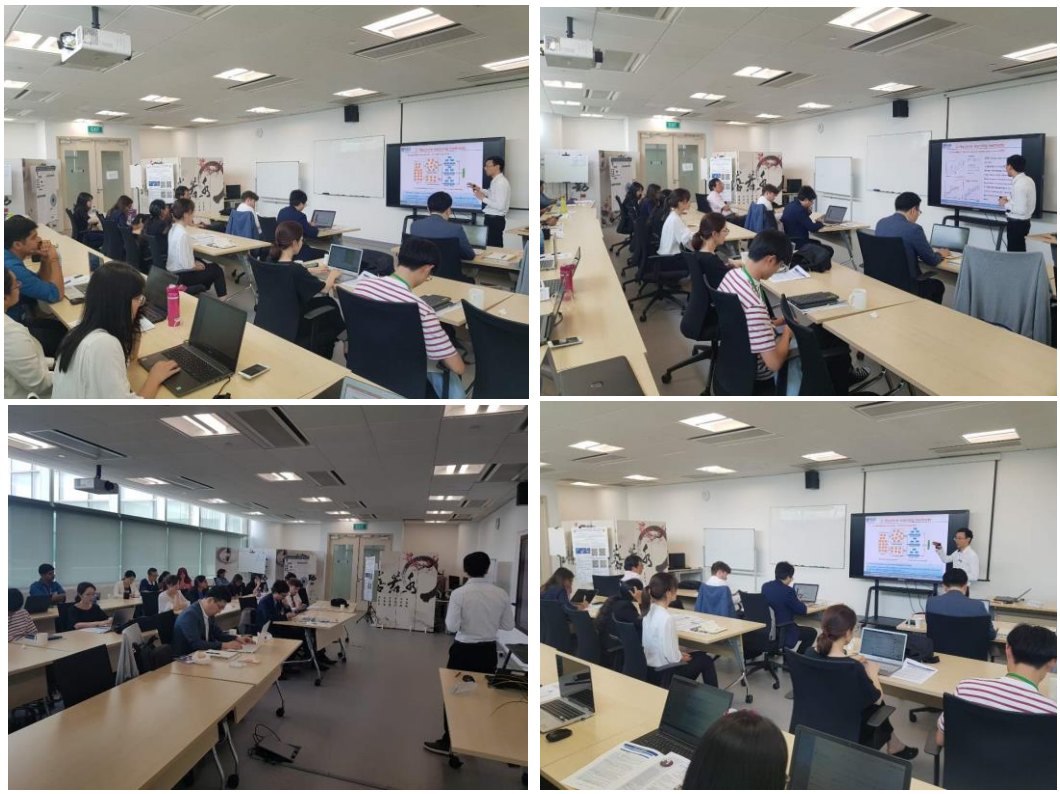


- Particulate plastics (PPs) are emerging pollutants of increasing concern in aquatic and terrestrial environments
- The occurrence and impact of aquatic PPs are extensively studied, but the studies on their occurrence in terrestrial ecosystems are mostly limited
- This review work focused on the characteristics of PPs in terrestrial ecosystems for better understanding their behavior and impact on terrestrial ecosystems. Important physical properties (i.e., size, colour, shape) and chemical properties (i.e., polymer type, associated chemical bonds, chemical additives) of PPs are discussed
- In addition, details on biodegradable and biosynthetic PPs, and associated trace metals in PPs are discussed
- Lastly, various analytical techniques that are used to extract, identify, characterize, and quantify (morphological and chemical characterization) the PPs in terrestrial environments are described

Speaker: Jie Li, National University of Singapore, Singapore

Title: Multi-Task Prediction of Hydrochar Properties from High-Moisture Waste with Machine Learning Methods



- Hydrothermal carbonization (HTC) is a promising way to treat sludge, food waste, and manure with hydrochar production due to its low energy intake and high efficiency
- The traditional way to understand these important characteristics of hydrochar is to conduct HTC experiments and then detect the characteristics individually, which is quite expensive, labor-intensive and time-consuming
- Machine learning (ML), as a data-driven approach, can perform prediction tasks after training with HTC dataset and facilitate understanding of the relative importance of input features
- In this work, three state-of-the-art ML models including supporting vector machine (SVM), random forest (RF) and deep neural network (DNN) were used to predict the characteristics of hydrochar
- The average R2 of single and multi-task prediction of the optimized DNN model were 0.87 and 0.91, which indicated that the multi-task prediction performance of DNN was the best compared to other two ML models
- This prediction can also help us make some evaluations about the hydrothermal technology and the application of hydrochar before taking action, which is beneficial to the labor, time, energy and resources saving compared with the experimental process

Speaker: Manu Suvarna, National University of Singapore, Singapore

Title: Co-Gasification of Microplastics with Biomass for Syngas Production and Simulation Analysis

- Co-gasification of microplastics with waste biomass to produce syngas serves as an effective means, to utilize biomass residue and mitigate the microplastics threat
- In this study, a steady-state simulation model for co-gasification of microplastics with biomass as the feedstock is developed using Aspen Plus
- The study investigates the role of parameters such as microplastics to biomass ratio (M:B) in the feed, operating temperatures, equivalence ratio (ER) and steam to feed ratio (SFR) on the resulting syngas composition and its lower heating value (LHV)
- Preliminary results suggest that, in presence of O_2 as the gasifying agent, increasing the M:B ratio in the feed, gasification temperature and SFR increase the concentration of H2 and CO in the syngas stream as well as its LHV
- ER has an antagonistic effect as its increase hampers the production of H2 and CO in the
- syngas stream and the corresponding LHV
- This study provides a qualitative support for co-gasification of microplastics with biomass to achieve final syngas with content (H_2 + CO) greater than 62 mol%, H2/CO molar ratio in range 0.81 – 0.96 and LHV in the range between 7.2-8.9 MJ/Nm3 for the various operational conditions investigated

Speaker: Pavani D. Dissanayake,

Title: Effect of Plastic Mulch Wastes on Soil Quality and Crop Productivity in Agro-Environments




- Plastic production has increased significantly due to their easiness for use, cost effectiveness and durability
- Plastic debris remained in natural environment has raised an emerging concern throughout the world
- Plastic mulching has become a globally applied agricultural practice for its instant economic benefits such as higher yields, weed control, increased water-use efficiency and reduction of soil erosion Long-term consequences in terms of potential for deteriorating soil quality or their trophic transfer are less explored
- This study is aimed to evaluate the effect of plastic mulch wastes on soil quality and crop productivity in agro-environments
- Plastic contamination in agricultural soils will be characterized and quantified in three agricultural sites in Korea and also soil properties and plastic degradability will be assessed
- Based on environmentally relevant plastic concentrations derived from previous monitoring results, microcosm experiments will be designed and conducted to evaluate long-lasting fate of plastic mulch wastes in agricultural soil
- In addition, recommended crops will be grown under same conditions and their growth will be assessed

Speaker: Nikita Choudhary, National University of Singapore, Singapore

Title: Microplastics Abundance, Distribution and Impacts in Tropical Urban Fresh Waters: A Singapore Case Study

- Information surrounding microplastics in fresh waters remains scant
- To address this knowledge gap, a literature review was conducted focusing on the global distribution and abundance of microplastics in fresh waters
- Early findings from the review identify the recurring source of microplastics as wastewater effluents, indicating a spatial association between the presence of plastic with its proximity to urban areas
- Finding a paucity of research in tropical freshwater systems, we followed this up with a study on selected reservoirs and canals of Singapore
- Through in-situ sampling, chemical digestion, filtration, and microscopy classification, we identified the most abundant type of microplastic pollution (particle size < 5 mm) across five freshwater systems (both lotic and lentic), and suggest key factors that could contribute to this abundance
- Results represent an important first step towards understanding the impacts of microplastic pollution in Singapore, and possibly other tropical freshwater systems

Speaker: Lanyu Li
Title: A Data-Driven Method for Constructing the Geography of Waste in Singapore

- Robust planning of the waste management system requires reliable information on waste generation
- It is an essential step to forecast the temporal-spatial variations of waste in the region for a given timespan
- However, no study has covered the forecasting of spatial distribution of the subcategories of municipal solid waste, which are essential when designing the specific waste-to-resource/energy pathways for a circular economy
- In the case of micro-plastic waste, it is important to know how the microplastic waste geographical distributes in order to better control it from source or remove it from the environment
- To fill the research gap, this project focuses on developing a data-driven method for the prediction of future waste production and mapping the geography of waste for different waste categories
- A "Geography of Waste" (GoW) approach containing the steps of data collection and analysis, visualization, data-driven modelling, and waste prediction is proposed in this work
- With the retrieved dataset, different machine learning algorithms including neural network and gradient boosting are employed to identify how significance each factor affects the waste generation compared with linear interpolation
- Results show that the gradient boosting model produces a reasonable prediction on the test dataset
- In future work, the model will be applied to study the geography of microplastics, and the prediction models will be integrated with the decision support tools for the planning of waste management facilities.

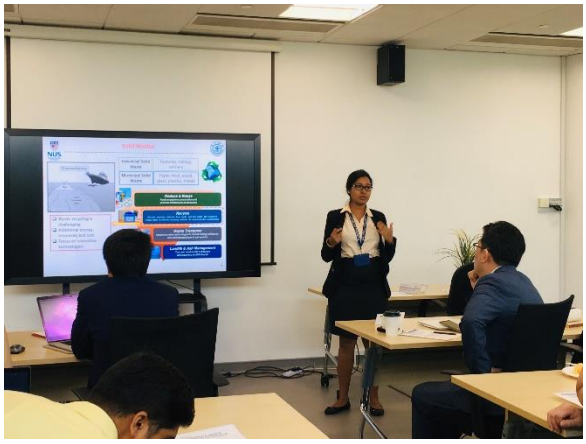
Plenary Talk: Karthikeyan Sathrugnan, Marketing, Frontier Laboratories, Singapore

Title: Sensitive Method for the Detection of Micro Plastics in Environmental Samples

- Recent focus is much towards microplastics- tiny plastic pieces ranging from 5mm down to 1 nm in diameter
- There are reports, detecting microplastics in bottled water, canned food and indoor air dust. This is a widespread problem in microplastics research that makes it hard or impossible to compare studies
- It is mainly because we don't have any good method yet to analyze microplastics in different matrices
- This paper presents a simple method for analyzing microplastics using pyrolysis coupled to Gas Chromatography-Mass Spectrometry (Py-GCMS)
- In the case of bottled water or other natural waters, there are no extraction required
- Water sample are filtered with prebaked glass fiber filter and microplastics retained on the filter will be directly analyzed by Py-GCMS
- The method suitability is demonstrated by standard addition method with plastic mix at low concentration levels. With the PYGCMS and suitable software, very low detection limits are achieved. The method has shown advantages in minimizing sample preparation steps for complex environmental matrices

Invited talk: Debirupa Mitra, National University of Singapore, Singapore

Title: Waste-Plastic Bottle Derived Composite for Sorption of Oil



- Oil spills in aquatic bodies are a huge threat to the environment and the ecosystem. Apart from oil spills, various industries generate massive volumes of oily wastewater that requires treatment to regenerate clean water either for reuse or discharge
- Most commercially available oil sorbents are made of synthetic polymers like polypropylene and polyurethane which have high sorption capacities, but the use of these introduces tons of non-biodegradable plastic into the ecosystem
- In this work, LCBW which is acid-leached carbonaceous solid waste from gasification of refinery bottoms, has been entrapped within PET to fabricate a novel composite oil sorbent material
- The results from this study showed that a 3D porous material fabricated by a low energy and facile process, entirely from used PET bottles and carbon waste from the refinery could be effectively used as a sorbent for oil spill containment or for removal of oil from o/w emulsions in the industries
- Thus, a potential way of tackling waste management as well as fabricating an effective oil sorbent material is achieved

Invited talk: Meththika Vithanage, University of Sri Jayawardenapura, Sri Lanka
Title: Vector Transport of Antibiotics by Microplastics in Water

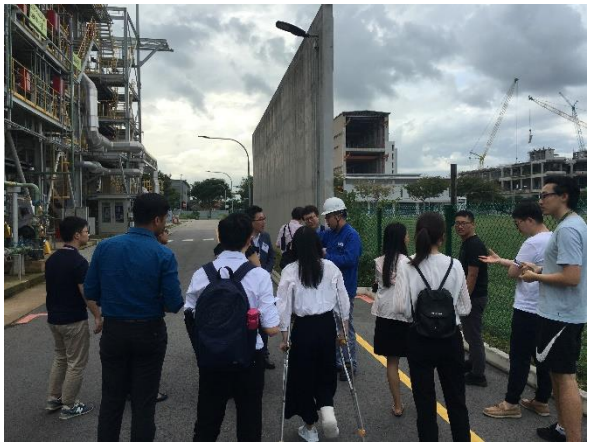
- The sorption behavior of Ciprofloxacin (CPX) antibiotic, (a common human and veterinary drug, on polyethylene microplastics (PEMP)) was studied through batch sorption experiments
- The sorption of CPX with pH had a gradual increase reaching a maximum sorption at pH 6-7 and then decreased which is likely due to the speciation of CPX at different pH
- In the presence of NaNO3, the overall CPX sorption capacity of PEMP decreased as the ionic strength increased revealing that the sorption mechanism was dependent of hydrophobic and electrostatic interactions
- Sorption capacity of CPX by PEMP decreased significantly in the presence of HA highlighting the influence of DOM in the aquatic environment towards the CPX sorption and mobilization by PEMP
- The spectrum for CPX sorbed PEMP, peaks for C=O, C-F and C-O-C confirmed bound CPX on MP surface
- The sorption kinetics model confirmed the parabolic diffusion model and the Elovich model in the presence of HA
- The isotherm equilibrium data was well fitted for Hill and Dubinin-Radushkevich models indicating sorption was controlled by pore filling mechanism accompanied by Van der Waals interactions on a heterogeneous surface

Speakers: Salsabila Masitah Hakim and Kadek Dimitry Wisha Anjani, Institute of Technology Bandung, Bandung, Indonesia
Title: Extraction of Cellulose Acetate from Cigarette Butts As Raw Material for Making Membranes




- Cigarette butts are the biggest marine contaminant. Cigarette butts is made by Ca which is a nonbiodegradable substance. Cellulose acetate can be used as membrane's raw material for desalination of sea water to overcome the water crisis
- Forward Osmosis membranes made from cellulose acetate is an economical tool for seawater desalination
- Literature studies show that there is a method for extracting cellulose acetate from cigarette butts. Leaching is carried out by solid-liquid extraction and followed by cellulose acetate precipitation 0.02% H_2SO_4 solution, ethanol, and diethyl ether are used for solid-liquid extraction
- Cellulose acetate precipitation is done by adding acetone and water which are then decanted and dried by the vacuum filtering method. The membrane has dope solution of cellulose acetate dissolved in a mixture of acetone, IPA, and lactic acid with an area of 0,0044 m^2
- The membrane performance determined has a flux of 1,3 $L.m^{-2}$ $hours^{-1}$ and a Natrium rejection percentage of 98%. MgSO4 with a concentration of 1,25 M is used as a draw solution with a flat sheet membrane configuration
- It takes 20% of cigarette butts waste in Indonesia to make a seawater desalination plant that produces 100,000 m3 / day of clean water

Technical tour: Waste to Energy Research Facility



The Waste-to-Energy Research Facility (WTERF) at Tuas South is based on high temperature slagging gasification technology and is the first of its kind waste treatment facility in the world to employ biomass charcoal as an auxiliary fuel. Jointly developed by the National Environment Agency (NEA) and Nanyang Technological University (NTU) through its Nanyang Environment and Water Research Institute (NEWRI), and supported by the Economic Development Board (EDB), it is an initiative under the Energy National Innovation Challenge (ENIC) to explore alternative measures to improve energy and resource recovery in the waste-to-energy domain.

The WTE Research Facility will treat waste at temperatures much higher than in typical mass burn incinerators, reducing the amount of ash produced. This ability to reduce ash for final disposal has the potential to help prolong the lifespan of Semakau Landfill, complementing the current mass burn technology in Singapore as part of its integrated waste management system.

The main by-product of slagging gasification process is slag, a vitrified (glass-like) material which because of its chemical inertness can potentially be used as an aggregate replacement in construction.

Through its plug-and-play features, the facility serves as an open platform for research, translation, demonstration and test bedding for new types of waste-to-energy related technologies. Other possibilities include the treatment of diverse mixed of waste streams, and the upgrading of syngas for enhanced energy recovery.

NTU-NEWRI Waste-to-Energy Research Facility:

https://www.youtube.com/watch?v=97lVNY5gCyc&feature=youtu.be

For more information, please visit here:
http://newri.ntu.edu.sg/Research/Applied%20Research%20and%20Translation/Waste%20to%20Energy%20Research%20Facility/Pages/home.aspx