NEWSLETTER

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E2S2-CREATE Webinar 2022

CREATE
Campus for Research Excellence And Technological Enterprise

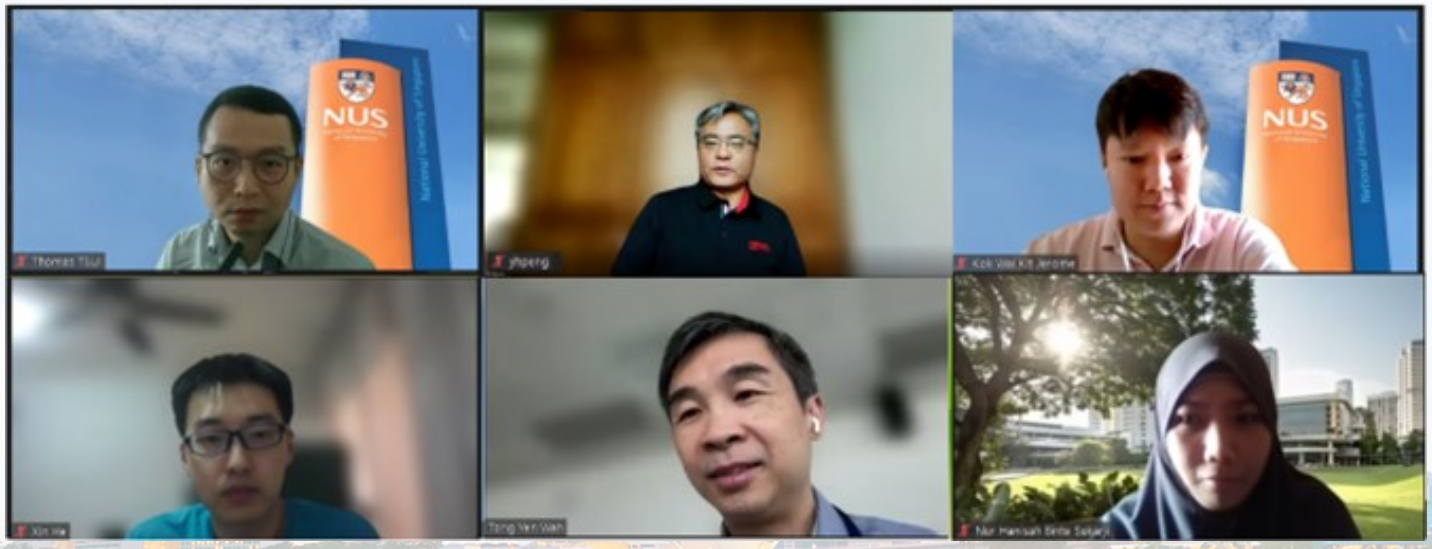
Programme

1000 h	Introduction of E2S2 program • Prof Peng Yinghong (Program Director, Shanghai Jiao Tong University) • Prof Tong Yen Wah (Program Co-Director, NUS)
1010 h	Young Scientist workshop • Dr Thomas Tsui (ES-1 Research Fellow) • Dr He Xin (ES-1 Research Fellow) • Ms Nur Hanisah Binte Sukarji (ES-2 Research Assistant) • Dr Jerome Kok (ES-2 Research Fellow)
1050 h	Q&A Session

Speakers

Dr Thomas Tsui, ES-1 Research Fellow
Dr He Xin, ES-1 Research Fellow
Ms Nur Hanisah Binte Sukarji, ES-2 Research Assistant
Dr Jerome Kok, ES-2 Research Fellow

For more information, please email Ms Candy Chen at chy@nus.edu.sg



E2S2-CREATE Webinar themed as young scientist workshop was held on 24 June, 2022 via Zoom. We invited Dr He Xin and Dr Thomas Tsui from ES-1 project, Dr Jerome Kok and Ms Hanisah from ES-2 project to share their works while working under E2S2 programme. There were over 50 attendees joining the webinar. In addition to present the research, the speakers were invited to share about their life in E2S2 programme. Dr He Xin shared that E2S2 colleagues have active mind and are very friendly so that he got a lot of helps from them. Ms Hanisah shared that she enjoyed working with staffs and students from SJTU for exchanging ideas on research. When asked about their future plan, Dr Thomas Tsui shared he would look for a faculty position where he could take advantage of his knowledge and skills and find more solutions to help on emerging urban challenges. Dr Jerome Kok shared that he intended to apply for part-time lecturing job in NUS and concurrently aimed to expand his research area to be more accessible to general audiences .

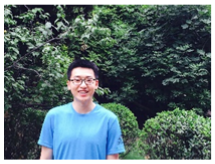
E2S2-CREATE Webinar 2022

Dr Thomas Tsui
ES-1 Research Fellow

Topic: Technological and Methodological Approaches Supporting Anaerobic Digestion of Food Waste in Urban Environments

Abstract:
Food waste management is highly constrained by space and complexity in urban environments. Anaerobic digestion is a proven technology for bioenergy recovery from food waste. Yet, many questions remain to be answered through the lens of engineering management. This presentation will discuss our recent research efforts covering both technological and methodological approaches in this regard. For the technological aspect, it will share how DIET (Direct Interspecies Electron Transfer) mechanism can be fundamentally applied in terms of flexible digesters' operation and sulfur contamination. For the methodological aspect, it will share cases of why/ how economic and life-cycle environmental perspectives need to be considered.

Short biography:
Education:
BEng and Ph.D. in Civil and Environmental Engineering (Hong Kong University of Science and Technology)
Postgraduate Certificate (UNESCO-IHE Institute for Water Education, the Netherlands)
Research Interests:
Bioprocess design and bioinformatics; Life-cycle environmental assessment; Techno-economic assessment; Machine learning applications



Dr He Xin
ES-1 Research Fellow

Topic: Advanced system engineering for sustainable non-food organic waste solution

Abstract:
Given the pressure of climate change and the growing primary energy demands, renewable energy technologies have shown good potential for sustainable energy utilization. Gasification integrated with power generation has been proved to be a standout solution for non-food organic waste compared with other thermochemical processes. To improve the economic, environmental and health impacts of gasification applications, multi-scale modeling embedded with core process system engineering techniques is illustrated in this presentation, including discrete wavelet transformation and multi-objective surrogate optimization. The proposed system engineering approach balances the numerical prediction accuracy and computational intensity, connecting the biomass particle fragmentation and shrinking observations to practical integrated gasification system assessments.

Short biography:
Dr. Xin He is a research fellow in CREATE E2S2 program at National University of Singapore. He had his Ph.D. in Chemical Engineering at West Virginia University in 2019. His research interests focus on the intersections of process system engineering and energy system, including numerical modeling, optimization, and advanced control for overall economic, environmental, and social benefits improvements.

Ms Nur Hanisah Binte Sukarji
ES-2 Research Assistant

Topic: Understanding Local Production of Cyanobacteria Metabolites Through Models

Abstract:

Algal blooms arising from eutrophication sometimes come with problematic cyanotoxin and off-flavour compounds. A mechanistic model was developed to predict microcystins (cyanotoxins) from local cyanobacteria and used to simulate microcystin in a local reservoir to identify its most influential factors, which was irradiation. However, microcystin concentrations depended heavily on the producer occurrence, but was unaffected by grazers or phages. For geosmin (off-flavour) and cylindrospermopsin (cyanotoxin), multi-linear regression models were built. Their predictors suggested they were mainly produced by actinobacteria and by cyanobacteria other than Raphidiopsis, respectively, in that reservoir, and factors like chloride could be further studied.

Short biography:

Hanisah has been working with A/Professor Gin since 2016. She graduated from NTU with a Bachelor's in Environmental Engineering and has recently completed her Master of Engineering in NUS. Hanisah's research focuses primarily on modelling of cyanobacteria and their metabolites.

Dr Jerome Kok
ES-2 Research Fellow

Topic: The unique potential toxicity of Synechococcus

Abstract: The recent discovery of cylindrospermopsin toxicity in tropical Synechococcus has urgent implications. We present two findings that build upon this discovery. Over a year-long field study, we observed Synechococcus densities accounting for ~17% of cylindrospermopsin variation, indicating its importance to toxin dynamics. Metagenomic studies also identified toxin gene components distributed across Synechococcus and its microbiome. These findings highlight two future impacts. Firstly, picocyanobacterial blooms especially driven by climate change scenarios may present an enhanced threat of toxicity. Secondly, microbiomes may provide a unique mechanism for rapid trait acquisition including toxicity. Further study is needed to understand and manage such dynamics.

Short biography: I am a research fellow with E2S2. My research is broadly focused on the biological and ecological dynamics of aquatic environments. I previously carried out my Ph.D. with NUS, where I studied coastal harmful algal bloom dynamics. My research is to understand the bloom and toxicity dynamics of freshwater cyanobacteria. My work involves field monitoring using integrated sensors coupled with analyses for nutrient and species biodiversity. I also conduct controlled lab experiments to investigate the effect of environmental conditions on growth and toxin responses. I am interested in understanding the ecological role and dynamics of cyanobacteria toxins, especially for species like Raphidiopsis where toxic and non-toxic strains can co-exist. Recently, I have also been working with the team to gain better insight into Synechococcus toxicity and its role in cylindrospermopsin dynamics.

Recent accepted/published papers from E2S2:

1 Freeze-casting multicomponent aerogel membrane with controllable asymmetric multilayer configuration for high flux gravity-driven separation of oil-water emulsion

Journal: **Separation and Purification Technology**

Authors: **Ming Hang Tai, Babu Cadiam Mohan, Chi-Hwa Wang**

Keywords: **Freeze-casting, Aerogel, Oil/water emulsion, Carbon, Multilayer**

Author's words:

Freeze-casting has been widely used to mix one or several functional components to form aerogel where the resulting structure is uniform and has no distinctive asymmetrical morphology and characteristics. Hence, a multilayered, multicomponent aerogel with tunable physical and chemical properties is desirable as it can extend the multifunctionality and versatility of the aerogel by integrating multiple functional materials. Here, a facile stacked freeze-casting method is reported to fabricate multilayered aerogel membrane with asymmetric morphology and opposing surface wettability from polyvinyl alcohol(PVA)/leached carbon black waste (LCBW) solutions and carbon nanotube (CNT) dispersion for separation of water-in-oil emulsions. The results show that the aerogel membrane can easily demulsify the emulsion at a remarkably high permeate flux (up to 427 ± 40 × 103 Lm−2hr-1bar−1) with rejection higher than 96% at an ultralow driving pressure of 640 Pa.

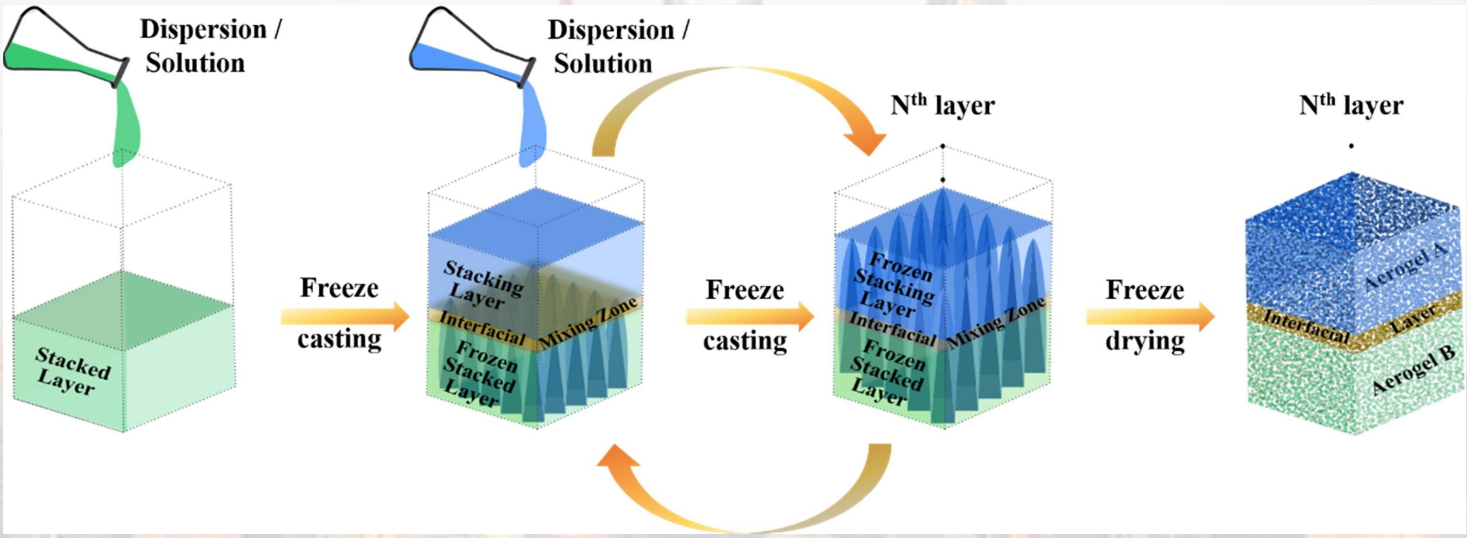


Fig. 1. Illustration of a multilayered aerogel construction based on stacked freeze-casting method (SFCM).

Highlights:

- Freeze-casting was modified to construct multilayered aerogels from solutions and dispersions.
- A multilayered aerogel with asymmetric structural morphologies and wettability was prepared.
- The aerogel could demulsified water-in-toluene nano-emulsion at a high permeate flux.
- Demulsification was done by solely gravity.

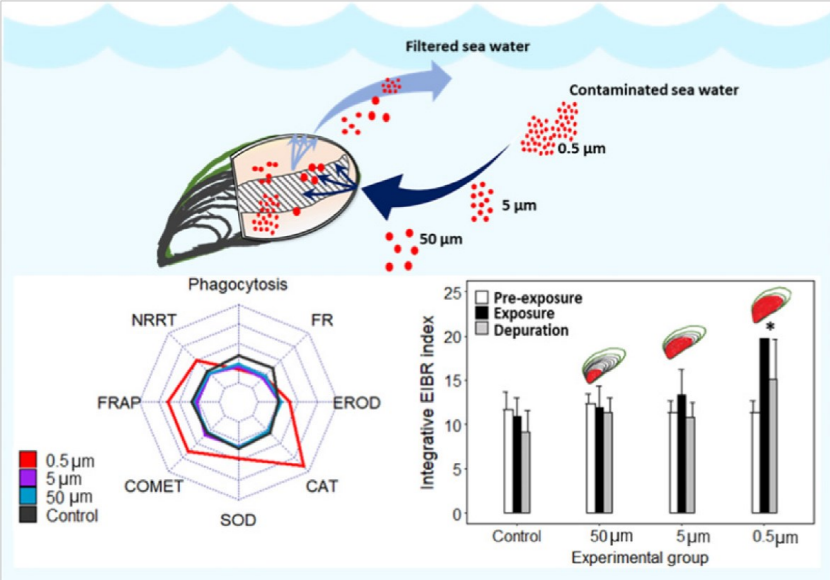
Recent accepted/published papers from E2S2:

2 Impacts of size-fractionation on toxicity of marine microplastics: Enhanced integrated biomarker assessment in the tropical mussels, Perna viridis

Journal: Science of the Total Environment

Authors: Mui-Choo Jong, Junnan Li, Hairati Mohd Noor, Yiliang He, Karina Yew-Hoong Gin

Keywords: Microplastics, Nanoplastics, Size-fractionation, Biomarker, Toxicity



Author's words:

Accumulation of microplastics (MP) in oceanic waters is eroding the health of marine biota. We investigated how size-fractionated MP influence the toxicity risks towards a tropical keystone species, Perna viridis. Tissue-specificbio-accumulation and in vivo toxicity of polystyrene (PS) particles (0.5, 5, and 50 µm) were measured upon continuous exposure for 7 days, followed by 7 days depuration. P. viridis were exposed to equivalent mass (0.6 mg/L), correspond-ing to 4.0–4.6 particles/mL, 4.6–7.1 × 103 particles/mL, and 1.1–4.8 × 106 particles/mL for 50 µm, 5 µmand 0.5µm PS particles, respectively. Onset toxicity were quantified through the enhanced integrated multi-biomarker response (EIBR) model, measured by weighting of biological organisation levels of eight biomarkers: (i) molecular (i.e., DNA damage (comet), 7-ethoxy resorufin O-deethylase (EROD), Catalase (CAT), Superoxide dismutase (SOD), Ferric Reducing Antioxidant Power (FRAP)); (ii) cellular (i.e., Neutral red retention (NRR), phagocytosis); and (iii) physiological (i.e., filtration rate). Data showed slightly elevated lysosomal instability (NRR) and antioxidant defences (FRAP, SOD, CAT, EROD) in specimens exposed to nano-PS (0.5 µm) compared to micro-PS (5 and 50 µm). Immunotoxicity (phagocytosis) and genotoxicity (comet) for haemocyte cells were significantly higher in specimens exposed to nano-PS ($p < 0.05$). EIBR index corroborated increasing toxicity modulated by MP sizes in descending order: 0.5 µm>5 µm > 50 µm, with nano-PS exerted significantly higher biological effects (EIBR = 19.77 ± 5.89) than the unex-

Highlights:

- P. viridis were exposed to size-fractionated MP and NP to estimate toxicity and bioaccumulation.
- The gut of mussels is the primary concentrator and repository for ingested MP.
- EIBR revealed heightened toxicity impacts inflenced by size: 0.5 µm > 5 µm > 50 µm.
- Toxic effects for 5 µm and 50µm were more readily reversed upon depuration.
- NP 0.5 µm caused significant immunological effects that were less readily reversible.

E2S2 joint PhD student

- Hu Hao

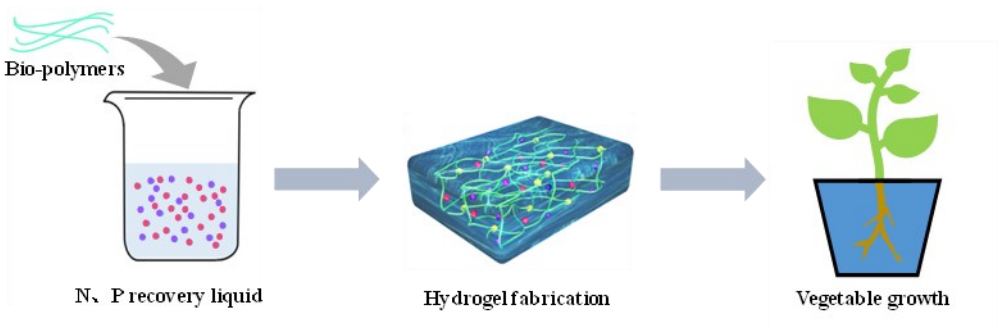
E2S2 joint PhD student

Hu Hao

Hu Hao obtained his Bachelor's and Master's degree in environmental engineering in 2018 and 2021 respectively. During his master's study, his research concentrated on the effects of oxytetracycline on nutrient removal and recovery from wastewater by phytoremediation. Currently, Hu Hao joins in the E2S2 project as an exchange PhD student under the supervision of Prof. He Yiliang (SJTU) and Prof. Tong Yen Wah (NUS).

His main PhD research field focuses on recycling resources from wastewater and other waste to produce hydrogel for a novel substrate to grow green, which originated from the fact that the vast majority of recyclable and precious resources in waste generated in our daily lives are not recycled well, causing significant losses and not in accordance with the guidelines of sustainable development. His ongoing research targets into the new sustainable solution to recycle the resources more effectively and environment-friendly.

Under the E2S2 program, he will be particularly focusing on the research for the synthesis of hydrogel using resources such as nitrogen and phosphorus gained from wastewater and evaluating the development and growth characteristics of vegetables which grow on this novel soilless substrate. During the first stage, the formula for hydrogel fabrication will be investigated to find the optimal synthesis route. The evaluation of hydrogel properties will be needed too to maintain the growth of the vegetable. In the next phase, the greenhouse gases emissions and the micro-environment profile of the vegetation rhizosphere will be analysed to illustrate its global warming potential. In general, these results will contribute to the construction of zero waste cities and the '30 by 30' strategies of Singapore.



The Scheme of Hydrogel Fabrication and Vegetable Growth