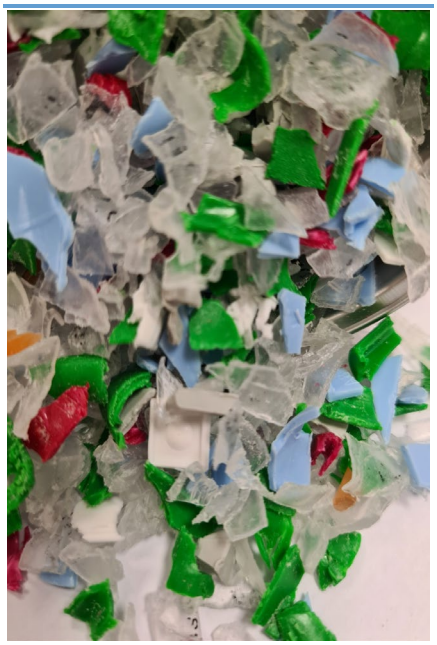
PLASTIC WASTE

RESEARCH AT NERI

NUS National University of Singapore | NUS Environmental Research Institute



THE GOOD & THE BAD

The invention of plastic has changed our daily lifestyle, and even more so following the introduction of single-use plastics several decades ago. Unfortunately, as plastic does not break down naturally, this has led to the escalation of plastic waste generation. According to the OECD Global Plastics Outlook Database, the global plastic waste generation was more than doubled over the last decade (OECD, 2022).

Plastic pollution has brought concerns as they find their way into the environment. Plastic waste in macro- or micro-sized (synthetic polymers smaller than 5 mm in diameter produced commercially or generated from the breakdown of larger plastics) have drawn tremendous attention as more studies have shown, in particular, the micro-sized plastics (more commonly referred to as microplastics), could pose potential harm to human and environmental health. The race is raging among the research communities to plug the knowledge gaps for more informed policies and solutions to address the concerns and management of plastic waste.

HOW NERI ADDRESSES PLASTIC WASTE . . . .

At NUS Environmental Research Institute (NERI), researchers have been conducting studies to deepen their understanding on the occurrence, fate and transportation of microplastics in the environment as well as its impact on aquatic and human health. This is achieved through field surveillance of microplastics in the environment, modelling the transport and fate of plastics, and evaluating the ecotoxicology through model organisms.

To mitigate plastic pollution, NERI researchers apart from looking into innovative ideas, solutions and technologies to manage the waste, they are also rethinking and redesigning how to reuse these plastic waste as valuable resources and products for a sustainable circular economy.

"PROTECTING AND CARING FOR OUR FRAGILE COASTAL ECOSYSTEMS IS THE MOTIVATION FOR OUR WORK"

ASSOC. PROF. KARINA GIN YEW-HOONG

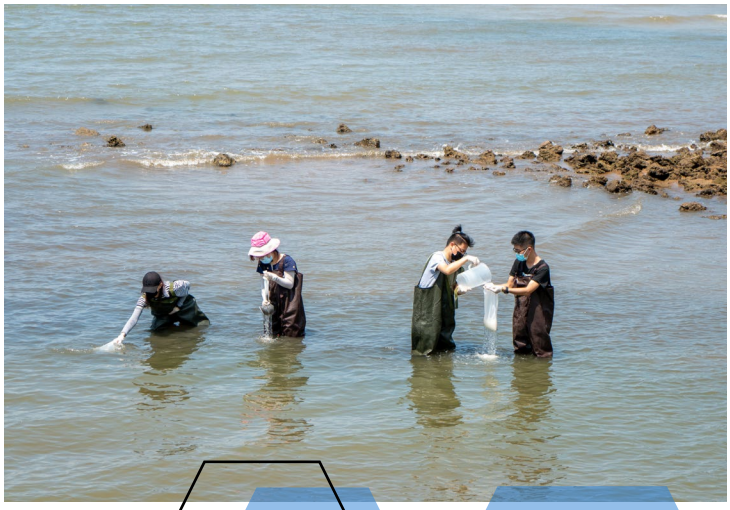
Sample collections from mangroves and seawater at the coastlines

Some of NERI's key research outcomes:

(A) MICROPLASTICS AND ITS DISTRIBUTION IN THE AQUATIC ENVIRONMENT

The first seasonal coastal microplastic report in South East Asia (SEA), comprising useful spatiotemporal information for pollution source apportionment, model prediction and mitigation planning under tropical circumstances, was produced by NERI's research team from the systematic study of microplastics distributions under the impact of prevailing Monsoons and other environmental factors.

Jong et al, 2022, "Microplastics in equatorial coasts: Pollution hotspots and spatiotemporal variations associated with tropical monsoons". Journal of Hazardous Materials, 424, Part C, 127626 [Abstract]



(B) MICROPLASTICS AND ITS EFFECT ON THE OCEANIC BIOTA

NERI researchers have demonstrated the bioaccumulation and toxicity effects of microplastics on oceanic biota. The findings showed increased biological impairment in the tropical keystone mussel species, *Perna viridis*, in the presence of finer microplastics (polystyrene (PS) particles, 0.5 µm > 5 µm > 50 µm). The immunocompetence deficiency and gill responses of the study specimens affected by the nano-PS experienced were not readily reversible. The findings from the research had suggested potential increase in the mussels' vulnerability towards further environmental stressors in the presence of microplastics.

Jong et al., 2022, "Impacts of size-fractionation on toxicity of marine microplastics: Enhanced integrated biomarker assessment in the tropical mussels, Perna viridis" Science of the Total Environment, 835, 155459 [Abstract]

Live tropical green-lipped mussels, Perna viridis, as model bioindicator for marine organisms

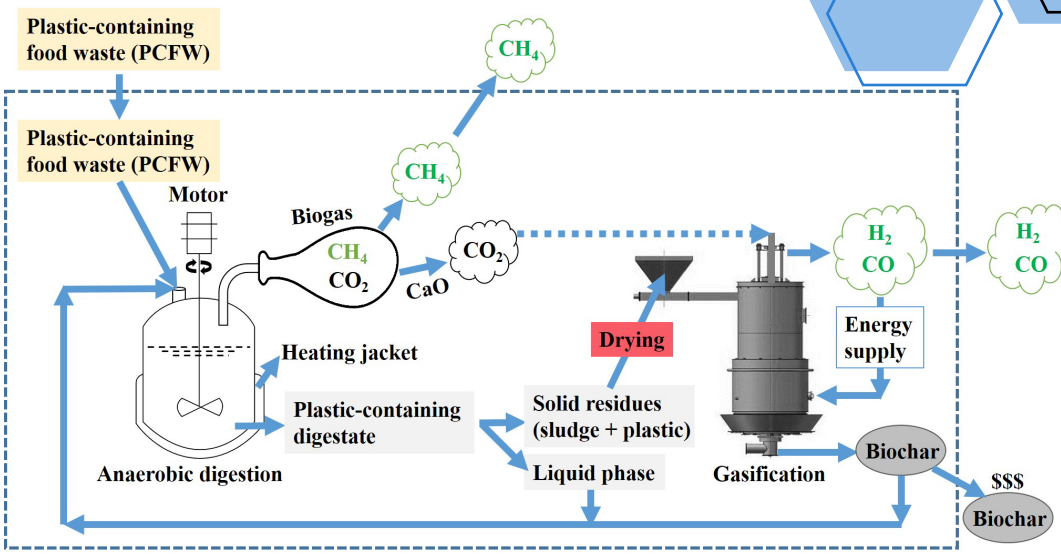
Visible microplastics fragments hand-picked from environmental samples

(C) PLASTIC WASTE TO VALUABLE RESOURCES AND PRODUCTS:

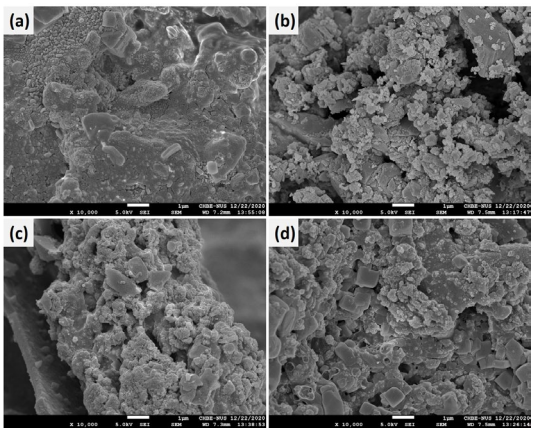
➢ *to Energy and Bioresources*

"FOOD WASTE ARE GENERALLY DISPOSED OF WITH OTHER MATERIALS SUCH AS PLASTICS AND PAPER. ONE OF THE METHODS TO MANAGE FOOD WASTE IS TO CONVERT IT INTO BIOGAS AND FERTILIZER THROUGH AN ANAEROBIC DIGESTION PROCESS, BUT THE PLASTICS WILL REMAIN IN THE FERTILIZER COMPONENT. THEREFORE, TO ELIMINATE THE PLASTICS, WE SEPARATE THE SOLIDS IN THE FERTILIZER AND CONVERT THEM INTO BIOCHAR THROUGH A GASIFICATION PROCESS, ALLOWING IT TO BE USED WITHOUT ANY PLASTIC RESIDUALS. WE CAN THEN FULLY UTILIZE THE WASTE AS RESOURCES FOR A CIRCULAR ECONOMY."

ASSOC. PROF. TONG YEN WAH



Bench-scale hybrid biological and thermal PCFW-to-energy conversion system



Images of biochar (a-sludge biochar; b-PE+sludge biochar; c-PS+sludge biochar; d-PP+sludge biochar)

NERI research team has developed a hybrid bio/thermal system, employing the anaerobic digestion and gasification technology, for plastic-containing food waste (PCFW) conversion to energy and bioresource (i.e. biochar). Higher syngas yields were produced during plastic/digestate gasification compared with pure digestate. Besides generating renewable bioresources from the waste materials, the hybrid system used for PCFW treatment could be a revenue generating technology. It is estimated that the system could provide an average profit of 20.7–64.2 US$/ton waste.

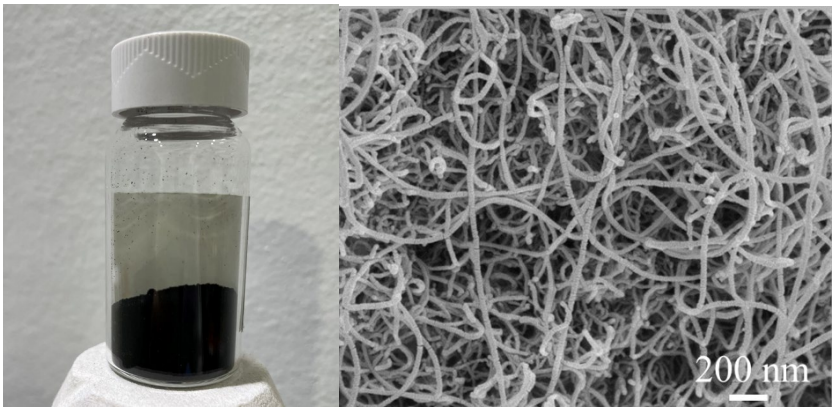
Zhang et al., 2022. "Plastic-containing food waste conversion to biomethane, syngas, and biochar via anaerobic digestion and gasification: Focusing on reactor performance, microbial community analysis, and energy balance assessment". Journal of Environmental Management, 306, 114471 [Abstract]

➢ *to Carbon Nanomaterials*

Catalytic Pyrolysis Reactor for Plastic Waste Conversion

Catalytic pyrolysis is a waste-to-resource method to address the rapid growth of plastic waste usage. NERI researchers have developed the novel bimetallic catalysts, Fe-Ni and Fe-Co. These catalysts are prepared by impregnation to convert plastic waste into carbon nanotubes. The catalytic pyrolysis generates micrometer-long carbon nanotubes and combustible gases for energy generation.

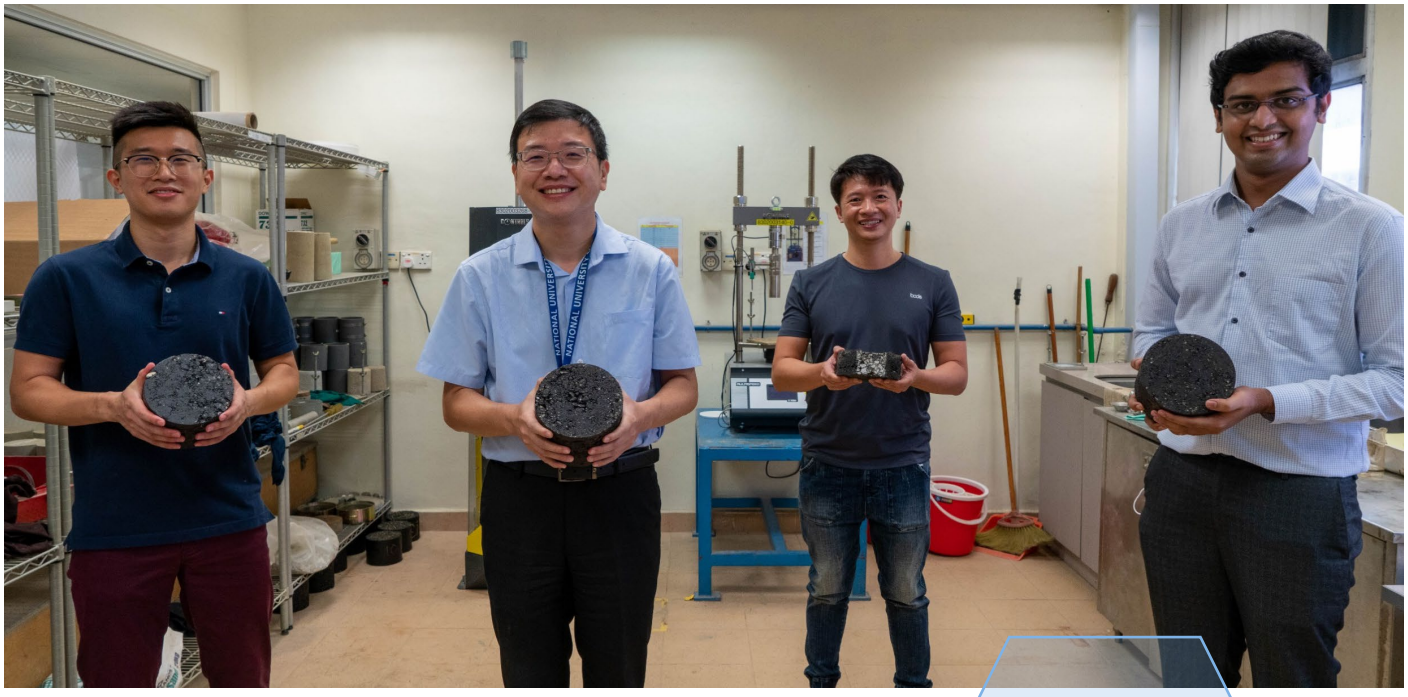
These novel carbon nanomaterials have strong (~180 mg/gCNM) adsorption capacity of metal cations such as Fe, Ag, and Ni, which aid in wastewater treatment.



Left image: Carbon Nanotubes synthesized from Plastic Waste; Right image: SEM image of Carbon Nanotubes synthesized from Plastic Waste

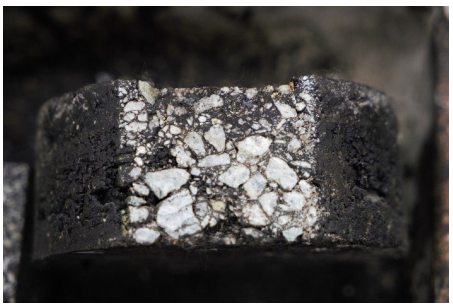
Yao et al., 2022. "Conversion of Waste Plastic Packings to Carbon Nanomaterials: Investigation into Catalyst Material, Waste Type, and Product Applications" ACS Sustainable Chemistry & Engineering, 10, 3, 1125-1136 [Abstract].

➢ *to Plastics-modified Bituminous Mixed for Roads Construction*



Research team in the waste plastics to roads studies
Left to right: Mr Li Mengfan, Research Engineer; Assoc Prof Raymond Ong, Lead Principal Investigator; Dr Albert Ng, Senior Research Fellow and Dr Ajayshankar Jagadeeshy, Research Fellow

Plastic Waste applied to road construction is another major research programme at NERI. The research team is looking into the use of plastic waste in bituminous pavement surfaces with the target of identifying the potential specifications that meet structural, functional, safety, urban cooling, noise and environmental performances that is typically required for most urban cities in developed countries. The multi-disciplinary team is also studying the air quality and fuming aspects of using plastic waste in bituminous pavement surfaces, and the recyclability of plastics-modified bituminous mix to deliver a true circular economy for plastics.



Asphalt sample with waste plastics wet-mixed into bitumen

Details of this research are available on the *videos*.

Please click here for the full list of NERI publications.

For more details on the following topics, please contact:

Microplastics in coastal environment and its effects on oceanic biota

Associate Professor Karina Gin Yew-Hoong

E-mail: ceeginyh@nus.edu.sg

Plastic-containing food waste conversion to biomethane, syngas, and biochar

Associate Professor Tong Yen Wah
E-mail: chetyw@nus.edu.sg

Waste plastics to carbon nanomaterials

Professor Wang Chi-Hwa
E-mail: chewch@nus.edu.sg

Waste plastics on roads

Associate Professor Raymond Ong
E-mail: ceeongr@nus.edu.sg

For more information on NUS Environmental Research Institute, please visit https://nus.edu.sg/neri/