NEWRI Update
Staying Connected with NEWRI
- ISSUE 15, 2019 -

A word from the Executive Director

It is hard to believe 2019 is nearly half way through and it is time to share our second newsletter of the year. I feel very fortunate every day to work with my colleagues at NEWRI and across the NTU campus, along with our global industrial, academic and government partners. In the past six months, we have achieved many successful new ventures, partnerships, projects and significant milestones in NEWRI.

For me, among the most exciting was the official opening of the Waste to Energy (WtE) testbed facility at Tuas. This project began as a vision to build a resource recovery system capable of treating all the mixed solid-waste of the NTU campus. Today, thanks to our government and industrial partners, this vision has been realised. I was greatly honoured to provide opening comments followed by speeches from Singapore's Minister for the Environment and Water Resources, Mr. Masagos Zulkifli, and NTU's President, Professor Subra Suresh. It was a very memorable event and my sincere thanks goes out to everyone who made this possible. Moreover, our primary industrial partner, JFE Corporation, has recently expanded their collaboration with NEWRI to investigate exciting water technological advancements. We look forward to using both our laboratory and testbed to investigate new technologies and applications, such as treatment of hazardous waste and increased energy yields.

Continuing our globalisation efforts, we had several opportunities to visit academic, government, and private corporate institutions from various geographies to enhance and expand our current collaborations and forging new partnerships. We also hosted distinguished guests, including the Minister of Egypt's Water Resources and Irrigation office as well as Temasek International Pte. Ltd., world-renowned city planner, Dr. Liu Thai-Ker and his colleagues from Morrow Architects & Planners, JFE Corporation, Agilent Corporation, as well as South 32 Executive Team from Australia, among others. It is noteworthy that NEWRI convened its Industrial Advisory Board (IAB) this quarter, bringing together leading experts from ten national and multinational companies and industrial organisations, as well as five of our key government entities. Our IAB members include leaders from Agilent, Citic Envirotech, Hyundai, Johnson & Johnson, Pepsico, Petrochemical Corporation Singapore, Singapore Chemical Industry Council, Sembcorp, Suez, and TrojanUV corporations.

As we embark on our second half of the year, we have begun the initial discussions regarding Tranche 4 (TR4) funding for NEWRI. This is a critical time, as our team of more than 300 people continue to work diligently hand-in-hand with our government partners towards this core funding renewal. I wish to acknowledge our core Singapore Government funding agency, the Economic Development Board (EDB) and thank our other partners; Singapore Public Utilities Board (PUB), the National Environment Agency (NEA), the National Research Foundation (NRF), the Jurong Town Council (JTC) and others for their generous support since our establishment.

I am especially happy to share that NEWRI Community, our philanthropic division enabled by the generous support of The Lien Foundation, has received forty new proposals for developing water and sanitation solutions for underserved communities in South Asia and South East Asia. New projects have already been awarded in Nepal, Malaysia, Thailand, and Myanmar, with several other projects under consideration. I am also excited that we potentially have new donors who are interested in providing additional funds towards our NEWRI Community mission of assisting and educating developing regions regarding safe and reliable water and sanitation.

Last, but surely not least, I need to thank the devoted NEWRI team of faculty, staff, visiting scientists, and students. We have established an exceedingly rigorous pace at NEWRI and if it was not for the dedication and tenacity of each team member, we could not achieve the successes you will read about in this newsletter. I am incredibly proud to work among this group of experts, but even more proud of their commitment to creating an amicable and diverse work environment that makes each day fun and exciting. Thanks, NEWRI!

Sincerely,
Prof Shane Snyder

NTU-NEA WtE Research Facility opens

Singapore's first-of-its-kind gasification waste treatment plant

Quick-fix wrap to strengthen buildings

New wrap that prolongs life of older buildings and structures

SMTC's Prof Chong One-on-one

Go one on one with SMTC's Prof Chong Tzyy Haur

Content

NEWSLETTER'S CONTENT

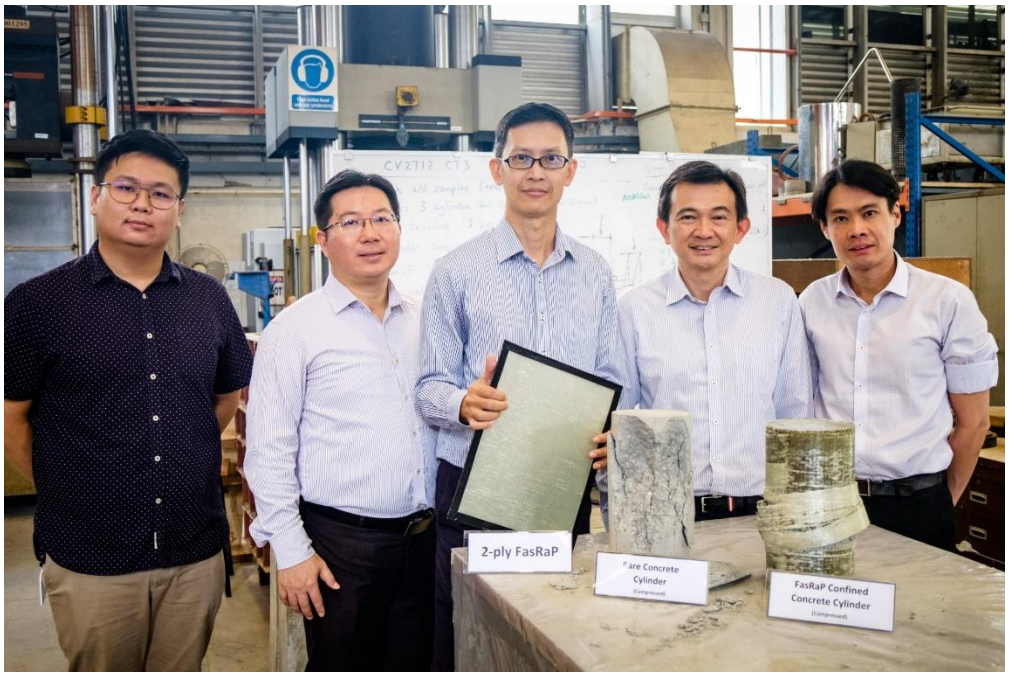
New ‘quick-fix wrap’ could strengthen buildings in half the time

Source: ST & CNA (9 April 2019)

NEWRI-ECMC’s Prof Ng Kee Woei was interviewed by CNA on his invention on “The Fast Wrapping Fibre Reinforced Polymer (FasRaP)”. It was jointly developed by scientists and engineers from NTU (Prof Ng Kee Woei, MSE and NEWRI), as well as engineers from statutory board JTC and civil engineering consulting firm Prostruct Consulting and is viable for preserving historical structures, protecting essential infrastructure.

Prof Ng commented that the team’s invention allows companies to save on manpower costs, increase efficiency and make structural reinforcement much easier to execute. "*This will help the industry prolong the life of older buildings and structures as Singapore and other urban cities age*," said Prof Ng, who is the lead project investigator of FasRaP. The joint research team is now working to commercialise their technology.

For the ST article, please click here.



(Left to right) Mr Choong Jun Jie, Research Associate, School of Materials Science and Engineering, NTU, Mr Ng Kian Wee, Senior Principal Engineer, R & D Dept, Future of Building & Infrastructure Division, JTC, *Associate Professor Ng Kee Woei (MSE & NEWRI, NTU), Dr Ang Choon Keat, (founder of Prostruct Consulting), Mr Calvin Chung (group director, engineering, JTC) with the FasRaP invention*

NEWRI AND AGILENT PAVES THE WAY IN WATER TESTING

For the full article, please click here for the PDF.

Fresh from a recent Memorandum of Understanding (MoU) signing with Agilent Technologies, NEWRI’s Professor Shane Snyder and Dr Tarun Anumol, Global Environment Market Manager at Agilent, are already solidifying their foothold in the market. Both parties are looking at regulated and unregulated water contaminants, as well as specifically focusing on areas such as analysing volatile organic chemicals in water.

Prof Shane goes on to mention that with over 15,000 new chemicals being registered in the chemical abstracts (CAS) every day, developing standards in chemical synthesis are being outpaced, leaving a large gap in the field of regulated water testing and testing of unregulated and emerging contaminants. This is one of the goals of the MoU, that is to identify new methods or new techniques to test water quality.

Dr Adil Dhalla, Chairman of the Steering Committee, SG-MEM, Singapore’s National Membrane Consortium

A CORNERSTONE IN SINGAPORE’S WATER INDUSTRY

Source: INSIGHT (Water & Wastewater Asia ● March/April 2019)

In the recent release of Water & Wastewater Asia (official newsletter of the Singapore Water Association (SWA), Dr Adil Dhalla, Chair of the Steering Committee for Singapore’s National Membrane Consortium (SG-MEM) and Chief Operating Officer of Nanyang Environment and Water Research Institute (NEWRI), was featured in the article which speaks of his contributions to the beginnings of the Separation Technologies Applied Research and Translation (START) Centre. He goes on to explain how SG-MEM was set up as an umbrella organisation to foster a vibrant academic and industrial ecosystem in the field of membranes, bringing together the minds from Singapore Membrane Technology Centre (SMTC) – NEWRI NTU, Membrane Science and Technology Consortium (MSCT) - NUS, and the Environmental and Water Technology Centre of Innovation (EWTCoI) – Ngee Ann Polytechnic. SG-MEM’s vision is broadranging, from chemical manufacturers whose products went into membrane fabrication, to the end users of membrane technologies. Dr Adil also shares his vision for the next step which is to have some of the world’s best products and processes in the field coming from Singapore.

For the full article, please click here for the PDF.

BACK to content page

WtE Research Facility @ Tuas South Officially Opens

Source: CNA, ST

The Waste-to-Energy (WtE) Research Facility at Tuas South is a 7000 square metre open platform plant that caters for test-bedding waste-to-energy technologies, and development through its unique plug and play features.

The WtE Research Facility is based on high temperature slagging gasification technology, and is the first of its kind waste treatment research facility in Singapore.

Jointly developed by the National Environment Agency (NEA) and the Nanyang Technological University (NTU) through its Nanyang Environment and Water Research Institute (NEWRI), and supported by the Economic Development Board (EDB), the project 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 facility serves as a demonstration plant for the use of biomass charcoal as an auxiliary fuel for the high temperature slagging gasification of municipal solid waste (feedstock), as well as exploring alternative measures to improve energy and resource recovery.

“To minimise the amount of waste headed for the incineration plants, we have gone one step further. We will recover value from ash or treated waste to optimise our remaining landfill, and keep it open as long as we can.“ said Mr Masagos Zulkifli, Minister for the Environment and Water Resources, who was guest of honour for the official opening of the facility on 27 May 2019.

"This new facility will enable our scientists to scale up promising ideas from lab prototypes into practical engineering solutions for sustainable waste management together with our industry partners, contributing to Singapore's vision of a zero-waste economy where waste is upcycled into valuable resources," said the president of NTU, Professor Subra Suresh.

*(Left to right: **Prof Shane Snyder**, Executive Director, NTU-NEWRI, **Prof Subra Suresh**, NTU President, **Mr Masagos Zukifli,** Minister for Environment and Water Resources, **Mr Tan Meng Dui**, CEO of NEA, at the plaque unveiling for the WtE Research Facility Official Opening on 27 May 2019*

"The university is committed to achieving a zero-waste target, and is an open test bed where Government, academia and industry leaders can collaborate to develop new innovations," he added.

The facility processes more than 11 tonnes of rubbish a day where waste materials are shredded, dried and converted into gas and other useful by-products.

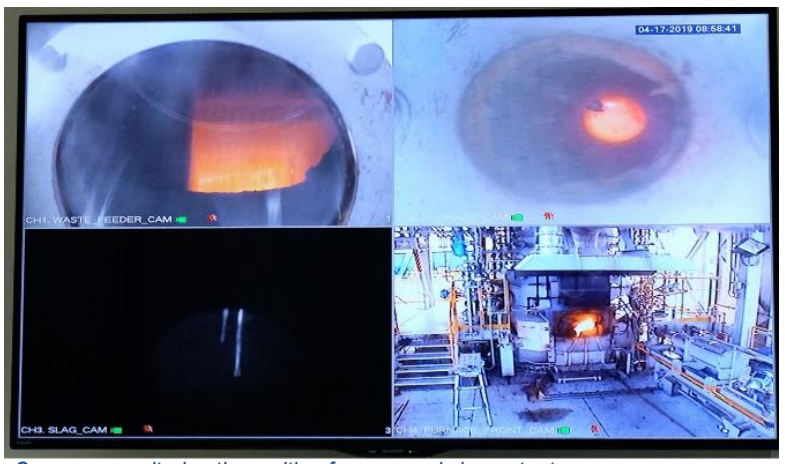
This gasification process converts municipal solid waste mostly into carbon monoxide and hydrogen, which is called a syngas. The syngas then is used to generate electricity.

In comparison, conventional mass burn incinerators operate at around 850°C. The remaining rubbish is converted into recyclable metal alloys and slag, which is a glass-like material that can be used as a replacement for sand and concrete. However, gasification as such is not novel. What is unique are its plug-and play features that allow de-risking of technologies to enhance waste treatment technology.

Continued next page

WtE Research Facility timeline

- Tender awarded end Jan 2017
- Ground-breaking – July 2017
- Commissioning Sep 2018 – Mar 2019
- Tests completed – Mar 2019
- Operation - Full handover March 2019
- Official Opening – May 2019



Cameras monitoring the melting furnace and slag output

QUICK FACTS

11.5 TONNES – amount of waste the facility handles daily
ABOUT 97% reduction in weight of waste to be disposed of after the process
UP TO 40 KILOWATTS under biomass charcoal operation
9 TO 10 operational personnel excluding researchers at the facility
0.7ha – size of land leased from JTC
PLUG & PLAY FEATURES enables testing of innovative technologies in waste-to-energy and waste-to-materials domains

BACK to content page

WtE Research Facility @ Tuas South Officially Opens

Source: CNA, ST

Asst Prof Grzegorz Lisak, Principal Investigator of the WtE Research Facility and Director of R3C-NEWRI, explaining to guests the key features of the facility.

"This plant will eventually be able to treat various types of material like hazardous waste and sludge. It also operates based on biomass charcoal, which is a more sustainable form of renewable energy," said principal investigator Asst Prof Grzegorz Lisak, Director of R3C-NEWRI. He also noted that this facility was proof that NTU-developed technology could work and be scalable in the future.

Although the facility is a demonstration plant, it is also a fully-equipped research platform. The plug-and-play features enable the de-linking of key components and testing of prototypes and pilot equipment. The expected areas for plug and play include but are not limited to:

- Syngas upgrade
- Diverse waste treatment
- Flue gas treatment
- Low grade heat recovery
- Gas separation membrane

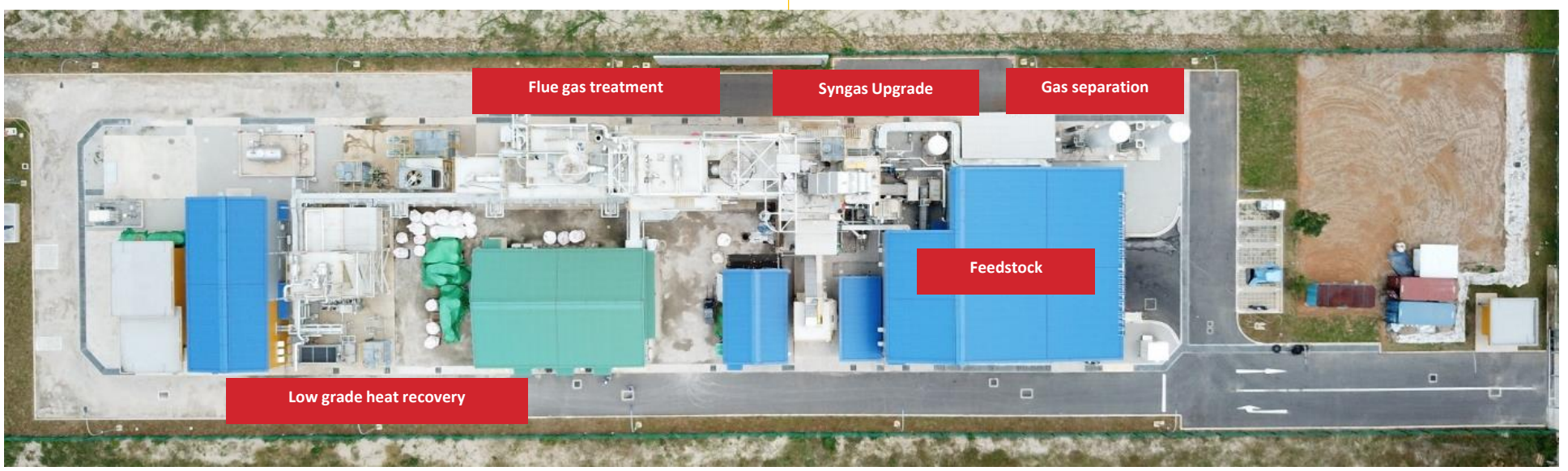
The facility aims to attract various R&D opportunities from universities, research institutes and industrial players that work on WtE or WtE related technologies.

Mr Tan Meng Dui, Chief Executive Officer of the NEA, said: "This partnership with NTU Singapore also reflects NEA's expanding focus on waste management technologies, building on NEA's traditional strengths in waste-to-energy facilities."

"The launch of this research facility in this Year Towards Zero Waste is thus timely, and holds special significance," he added.

Mr Tan, Minister Masagos Zukifli, and Prof Suresh holding the reused concrete made from using the byproducts (metal/slag), and biomass charcoal used by the facility as auxiliary fuel.

Minister Masagos congratulates Prof Synder on the success of the WtE facility opening.



Top view of the WtE Research Facility

BACK to content page

IN VITRO BIOASSAYS AS A MEANS OF WATER QUALITY ASSESSMENT

An introduction to *in vitro* bioassays as a means of water quality assessment

Contributed by: Prof Shane Snyder, Dr Li Caixia & Dr Joon Chuah

SAY, WHAT'S IN THIS DRINK?

Man-made products containing >100,000 chemicals are registered in the EU while in the US has tens of thousands are listed; and the USEPA is struggling to get a handle on which are being produced and used. In developing nations, the situation is likely to be even more dire.

This then presents a difficult challenge for environment and water agencies when it comes to monitoring the quality of drinking-water supplies, wastewater effluent and water bodies.

THE RIGHT TOOLS FOR THE RIGHT JOB

While targeted chemical analysis is often used, it is not feasible to comprehensively capture such a diverse range of chemicals potentially present.

Instead, *in vitro* bioassays can be applied to complement chemical analysis as they can incorporate the mixture effects of all active chemicals in a sample.

AN EFFECT-BASED TOOL

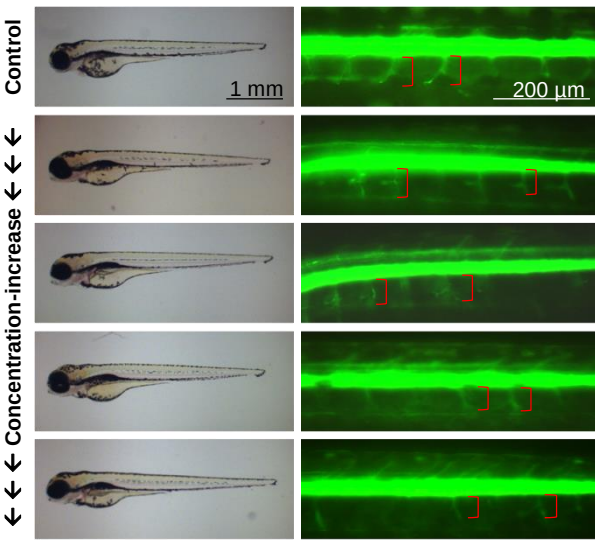
In vitro biological assay (bioassay) is the process by which the potency of a substance or the combination of substances is measured on components of an organism (e.g. cells, tissues) rather than the organism itself (*in vivo*).

Although technically *in vivo*, early life-stage whole organism assays, such as the fish embryo toxicity (FET) assay, are considered legally as *in vitro* and have been applied to evaluate the quality of water.

THE FUTURE OF H_2O QUALITY MONITORING?

While there are limitations (e.g. common sample preparation methods not ideal to enrich volatile chemicals), a lot of progress has been made to advance this science in recent years.

When applied together with analytical chemistry methods, *in vitro* bioassays can provide valuable holistic and integrative assessment of water quality.



Δ *Zebrafish have been widely used as they develop as "see through" embryos i.e. all internal development can be clearly observed from the outside. In a recent study, Li et al. observed the development of shorter nerve fibres of motor neurons in zebrafish embryos dosed with different concentrations of wastewater treatment plant effluent.*

References ***and further reading*** :

Snyder (2014). Emerging Chemical Contaminants: Looking for Better Harmony. Journal of the American Water Works Association. 106(8):38-52.

Jia et al (2015). In vitro bioassays to evaluate complex chemical mixtures in recycled water. Water Research. 80: 1-11

Leusch & Snyder (2015). Bioanalytical tools in water quality assessment: Half a century of application to recycled water. Environmental Science: Water Research & Technology. 1: 606-621

Li et al (2018). An integrated approach with the zebrafish model for biomonitoring of municipal wastewater effluent and receiving waters. Water Research. 131: 33-44

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BACK to content page

FAST WRAPPING FIBRE REINFORCED POLYMER (FASRAP)

Withstanding earthquakes or bomb blasts with Fast Wrapping Fibre Reinforced Polymer (FasRaP)

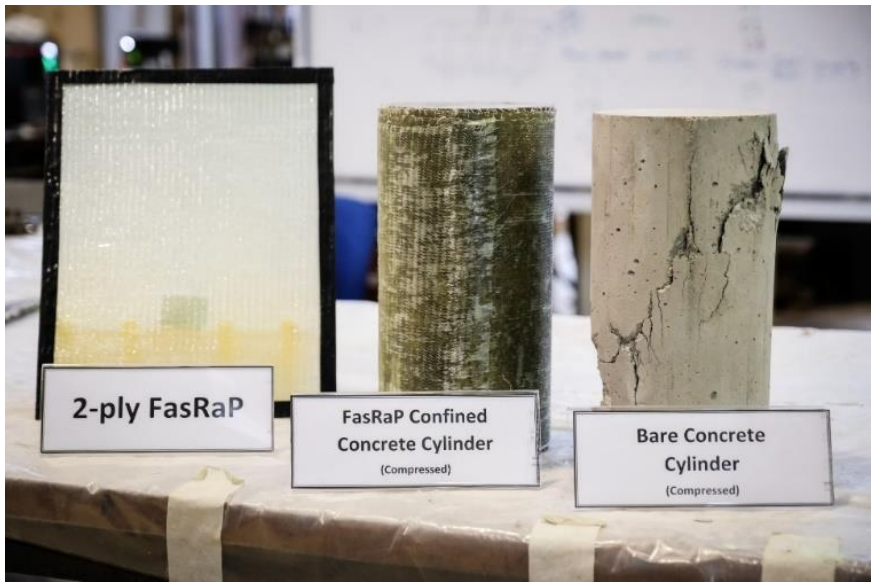
Principal Investigators: Assoc Prof Ng Kee Woei
Contributed by: Choong Jun Jie, Research Associate, MSE

Fibre reinforced polymers (FRPs) are widely used to strengthen structural elements such as columns, beams and walls. Besides conventional loading, FRPs are also used to strengthen structures against extreme loadings including blast from explosions.

Although effective and simple, the conventional application process of FRPs, however, is tedious, labour intensive and skill sensitive. Quality and consistency of the outcome is highly dependent on the experience and skill of the workers involved.

Team from NTU, School of Materials Science and Engineering

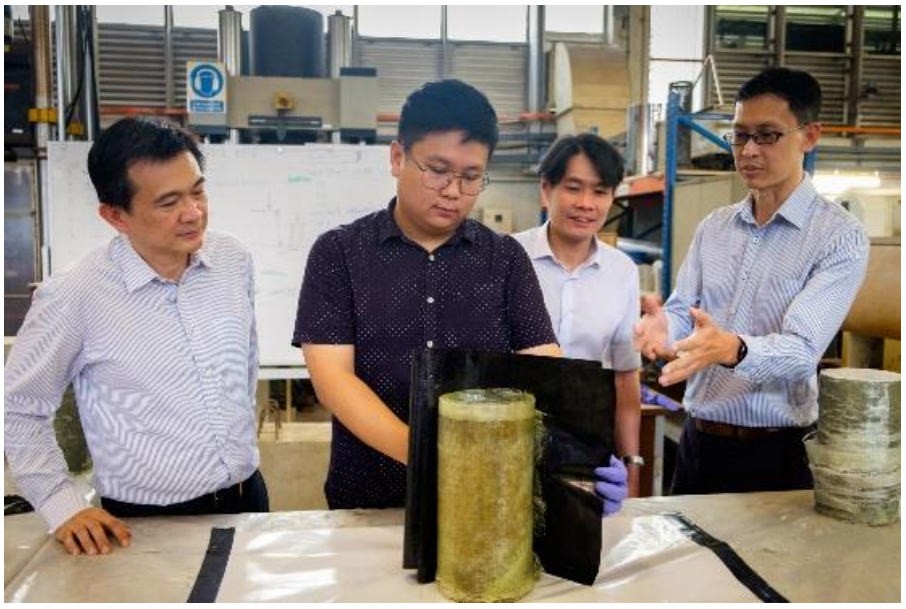
Jointly developed by engineers and scientists from NTU, JTC and Prostruct Consulting Pte Ltd, FasRaP is a fast wrapping FRP system that is pre-fabricated into rolls which can be readily applied on-site without the need for additional mechanical fasteners.



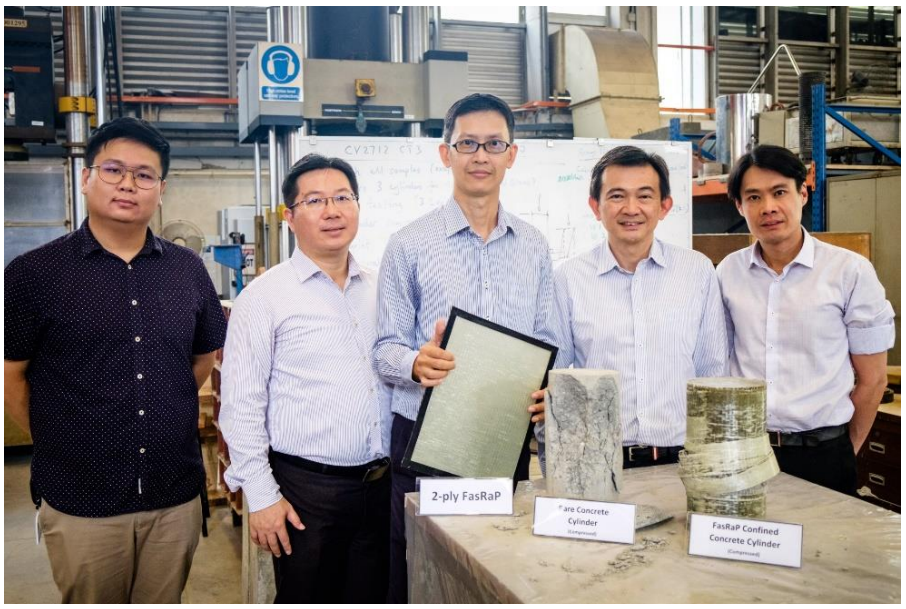
From Left to right: Sample of 2-ply FasRaP panel, FasRaP confined concrete cylinder, compressed concrete cylinder

Analogous to the ‘double-sided’ tape, the uniqueness of FasRaP lies in its ability for immediate on-site application onto the structure to be reinforced. A backing layer that prevents FasRaP from sticking onto itself is then peeled off to allow the second and subsequent layers to be applied to achieve layering effect, where necessary. There is no need to apply any resin separately and thus this approach is not dependent on the experience and skills of workers to achieve consistent finishing.

The need for resin mixing or dipping equipment on-site is also eliminated. Essentially, there is minimal technical work on-site using FasRaP. This concept therefore promises an easy-to-apply and consistent pre-fabricated FRP that significantly improve productivity.



Mr Choong demonstrating the wrapping of a concrete cylinder using FasRaP.



From Left to right: Research Associate Mr Choong Jun Jie (NTU), JTC Thrust leader Mr Ng Kian Wee, Associate Professor Ng Kee Woei (NEWRI-ECMC), Dr Ang Choon Keat (Managing Director of Prostruct Consulting Pte Ltd), Mr Calvin Chung (Group Director of Engineering at JTC)

Please click here for CNA video link

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Click here

BACK to content page

NANOSTRUCTURE MATERIALS FOR SEAWATER DESALINATION

Modelling and design of nanostructure materials for seawater desalination

Principal Investigators: Assoc Prof Law Wing-Keung, Adrian and Assoc Prof Zhou Kun
Contributed by: Madhavi Dahanayaka and Zhang Hui, EPMC

Seawater desalination is a promising solution to address water demands across the world, particularly under the increasing uncertainties due to climate changes. According to the permissable limit of salinity in drinking water is 500 ppm, therefore any desalination process will require a significant amount of energy to remove salts and minerals from the water.

Reverse osmosis, membrane distillation, forward osmosis and electrodialysis are the widely adopted technologies for seawater desalination. The main components of these technologies are the semipermeable membranes which are fabricated from polymers and inorganic materials such as zeolite and metal organic frameworks (MOFs), as well as 2D nanomaterials such as graphene (GE), graphene oxide and C_2N. The existing development processes of these membranes are typically lab-based, chemically intensive and time consuming.

Recently, with the rapid development of high performance computing, numerial modelling based on molecular dynamics (MD) simulations have shown promises as an efficient method in investigating the water and ion transport behaviours across membranes, and thus provide a powerful tool for the design and evaluation of nanomaterial-based membranes.

Using MD simulations, our group has analysed the performance of 2D nanomaterials namely GE, C_2N and MOFs as membrane materials. Their selectivity, the effects of pore size, the film morphology, and the role of functional groups have been systematically explored.

The research studies have demonstrated that the results of these simulations can be utilised to provide guidance to accelerate the development of advanced nanomaterial-based membranes for seawater desalination thus potentially bringing better products to the market places in a faster pace.

References:
Hu, Z., B. Liu, M. Dahanayaka, A. W.-K. Law, J. Wei and K. Zhou (2017). "Ultrafast permeation of seawater pervaporation using single-layered C 2 N via strain engineering." Physical Chemistry Chemical Physics **19**(24): 15973-15979.

Zhang, H., B. Liu, M.-S. Wu, K. Zhou and A. W.-K. Law (2017). "Transport of salty water through graphene bilayer in an electric field: A molecular dynamics study." Computational Materials Science **131**: 100-107.

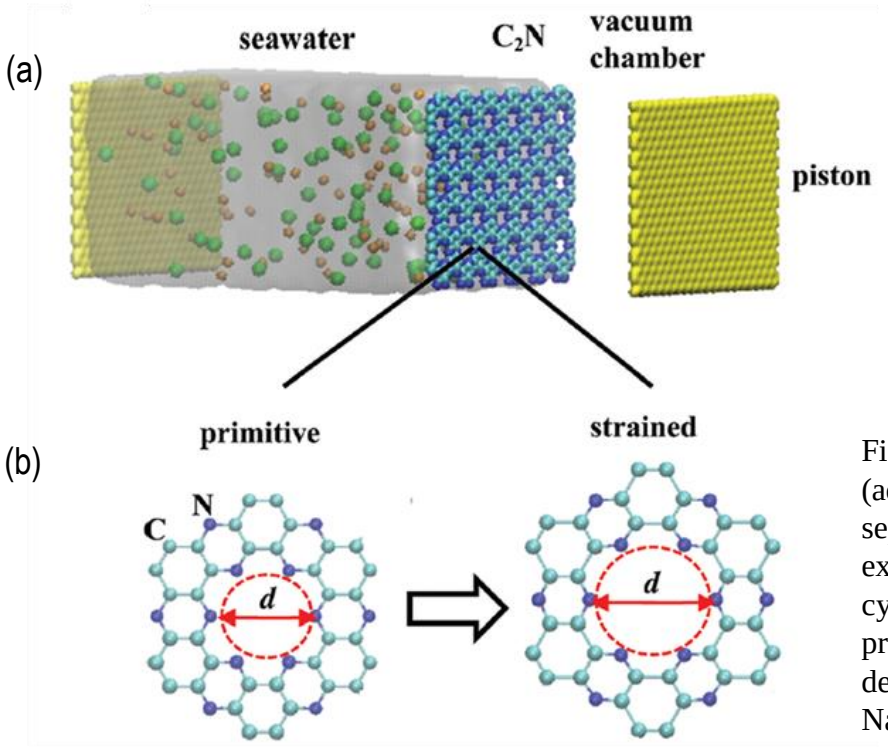


Figure 3. (a) Schematic illustration of the simulation system. Two chambers (aqueous solution with 0.5 M NaCl on the left and vacuum on the right) are separated by a C_2N membrane. Two pistons are put on both ends: the left one is exerted by atmospheric pressure (1 atm) and the right one is fixed (C of C_2N: cyan; N of C_2N: blue; Na^+: orange; Cl^-: green), H_2O: grey; piston: yellow). (b) primitive and strained C_2N layers. (c) MD simulation model for seawater desalination through a graphene bilayer (yellow and green colors represent the Na^+ and Cl^- ions, respectively).

More about Modelling & Sensing in EPMC @ NEWRI,
Click here

BACK to content page

NEW SOLUTIONS FOR SUSTAINABLE URBAN GREENERY

New Soil-water Management Technologies For Sustainable Urban Greenery

Principal Investigator: Prof Harianto Rahardjo
Contributed by: Johnatan Ramos Rivera, EPMC

Singapore is a "city in a garden" which treasures its urban greenery. The urban greenery comprises large populations of planted mature trees and shrubs. The ready availability of soil-water is fundamental to plant growth, health, and tree stability. Conversely, too much soil-water within the root zone can be detrimental to plants.

Real-time measurements of soil and water balance status have been recognised as a promising approach for efficient water management for urban greenery (Louren, 2011). Identification of proper irrigation set points is crucial for optimal growth of plants and optimal use of water.

The overall objective of this study is to develop and build prototype instruments that record parameters associated with changes in the soil-water balance. The quantification of these parameters permits the assessment of the effects of the environment and management techniques on plant health and vitality (Louren, 2010). These instruments and the water balance models will help to improve the irrigation strategies and predict areas of water balance excess and deficit in our parks.

A new Polymeric Osmotic Suction Sensor (POSS) for direct measurement of matric suction is currently being developed in NTU.
It is designed to allow direct measurement of negative pore-water pressure based on the osmotic technique principle (Biesheuvel, 2000). This sensor is expected to measure pore-water pressure in the field close to the wilting point of 1.5 MPa.

References:
Biesheuvel, P. M., et al. (2000). "A prototype osmotic tensiometer with polymeric gel grains." European Journal of Soil Science 51(2): 355-364.

Louren, et al. (2011). "Towards a Tensiometer Based Suction Control System for Laboratory Testing of Unsaturated Soils." Geotechnical Testing Journal 34(6): 755-764.

Van der Ploeg, M. J., et al. (2010). "Polymer tensiometers with ceramic cones: direct observations of matric pressures in drying soils." Hydrol. Earth Syst. Sci. 14(10): 1787-1799.

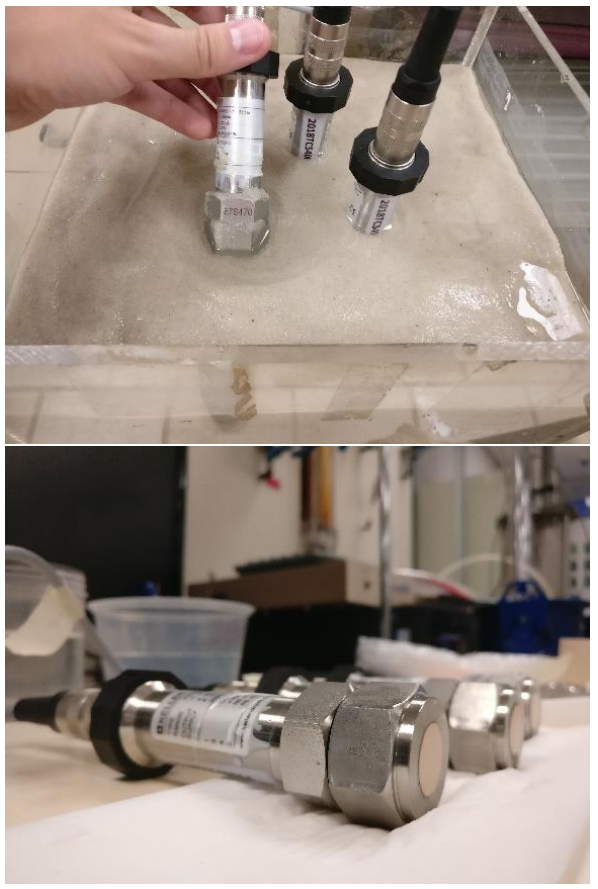
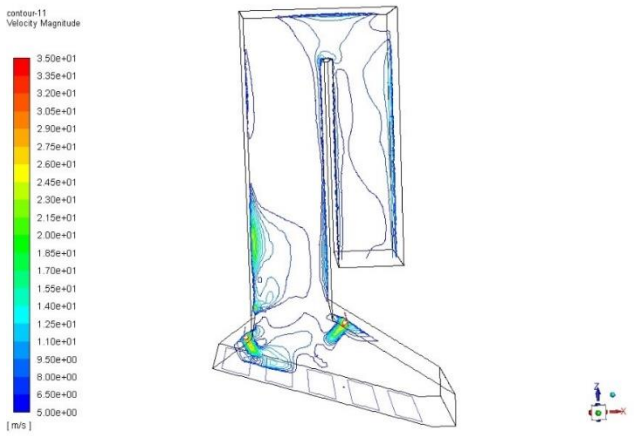


Figure 1: Polymeric Osmotic Suction Sensor (POSS)

NEW SOLUTIONS FOR INCINERATION WASTE BED

Modelling of Waste-to-Energy (WTE) plants – Lagrangian model of incineration waste bed

Principal Investigators: Assoc Prof Law Wing Keung, Adrian;
Contributed by: Dr Lai Chun Hin, Adrian



Incineration has become increasingly important for solid waste management due to its benefits of energy production and large reduction in the waste volume to landfills. However, the environmental impact of the pollutant gases emitted from the incineration process is a concern. To minimise the pollutant gas emission levels, as well as to maximise the energy efficiency, it is critically important to optimise the combustion performance of an incinerator freeboard which would require the development of reliable approaches based on computational fluid dynamics (CFD) modelling.

In this project, a one-dimensional Lagrangian model for the incineration waste bed has been developed, which can be coupled to the furnace CFD model. The changes in bed mass due to drying, pyrolysis, devolatilisation and char oxidation are all included in the model. The Lagrangian model has been validated by comparing its prediction with the experimental data in the literature. The predicted waste bed height reduction, temperature profile and gas concentration are in reasonable agreement with the observations.

A more detailed validation of the method would be conducted when additional information on incinerator geometry, waste characteristics, operating conditions, and measurement data are available.

References: Lai, A. C. H. and Law, A. W. K. (2018). "Numerical modeling of municipal waste bed incineration", *Int J Numer Method H*, 29(2), p. 504 – 522

More about Modelling & Sensing in EPMC @ NEWRI. **Click here**

BACK to content page

PORTABLE MICRO TOTAL ANALYSIS (µTAS) SYSTEM AWARDED FUNDING

Further development of a portable micro total analysis (µTAS) system for rapid on-site determination of heavy metals and phenolic compounds.

Contributed by: Dr Ge Liya, Senior Research Fellow, R3C

Highlights:

- Development of µTAS chip to pre-concentrate heavy metals, and conduct heavy metals and phenolic compound detections.
- Portable µTAS instrument to automatically conduct the detections with one-button-push analysis after sample loading.

Recently, R3C has been awarded Urban Solutions and Sustainability Integration Fund from the National Environment Agency (NEA) for a further development of a portable micro total analysis (µTAS) system for rapid on-site determination of heavy metals and phenolic compounds.

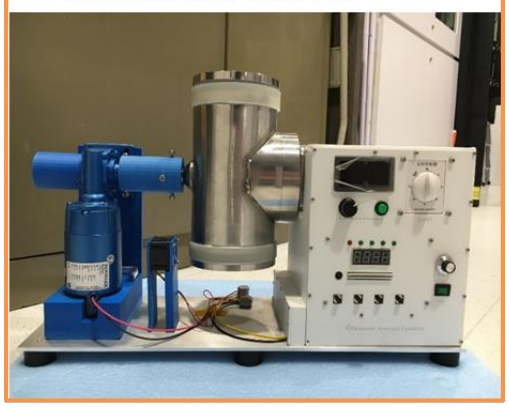
The project aims at commercialisation of the invention.

Previously, R3C has been devoted to developing a set of portable systems for rapid on-site determination of heavy metals in waste materials under the Environment Technology Research Programme (ETRP) supported by NEA.

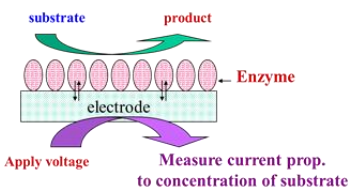
Compared with the current toxicity characteristic leaching procedure (TCLP), which requires large amount of samples and 18 hours leaching procedure followed by extensive measurement protocol, the portable systems can be used for lesser sample amount and enable a layman to perform tests on-site within an hour.

As a further extension of the earlier work, the main purpose of this awarded project is to improve the portable system, expand its application portfolio and explore possibility of its mass production and commercialisation.

Task 1: Finalize the tumbler protocol and correlate with TCLP



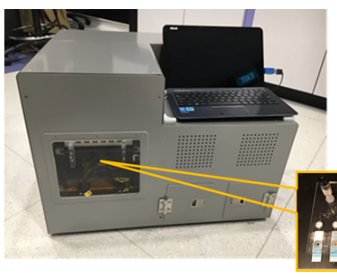
Task 2: EC chip and protocol development for total phenolic compounds



Task 1-4 show the scope and approaches of the awarded project.

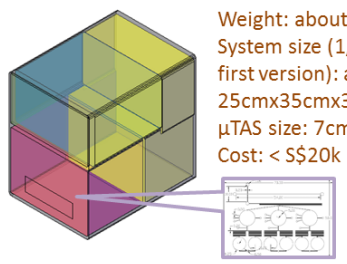
Task 3: A set of heavy metal protocols for handheld EC reader

Task 4: Development of miniaturized and light-weight SPE-EC-CE-C4D system



Weight: 11kg
System size: 65cmx45cmx45cm
µTAS size: 12.5cmx10.5cm
Cost: > S$40k

Current version includes: 4 commercial instrument, 5 motors, 14 pumps, 22 valves, 3 SPE columns, 6 EC chips, fan, and a laptop with touch screen, etc.



Weight: about 3 kg
System size (1/4 of first version): about 25cmx35cmx35cm
µTAS size: 7cmx5cm
Cost: < S$20k

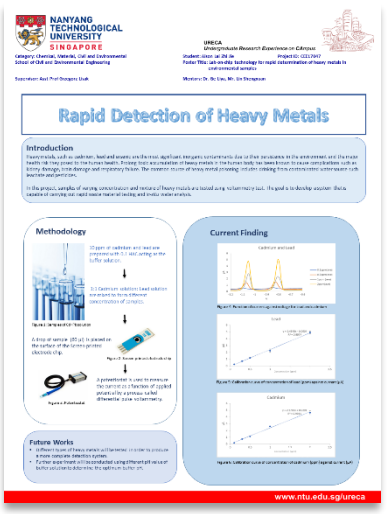
New version includes: 1 commercial EC instrument , home-made CE-C4D detector, certain motors and solenoids, pumps and valves. Touch screen, no laptop

URECA STUDENT AWARDED BEST POSTER IN COMPETITION

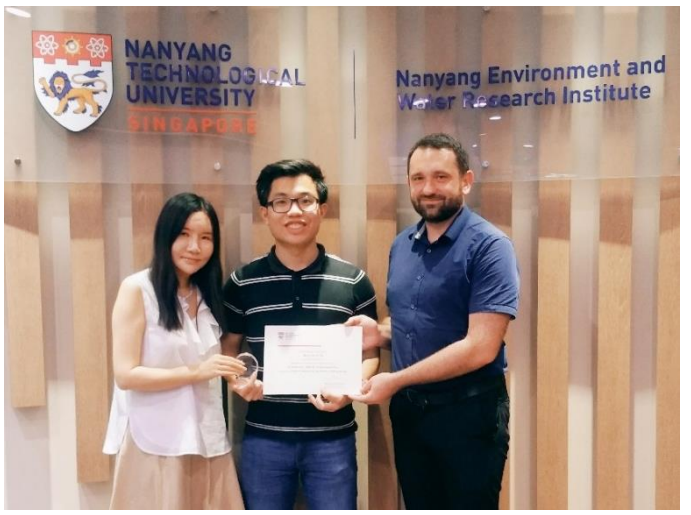
The URECA student (Alson Lai Zhi Jie, CEE student) representing both NEWRI-R3C and School of Civil and Environmental Engineering (CEE) has been awarded the best poster in the URECA poster competition in the category of civil and environmental engineering. His poster was entitled "Lab-on-chip technology for rapid determination of heavy metals in environmental samples".

Alson's research work aimed to develop a rapid detection system of heavy metals which is accurate, cost effective and time efficient.

Heavy metals are the most significant inorganic contaminants due to their persistence in the environment as well as the major health risk posed to human beings. With further testing and verification, his detection system has the potential to be developed as a small, lightweight and handheld device for rapid detection of heavy metals.



Alson's award winning poster



URECA student, Alson Lai Zhi Jie (center) was awarded the first prize in URECA poster competition seen here with Dr Liya (left) and Prof Grzegorz Lisak (right)

More information about Resource Recovery in R3C @ NEWRI, **Click here**

BACK to content page

JFE AND NEWRI IN COLLABORATION TO DEVELOP A FORWARD OSMOSIS SYSTEM

IN COLLABORATION TO DEVELOP A FORWARD OSMOSIS SYSTEM FOR ZERO LIQUID DISCHARGE

Contributed by: Dr Wang Yining, Senior Research Fellow , SMTC

Forward osmosis (FO) is an increasingly important technology that has been deemed promising for addressing the global issue of water scarcity. In specific, it has potential to overcome the challenges faced by reverse osmosis (RO) technology, such as further increasing water recovery / treating highly concentrated stream (e.g., RO brine). With a proper draw solution, FO could maximize membrane system recovery and minimise brine volume sent to downstream thermal systems to achieve zero liquid discharge (ZLD).

JFE has developed a novel thermo-sensitive polymer which can be used as draw solute in FO process (Figure 1). The polymer solution can achieve a high osmotic pressure of ~15 MPa (150 bar). It is expected that this draw solution can be used to concentrate feed solution to a great extent. The polymer regeneration using waste heat does not impose extra cost to the FO process, making it an ideal draw solution for FO application.

A team from NEWRI led by Profs. Wang Rong and Shane Snyder with extensive experiences in membrane fabrication and characterisation, membrane process operation and water quality analysis has been formed to collaborate with JFE. The objective of this collaboration between NEWRI and JFE is to evaluate the performance of this novel draw solute in FO process and the feasibility of the FO-based water treatment for achieving ZLD.

More information about membrane technology in SMTC @ NEWRI, **Click here**

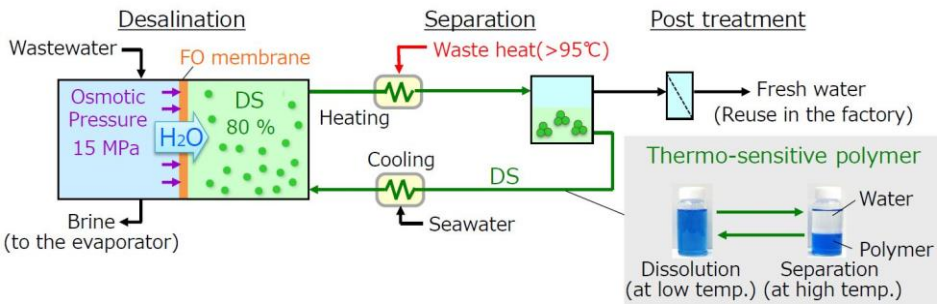


Figure 1. Conceptual diagram of FO system with JFE's polymer draw solution.

JFE and NEWRI (led by Prof Wang Rong and Prof Shane Snyder) in collaboration

PLASTICS WASTE: WHERE ARE WE HEADED FROM HERE?

Contributed by: Mr Bill Ho, Director, NEWRITech

Plastic waste is becoming a direct growing problem in South East Asia. Since China's ban on waste imports, global plastic exports to China were forecast to fall from 7.4 million tonnes in 2016 to 1.5 million tonnes in 2018. Analysis of the NEA data by Reuters showed that plastic waste per capita has increased nearly 20 percent over the last 15 years.

To raise awareness of waste issues in Singapore, the Ministry of the Environment and Water Resources (MEWR) has designated 2019 as the Year Towards Zero Waste. This brings into focus Singapore's planning of the waste management cycle for three major streams: Food waste, packing waste and e-waste, under its first Zero Waste Masterplan, as shared by Minister for Environment and Water Resources Mr. Masagos Zulkifli. To bring Singapore closer to its zero-waste goals, S$45 million has been invested in harvesting smart technology, as well as research and development. Mr Masagos said an example is finding other uses for the country's incinerated bottom ash (IBA), which is usually dumped into the Pulau Semakau landfill.

Semakau island was supposed to meet Singapore's dumping needs until as late as 2045, according to environment ministry documents. But with the use of disposable products growing at a rapid rate, the ministry's most recent estimates show that Semakau could be full a decade earlier.

Complementing plastic use reduction is circular economy design – investment in producing thoughtful, well-made products that stand the test of time, and potentially a sector of opportunity for Singapore going forward. In a recent CNA article about 'Singapore's growing multimillion-dollar addiction to bottled water?', Prof Shane Snyder commented on the *'ease of getting a plastic bottle of water in Singapore'* which contributes to the growing plastic waste problem. Mr Ravi Krishnaswamy, senior vice president of energy and environment at Frost & Sullivan Asia Pacific also commented "*I don't think people have yet to realise the plastic waste generated from the bottled water is a huge environmental issue*".

At the Nanyang Environment & Water Research Institute (NEWRI) work is being carried out by our researchers, in collaboration with industrial partners, to derive constructive solutions to be implemented as quickly as possible in conjunction with Singapore's initiative to tackle waste problems. One such initiative is the Waste-to-Energy Research Facility (WtE) at Tuas South which aims to help reduce, and also to a large extent reuse, post-treatment residue.

Where NEWRI stands out among major academic research institutes, is in its capability to build prototypes at scale - translating technology developed in a laboratory to a level that would convince an industry partner to embrace and further refine it to enable commercialization. These strategies employed by NEWRI include its commercialization platform for global partnerships to tackle environmental issues.

More information about business development @ NEWRI, **Click here**

BACK to content page

A CLOSER LOOK AT OUR ANALYTICS

In the NEWRI Analytics Cluster, the state of the art equipment in the NEWRI laboratories offer a strong analytical support to researchers. A new series of seminars - Pitch to NEWRI's Analytical Needs, conducted by NEWRI Analytics Team, offer to address common yet challenging analytical issues faced by our researchers. The seminars intend to cover topics that are highly relevant to NEWRI research fields, basic theory, and practical tips.

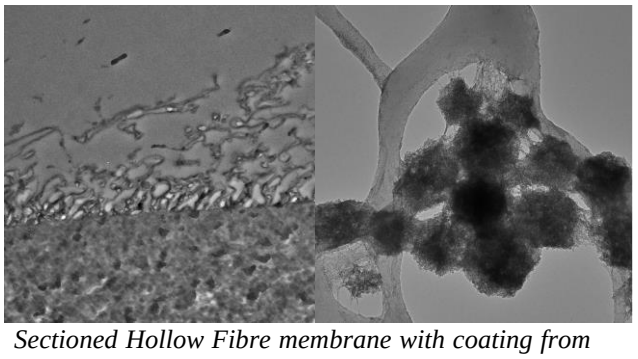
Ms Janelle Ng presenting the seminar on 11 Apr 2019

The first seminar of this series which focused on Transmission Electron Microscope (TEM) sample preparation techniques was presented by Ms Janelle Ng (NEWRI Analytics Cluster) on 11 Apr 2019 to some 30 researchers.

Aside from skilled TEM operation, sample preparation is actually one of the most critical determining step in obtaining a good TEM image. The unique challenge presented to NEWRI is that it deals with both material and biological samples.

With this in mind, the seminar covered both basic theoretical understanding and practical steps of material and biological sample preparations.

The seminar was very positively received, with some participants hoping for more of such similar seminars for other high-end instruments.



Sectioned Hollow Fibre membrane with coating from SMTC (left), Nanoparticles from AEBC (right)

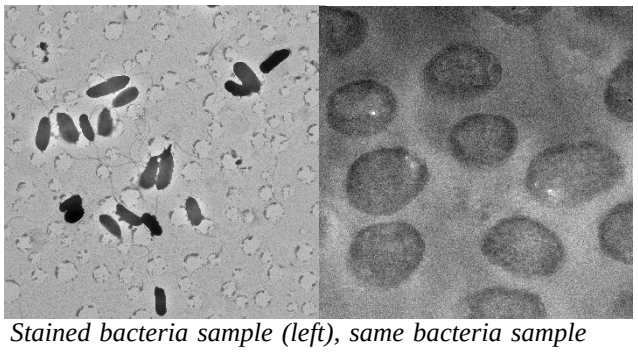
TEM is becoming more recognised in publications as an advanced characterisation technique that is able to capture images of the sample's internal structures and lattice spacing at extremely high magnifications. Combined with elemental composition detection, it has helped researchers gain invaluable insights of what is going on in their samples.

What is the general criteria for samples to obtain a good TEM image?

No solvents or salts, homogenous size (for particles), well dispersed, no deformation under vacuum, less than 200nm thickness, and good contrast.

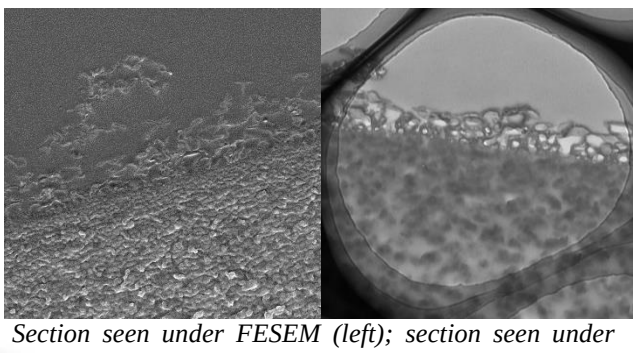
How do I prepare biological samples for imaging?

- Fixation (no deformation under vacuum)
- Gelatin & trimming (easier pelleting)
- Staining (good contrast)
- Dehydration (better for vacuum & resin infiltration)
- Resin embedding (enable sectioning)
- Ultramicrotome sectioning (thin sample to <200nm)



Stained bacteria sample (left), same bacteria sample but sectioned (right)

Good sections seen as white and homogenous in colour (left); poor sections with a thicker portion in gold in the middle (right)



Section seen under FESEM (left); section seen under TEM (right)

How do I know whether to use TEM or Field Emission Scanning Electron Microscope (FESEM)?

The most important consideration is whether the user wishes to see internal or external structures. With FESEM, only loading and coating is needed (completed in less than 10 min), and only 2 alignments are needed to image. If a user wants to see external structures, FESEM is a much more efficient method.

TEM is preferred as it can go to higher magnifications than FESEM if a sample is at nano-scale.

TEM takes up a lot of time and requires a lot of optimization and practice. Preparing one sample takes 1-7 days, and can be observed if the sample is prepared well after imaging. Users usually take at least 10 hours of practice to get a decent basic image. Each sample also takes about 1h to image. If the sample is not prepared well, the user will have to repeat sample preparation, optimization, and imaging. If the user is prepared to go through this process, then TEM is worth exploring.

How do I tell whether a section has been sectioned well?

A homogenous section will have the same colour throughout. The whiter the section, the thinner it is. Generally, it is more preferred to have thinner sections as the sample will look clearer under the TEM.

What is the difference between using a glass knife and an ultrasonic diamond knife for sectioning?

A glass knife is blunter than a diamond knife. Cost-wise, the diamond knife is more than 100-1000 times more expensive. The normal system will use a chopping motion to cut the sections. An ultrasonic system will help the knife to move in a sawing motion, while slicing the section. The sawing motion helps to make the section cut more easily, and reduce compression effects.

More information about Analytics Cluster @ NEWRI, **Click here**

BACK to content page

AN INTERVIEW WITH *Assistant Prof Ziggy Chong Tzyy Haur*

Assistant Professor Chong Tzyy Haur (Ziggy) is the Deputy Director, Singapore Membrane Technology Centre, Nanyang Environment and Water Research Institute (NEWRI-SMTC). A pioneer researcher from the early days of NEWRI, Prof Chong has since grown leaps and bounds, having published several papers and journals. We caught up with Prof Chong for a quick interview.

Could we know about your background and expertise?
What attracted you to your field of research, and eventually to NEWRI?
My background is in Membrane Process Intensification: "*Engineering for Efficiency and Sustainability*". It compliments the research interests of NEWRI-SMTC which are focused on enhanced module and system design, fouling control, non-invasive sensors, hybrid membrane chemical and bio-reactors, energy and sustainability related issues. I started my research career at NEWRI-SMTC after completing my PhD degree at CEE, NTU in 2007. I first joined NEWRI as a Research Fellow in 2008, one of the pioneer batch of researchers at NEWRI. I became a Senior Research Fellow in 2011, and later joined CEE as a Faculty in 2014 and as Deputy Director of SMTC since January 2015.

Asst Prof Chong Tzyy Haur (left) with Prof Willaim Krantz (Professor Emeritus & President's Teaching Scholar, University of Colorado, Professor Emeritus & Ohio Eminent Scholar, University of Cincinnati) upon winning the Global Water Challenge award 2017.

Which projects from your career are you most proud of?
Why and what is the impact of that?
Module and System Design:
This project aims to improve the efficiencies of seawater desalination process. The first approach is through a multistage-process known as the energy-efficient reverse osmosis (EERO), which combines NF and RO membranes to reduce the osmotic penalty for high water recovery, i.e., from current limit of 40-50% to ≥60%, at modest energy consumption. The EERO process is also suitable for handling high salinity brine such as produced water.

The second approach is to enhance the hydrodynamics thus reducing the irreversible losses such as concentration polarisation and fouling in spiral wound module (SWM) with novel-designed spacers fabricated via 3D-printing technology.

Sensors:
Early fouling detection is critical for plant operators to optimise the timing to implement mitigation measures, such that membrane fouling can be controlled within an acceptable level, excess chemical consumption can be avoided and frequency of cleaning-in-place can be reduced significantly, thus lower the overall cost of production. Examples of novel non-invasive fouling sensors include the electrical impedance spectroscopy (EIS), which are more sensitive than current method based on delta pressure drop and can be easily installed in the plant. The application of this technology in seawater desalination is in collaboration with Kurita R&D Asia Pte. Ltd.

Can we have some examples of how your projects have helped address specific challenges in Singapore, e.g. novel membranes and new developments?
Sustainable water supply and management is critical for Singapore. Membrane technology has an important role in the water cycle, for example in water and wastewater treatment as well as desalination and reclamation. Thus, an improvement in the process design and operation can lower the energy consumption and water production cost.

What do you see as some of the key future directions for SMTC?
SMTC has established itself and internationally recognised in the domain of membrane for water and environment over the past 11 years. But, it shall be noted that membrane technology has a wide application in other industries such as bio-pharma, food & beverage, petro-chemical etc. for separation, concentration or recovery of resources. Thus, our center will extend the research activities to cover these areas and industries which are the key pillars of Singapore's economy.

Asst Prof Chong Tzyy Haur (right) with Director of SMTC, Prof Wang Rong, upon receiving the Nanyang Education award in 2018.

What is your research and career plan for the next few years?
To stay competitive in research and aspire to bring the discovery in laboratory to application and implementation in the industries that benefit Singapore and globally.

What do you think NEWRI should do to not only maintain but grow its recognition as one of the world's best environment and water research institutes?
I believe to move beyond water and environment, the extension to sustainable urban solutions and circular economy will help growth.

For more information about SMTC,
Click here to view SMTC @ NEWRI

BACK to content page

PUBLICATIONS FOCUS

In this series, we bring to light a few from the numerous publications to highlight in this segment. At NEWRI we do not forget our foundation which is deep scientific research. NEWRI's researchers and professors from our various Centres of Excellence publish frequently in journals, conferences and keynotes.

Journal of Membrane Science
Volume 558, 15 July 2018, Pages 34-44

Coarse-grained molecular dynamics study of membrane distillation through meso-size graphene channels

Hui Zhang, Bo Liu, Hieu Trung Kieu, Mao See Wu, Kun Zhou, Adrian Wing-Keung Law

Abstract

Molecular dynamics simulations have now been broadly applied to investigate membrane transport and optimize membrane design, but mostly for nanostructures without the involvement of phase change due to the enormous computational time and spatial scale requirements. In the present study, a coarse-grained molecular dynamics model is developed to overcome the limitations in simulating membrane distillation through meso-size (2–5 nm) channels formed by graphene bilayer at the direct contact mode.

The new coarse-grained approach enables the comprehensive evaluation of the influences of channel opening, hydrostatic pressure, and temperature. In addition, the evaporation processes at the membrane surface as well as the water vapour transport can now be analysed in a statistically reliable manner. The coarse-grained results show that the permeate flux through the graphene bilayer channels is almost three-order-of-magnitude higher than the commonly used microporous polymer membranes nowadays, which demonstrate the significant application potential. Increasing the hydrostatic pressure is found to be uneconomical due to its limited effects. The enhanced evaporation at small channel opening is due to the elevated collisions among the interface water molecules. Most importantly, the permeate flux shows a non-monotonic dependence on the channel opening. The flux is highest when the channel opening is 2 nm, after which the dominant transport of water molecules inside the channel transit from surface diffusion to activated Knudsen transport.

This finding has an important implication towards the design of graphene bilayer membranes for membrane distillation in the future.

Electrochemistry Communications
Volume 101, April 2019, Pages 11-18

Plastic derived carbon nanotubes for electrocatalytic oxygen reduction reaction: Effects of plastic feedstock and synthesis temperature

James Guo Sheng Moo, Andrei Veksha, Wen-DaOh, Apostolos Giannis, W.D. Chanaka Udayanga, Sheng-Xuan Lin, Liya Ge, Grzegorz Lisak

Abstract

Closing the resource loop by transforming plastic waste into higher value products is an important step for changing from a linear to circular economy. Using a sequential pyrolysis and catalytic chemical vapour deposition process, plastics have been successfully converted into carbon nanotubes (CNTs). Pure low density polyethylene (LDPE), polypropylene (PP) and mixed plastics (MP) were used as raw materials in the two-stage process.

In the first stage, the plastics were pyrolysed at 600 °C. In the second stage, the non-condensable gases were converted into multi-walled CNTs over a Ni-based catalyst at two different temperatures, 500 and 800 °C. The influence of plastic feedstock and synthesis temperature on the performance of plastic-derived CNTs as electrode materials in electrocatalysis was investigated.

The CNTs were evaluated as electrode materials for their heterogeneous electron transfer rate using a redox probe, which showed improved electrochemical behaviour. For oxygen reduction reaction (ORR), CNTs produced at 500 °C demonstrated superior performance compared to those produced at 800 °C. Influence of feedstock on electrocatalytic ORR activity of the as synthesised CNTs was marginal.

Temperature was the governing factor influencing the properties of CNTs due to annealing and oxidation of edge defects generated during synthesis at higher temperatures.

To view the catalog of titles, you can log on to the NEWRI webpage on PUBLICATIONS for more information.
CLICK HERE for more NEWRI publications.

BACK to content page

PHILANTHROPY EFFORTS

NEWRIComm Expansion Efforts in Yangon, Myanmar

Since October 2018, NEWRIComm's philanthrophic efforts in St John Bosco Kindergarten has benefited over 1,500 residents with clean water access in Hlaing Thar Yar township. The reverse osmosis treated water is distributed to over 200 families and 500 St John Bosco students, staff and resident nuns.

Over 1500 residents in Hlaing Thar Yar is now accessible to affordable safe clean water .

With strong support from community influencers such as the district monastery's head monk and village head, NEWRIComm continues to expand its work on Kalar Gyi Su quarter's communal ponds to provide clean water access in in Hlaing Thar Yar Township. The project is expected to benefit over 3,000 residents, students and monks.

Hlaing Thar Yar is an industrial city in the Yangon Division which host many factories and migrants originated from different parts of Myanmar. Due to the slum-like conditions, the town faces poor waste management and access to clean water. Many of its residents rely on communal pond and bottled portable water for their daily needs.

Community leaders and residents gathered in celebration of the launch of water treatment plant at Don Bosco kindergarten.

NEWRIComm Engineers work closely with appointed contractor to ensure WHO water quality standards are achieved.

Lien Environmental Fellowship (LEF) Programme Call for Proposal Results

NEWRIComm's fourth call for proposal has concluded and 6 projects have been selected to receive funding in 2019.

The LEF call for proposal exercise has received over 40 applications from various institutions in South East Asia and South Asia region. The proposals submitted identified various environmental research and problems associated in the area of sanitation and clean water access. After careful review of all completed applications and submitted recommendations, a final approved list of projects with site assessments were accepted. The new projects will expand NEWRIComm's geographical footprint regionally.

NEWRIComm is excited to welcome new fellows on board and looks forward to beginning a new chapter to benefit more underserve communities in Asia.

NEWRIComm management conducted site assessment for LEF fellowship at Khon Kaen, Thailand

NEWRIComm management conducted site assessment for LEF fellowship at Khon Kaen, Thailand

NEWRIComm administers the Lien Environmental Fellowship (LEF). The LEF programme aims to enable successful applicants from universities, research institutions, government agencies, non-government organisation and non-profit organisation based in Southeast Asia, and South Asia to improve water and sanitation management for their home communities by developing and implementing scalable and sustainable technology-based solutions. With an emphasis on full-scale implementation and education, LEF seeks to accrue benefits beyond the award recipients, and towards the communities. Through NEWRIComm, NEWRI's know-how is deployed to help communities through training, education, and implementation of engineering solutions.

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BACK to content page

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Environmental microbiology

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Bioelectrochemistry, resource recovery

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Water treatment and recycling, biosolids management

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Cluster Leader
A/Prof Irvine Kim Neil
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Asst Prof Xu Chenjie
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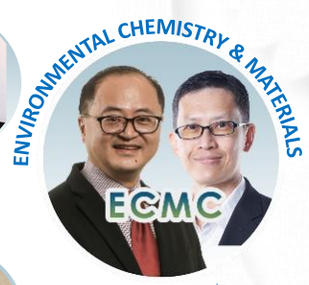

Director
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Nature derived nanomaterials and nanotoxicology

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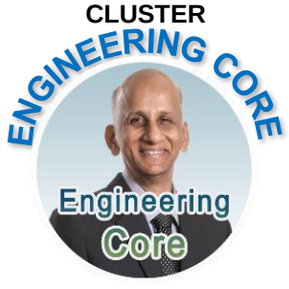

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Engineering & operations

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Asst Prof Thomas Fang

Manager
Dr Han Yuan

Analytical laboratories & systems

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Mr Bill Ho
Technology and commercial development

BACK to content page

EVENTS & SEMINARS

Enhancing staff knowledge and experiences, NEWRI holds regular in-house workshops and seminars by fellow researchers and visiting professors, scientists, institutes, and external visitors; allowing knowledge to diffuse throughout the organisation. Here are some highlights:

"Disinfection By-Products"
(6 May 2019)
Prof Jean-Philippe Croué, Environmental Science and Engineering, University of Poitiers, France

"Dynamics of Fluid Flows at Interfaces" (9 May 2019)
Prof Emilia Nowak, Senior Lecturer, School of Food and Advanced Technology, College of Sciences, Massey University

"Advanced Materials and Technologies for Modular Water Treatment" (16 April 2019)
Prof Jaehong Kim, Henry P. Bectron Snr. Professor of Engineering and Department Chair of Chemical and Environmental Engineering in School of Engineering and Applied Science, Yale University

"Pitch to NEWRI's Analytical Needs: TEM Sample Preparation Techniques (Membranes, Bacteria, Powders & Nanotubes)" (11 April 2019)
Ms Janelle Ng, NEWRI Analytics Cluster

"Starch-based Plastic Materials: Opportunity and Challenges" (2 April 2019)
Prof Long Yu, Director of Sino-Singapore Joint Research Institute (SSIJRI) and Professor in South China University of Technology, Guangzhou China

"K-water's Appropriate Technology: A Rapid, Reliable Total Coliforms Test Method that Does Not Require an External Energy Source" (2 April 2019)
Prof Gyucheol Lee, Principal Researcher, K-water.

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STUDENT LIFE

In our student segment, we speak with our students and discover their experience, thoughts and aspirations. Find out what's burning their midnight oil and what is driving them forward.

NEWRI works like a big family with different cultures. I have made lots of friends with different backgrounds, and we communicate and learn different cultures from each other in our daily life. The admins and staff here are very nice and helpful; they helped me a lot during the study.

Much like an incubator for the potential researchers with a nice academic atmosphere. There are lots of facilities as well as professional technicians which would make sure the research goes well. Also, the cooperation between different disciplines is highly recommended. Experts from different domains join in discussions on experimental design. In summation, I enjoy studying here and I think it has provided me all what I need for PhD life.

Bao Yueping - Currently final year (ECMC/SMTC)
Current research area - Advanced oxidation processes combined with membrane technology for water purification.

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The PIs and the members of their research groups are very knowledgeable in their area of research. They are very open to collaborations with the industry and other areas of study, thus bringing their work to a new level.

The advanced and continuously upgraded facilities greatly supported research work, as well as a proper management system which ensures safe and smooth operation of the laboratories.

Annie Soh Yan Ni - Currently final year (AEBC)
Current research area - changes in the production of soluble microbial products during anaerobic wastewater treatment.

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Inquiries about our environmental science and engineering research?
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BACK to content page