NEWRI Update
Staying Connected with NEWRI
- ISSUE 16, 2020 -

NEWRI WELCOMES THE YEAR OF THE RAT 2020

Associate Prof Zhou Yan
wins 2019 ASEAN-US Science Prize for Women

The 2019 ASEAN-U.S. Science Prize for Women, organized by ASEAN and USAID, highlighted the theme on the "Circular Economy". Prof Zhou Yan was recognized at the ASEAN Ministerial Meeting on Science, Technology, and Innovation in Singapore (Oct 2019).

Zebrafish as a biomonitoring tool for wastewater effluent

A model for toxicological studies

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Singapore Vision on Zero Waste Masterplan and Climate Change Challenges

Highlights

Prof Shane Snyder in CNN's INNOVATIVE CITIES looks at how Singapore tackles water shortage

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Dr Adil Dhalla speaks with the WEFTEC NOW studio about membrane technologies

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Mr Dinesh Sharma, VP of SWA in 'Emerging Trends in the Water Industry' inaugural seminar

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NEWRI Update

A word from the Executive Director

Dear Friends and Colleagues,

Happy New Year! We just entered 2020 and the Lunar New Year is just ahead. For me, this marks the beginning of my third year at NEWRI. It has been an amazing experience to work with the world's best and brightest faculty, students, and staff.

In addition, we have forged many new public and private partnerships for bilateral co-creation of transformative technologies to improve and sustain our planet. In this newsletter, you will hear about only a few examples of our recent achievements and partnerships. I encourage you to investigate our website to read more about NEWRI, or better, to arrange a tour of our facilities and meet with our team.

Today, NEWRI remains a team of more than 300 people with an average annual research expenditure of approximately $30 million USD. While NEWRI already has generated over 1500 peer-reviewed publications and more than 150 intellectual property filings, we are continuing to grow year after year. For 2020, we look forward to expand our efforts in artificial intelligence and machine learning, create newer generations of inorganic and hybrid membranes, create and deploy a new generation of catalytic materials for oxidation and reduction of water contaminants, engage more deeply into value added resource recovery from plastics, sludge, and other wastes, and most importantly, continue to education the future thought leaders through our education programs.

We also have substantially increased our core analytical capabilities with several new mass spectrometers, pathogen identification systems, and in-vitro bioassays using human cell cultures and zebrafish embryos. Our philanthropic work has now benefited over two million people in underserved communities of Asia, and we will soon announce bold new plans to empower these underserved communities further with water recycling technologies.

Together, NEWRI and our partners are entering into 2020 with an unprecedented optimism and recording breaking funding from competitive grants. We continue to recruit new talent with even greater diversity and breadth of expertise. I very much appreciate the opportunity to serve as Executive Director of NEWRI, but also to continue my own research endeavors as a faculty member. Without question, we are off to a great start for 2020 and I strongly encourage you to communicate with us and to join our Research, Engineering, and Development (RED) journey!

Sincerely,
Shane A. Snyder

NEWSLETTER'S CONTENT

NEWRI Update

Climate Change gets Personal

Joshua Lim (of CNA's *Why It Matters* series) talks to some prominent figures in climate change including Prof Benjamin Horton, Asian School of the Environment, NTU), Dr Huang Danwei (Dept of Biological Science, NUS), Dr Adam Switzer (EOS, NTU) and NTU NEWRI's Prof Shane Snyder. Prof Shane goes on to speak about climate change, fresh water issues, and desalination.

Watch the CNA episode here.

Source: CNA (Dec 2019)

Source: WEFTEC (Oct 2019) screenshot from video

Dr. Adil Dhalla in the WEFTEC Now Studio

Dr. Adil Dhalla, Managing Director, START Centre, NTUitive, and Chief Operating Officer, NEWRI, NTU Singapore visited the (Water Environment Federation Technical Exhibition and Conference) WEFTEC Now Studio to discuss membrane technologies and surrounding business practices. Dr Adil also shared his views on how and why Singapore has developed a diverse portfolio of water resources. Interviewed by WEF's Travis Loop, Dhalla explained how Singapore has taken steps to capture rainwater for use as well as reclaim its wastewater to standards "beyond drinking water quality." Watch the interview here.

Emerging Trends in the Water Industry Inaugural Seminar @ Cleantech One

NEWRI and several water industry stakeholders shared interesting and eventful network sessions at the inaugural and insightful seminar "Emerging Trends in the Water Industry" on 10 October 2019. SWA Vice-President (Administration), Mr Dinesh Sharma (SWA's Vice President) delivered his welcome address to more than 70 participants while NEWRI Executive Director, Prof Shane made his opening address by giving an overview of water problems in South East Asia.

Please click for SWA website, and their links to events

Image by NTU NEWRI

Screen capture from CNN's Innovative Cities (Sept 2019)

How Singapore is using technology to solve its water shortage

Rapid urbanization and rising global temperatures are making access to natural water sources increasingly hard to come by. Today, a quarter of the world lives in areas of high water stress. "*Singapore truly has become a global water hub*," said **Prof Shane Snyder**, executive director of the Nanyang Environment & Water Research Institute at Singapore's Nanyang Technological University. "*But as it stands, it imports approximately 40% of its water today. And with climate change, that water has become far less dependable*."

For the CNN video, please click here.

One of Singapore's oldest water treatment plants upgraded for $162m to boost water resilience

"*New ceramic membranes at the Choa Chu Kang plant could tackle a wide range of water quality. This will allow Singapore to be more secure in providing safe and reliable water to its citizens*" **Prof Shane Snyder** commented in an article on the upgrading of one of Singapore's oldest water treatment plant; Choa Chu Kang Waterworks.

For the ST article, please click here.

Source: ST & Newpaper (29 Aug 2019)

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ASSOCIATE PROFESSOR ZHOU YAN

https://asean.org/asean-us-announce-winner-asean-us-science-prize-women-2019/

Associate Professor Zhou Yan, Deputy Director of Advanced Environmental Biotechnology Centre, Nanyang Environment and Water Research Institute (NEWRI-AEBC) recently awarded ASEAN-US Science Prize for Women 2019. She represented Singapore and NTU in this prestigious competition.

Prof Zhou was the winner of the fifth Annual ASEAN-U.S. Science Prize for Women representing Singapore, which promotes research focusing on the circular economy from the ASEAN region. (Video Here). The prize recognises women who are working in applied science and their work that improves society in safe and sustainable ways. The award also provides a platform for women scientists to become role models for other women working in and pursuing careers in science, technology, engineering and mathematics careers.
Associate Professor Zhou Yan is currently the Deputy Director of Advanced Environmental Biotechnology Centre (AEBC) and has come a long way from being a pioneer researcher from the early days of Nanyang Environment of Water Research Institute (NEWRI).

In 2014, she joined NTU School of Civil and Environmental Engineering (CEE) as Faculty. Nearly 5 years later Prof Zhou was promoted to Associate Professor with Tenure at the conclusion of the recent Faculty Promotion and Tenure Exercise, and continues to be an invited guest speaker at international conferences such as the 5th International Water Industry Conference in Korea.

Prof Zhou did an oral presentation at 5th International Water Industry Conference 2019, held in Sept'19, Daegu Korea, on the topic of "membrane fouling control in anaerobic membrane bioreactor based on quorum quenching".

What are your thoughts about being the winner of the 2019 ASEAN-U.S. Science Prize for Women?
I am deeply honoured to be chosen as the final winner. I am really happy that my research and contribution are recognized. I shall continue my research in the sustainability and circular economy area and produce more impactful and applied solutions.

What do you think this signifies for women in the water and wastewater industry?
I hope I can be a good role model for the women in the water and wastewater industries and encourage women scientists to pursue their research career in this field.

What do you think is the deciding factor that got you pick as one of the finalists?
Perhaps, my engineering experience which helps me to translate my research into application and practice, is the deciding factor. Maybe my contribution in our philanthropic projects that benefits almost 2 million people in ASEAN region is another.

What are some of the biggest challenges that women who want to come into the water & wastewater industry will face today?
The biggest challenge could be that people always have doubt on women's' capability in the engineering field. They are not confident with our engineering design and the ability for project execution and delivery. To tackle this, we really need to prove ourselves with a successful track record. It would be very difficult at the beginning, but we have to try our best.

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What steps should be taken to attract women into the water and wastewater industry?
First of all, we need more opportunities for women. We should be given a chance to demonstrate our capability. Women can also make a difference and significant contribution in industries. This applies in all engineering fields.

What would be your message for women coming into this industry?
Every first-time entry will be challenging. This is especially more challenging for women juggling both family and career. But women definitely have advantages in the environmental field. We are good at overall project design and planning while we are also very efficient in micro-level management. Do not give up when you encounter difficulties, it is a part of learning process. Your additional effort will be eventually pay off.

Prof Yan's educative mindset has her leading her students in many discussions.

Prof Zhou Yan very much at home in the NEWRI lab

ABOUT PROF ZHOU YAN

Could you share with us on how you stepped into researching for energy efficient water treatment and reclamation, and resources recovery from sludge and waste?
It has been too long that people only focus on linear economy. Huge amount of resources are wasted. In the wastewater treatment area, intensive energy and chemicals are consumed during the treatment process. Actually, there are much more energy and chemicals we can recover from wastewater. So I decided to move away from wastewater treatment and into water and resources recovery from wastewater.

How has your background prepared you for your success in the industry?
I started with fundamental research on the development of energy efficient wastewater treatment process and energy recovery from wastewater and sludge. I had some break-through findings and novel ideas that are published in top tier journals. However, I believe the research results should be translated into engineering application so that the value of research can be realized. Hence, I seek support from local funding agencies and my research institute to scale-up my technologies. Meanwhile, I am active in philanthropic projects in ASEAN region via NEWRIComm. Through these ways, I've gained intensive engineering experience to deploy the research knowledge into real application.

What are some of your proudest achievements and how has it shaped you as a person? Can you share with us of an interesting project which you've done that has made a huge impact?
I am a member of Lien Foundation - Environmental Fellowship Program mentor team. I am very proud to be involved in the philanthropic projects, to deploy my research experience and knowledge into the projects in developing countries to solve their water and waste issues. One of the projects that I am proudest is the project in Kandy, Sri Lanka. I am one of the key contributors to the design of a wastewater treatment facility for the Temple of the Tooth and also a team member in remediating Kandy Lake. Through that project, I started my collaboration with University of Peradeniya (UOP) to further develop anaerobic technologies according to the local context. The project was accorded the IES Prestigious Engineering Achievement Award and ASEAN Outstanding Engineering Achievement Award in 2017.

What's next? / What are you watching out for?
For the next few years, I am looking at valuable products recovery from wastewater and waste that can potentially transfer a wastewater treatment plant into a power and chemical production plants. Chemicals, like cellulose, short-chain and medium-chain fatty acids, biodegradable plastics – PHA, and nutrients – fertilizers, can all be produced and recovered at the lab-scale currently. The challenges in the next phase will be process scale-up and how to seek interests from market.

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ZEBRAFISH AS A BIOMONITORING TOOL FOR WASTEWATER EFFLUENT AND ITS RECEIVING WATER

A model for toxicological studies

Contributed by: Dr Li Caixia

Zebrafish (*Danio rerio*) has been used as a model for toxicological studies for decades. In recent years, this model organism has swum into the greater wild as its application in the field of environmental risk assessment broadens.

Complementary to conventional physical and chemical analyses, this biomonitoring tool provides insight into the potential adverse effects caused by total trace chemicals present. One example is the evaluation of toxicity of effluent from wastewater treatment plants (WWTPs), which are usually directly discharged into river since values of the common monitoring parameters are not alarming. However, assays using zebrafish might pick up points to be more cautious to deal with.

Our group has tested effluent from WWTPs from different regions in a short-term zebrafish embryo assay setup. While some effluent samples did not cause apparent changes, others did affect the fish in aspects such as morphological abnormality, touch response and heartbeat rate.

Figure 1. Gross changes observed in embryos exposed to WWTP effluent samples. Embryos with curved spinal cord or oedema in the heart (B-C) were observed in test groups but not the control group (A).

Expression of key genes of the fish can also be examined to gain insight of subtle effects and which organs or which physiological processes might be affected, by fluorescent reporter or qPCR assays. To gain more information from site-specific samples, advanced genomic techniques can be applied to examine the genome-wide expression changes. In one of our study on direct effluent of a WWTP, no alarming results were found in cytotoxicity test. Yet, using morphological and genomic analyses on embryos, we found adverse changes and markers associated with effluent exposure. We further validated these markers in independent samples from the same WWTP and more sites along its receiving water, proving the importance and effectiveness of the zebrafish assay in biomonitoring.

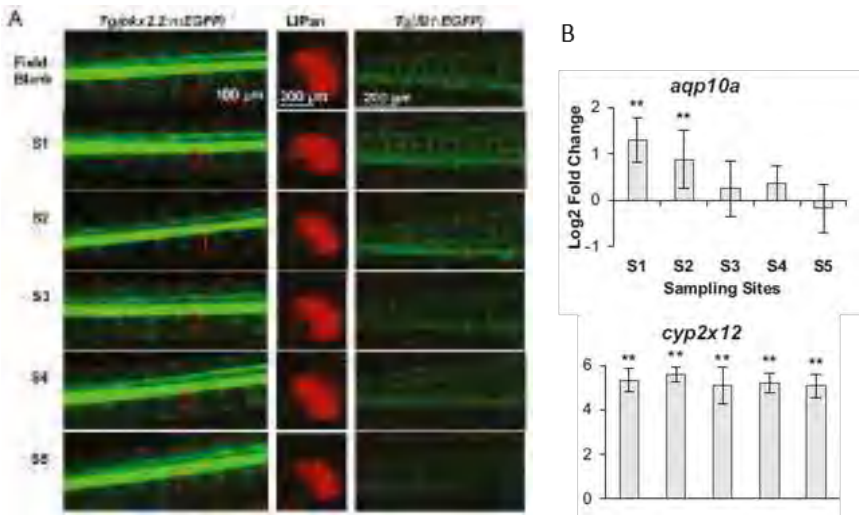

Figure 2. Fluorescent reporters and gene markers evaluated in direct effluent of a WWTP (S1) and the downstream sites (S2-5) of its receiving water. (A) Despite absence of gross morphological abnormality, zebrafish embryos with fluorescent markers in axon, liver and blood vessels revealed adverse effects. (B) Selected gene markers identified from the genomic analyses of direct effluent could be used to monitor potential molecular effects of the same effluent site and its receiving waters. * Statistically significant changes in the expression of the gene.

Further reading / References:

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..

Chen et al (2017). Common deregulated gene expression profiles and morphological changes in developing zebrafish larvae exposed to environmental-relevant high to low concentrations of glucocorticoids. Chemosphere. 172: 429-439.

More information about Biotechnology & Bioprocesses in AEBC @ NEWRI, **Click here**

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DIGITAL TWINNING OF SECURE WATER TREATMENT FACILITIES

Protecting and optimizing critical water infrastructures

Contributed by: Prof Adrian Law and Ms Dawn Pang

EPMC has been awarded the project, Digital twinning of secure water treatment facilities, by the National Satellite of Excellence, Design Science and Technology for Secure Critical Infrastructure (NSoE DeST-SCI) Grant.

This 2-year project, starting in November 2019, aims to develop a digital-twin system concept, termed as "Smart Digital Water Twins (SDWT)", to protect and optimize critical water infrastructures. The project is in collaboration with CAD-IT Consultants (Asia) Pte Ltd.

SDWT shall build on the ThingWorx commercial platform for real-time data communication and management. It will leverage on advanced machine learning algorithms for predictive analysis, to provide effective and instant safeguards against operational anomalies and cyber/physical-attacks in critical water treatment infrastructures.

In addition, a unique computing architecture shall be developed comprising of a dual neural network (NN), that combines a policy NN with supervised learning from experts with a value NN with reinforced learning, to derive the outcomes of optimal energy and material consumption per unit volume of water treated.

The true capability of SDWT will be examined independently in SUTD's lab-scale Secure Water Treatment (SWaT) iTrust Testbed. During the project, predictive maintenance for the simulated units will be carried out to evaluate the amount of material and energy savings for the known intake conditions. Cyber/physical-attacks will also be simulated with and without simultaneous technical anomalies, to test the capability of SDWT in protecting the system operations.

References:

Chew A.W.Z. and Law A.W.K., (2019), Feature engineering using homogenization theory with multiscale perturbation analysis to model physical clogging condition in seepage filters, Journal of Computational Science, 32, 21-35.

Chew A.W.Z. and Law A.W.K., (2019), Homogenization theory with multiscale perturbation analysis for supervised learning of complex adsorption-desorption process in porous media systems, Journal of Computational Science (Under review)

More information about Modelling, Sensing & AI in EPMC @ NEWRI,
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A NOVEL INTEGRATED PROCESS FOR CO_2 CAPTURE, STORAGE AND UTILIZATION (CCSU) WITH WASTES BY USING INCINERATION BOTTOM ASH (IBA) AND SEAWATER DESALINATION BRINE (SDB)

Combating climate change and closing the waste loop.

Contributed by: Asst. Prof. Grzegorz Lisak, Asst. Prof. Liu Wen, Dr. Andrei Veksha, Dr. Chan Wei Ping and Mr. Kumaran S/O Tamilselvam

R3C has been awarded the project, "A Novel Integrated Process for CO2 Capture, Storage and Utilization (CCSU) with Wastes By Using Incineration Bottom Ash (IBA) and Seawater Desalination Brine (SDB)", by Singapore Energy Centre (SgEC-Core2019-34) .

This 2-year project, starting in November 2019, aims to develop an integrated process for CO_2 (50 million tonnes/year) capture and storage by using incineration bottom ash (600,000 tonnes/year) and seawater desalination brine (140 million m^3/year). Synergistic utilization of both wastes streams while concurrently producing value-added products can improve the overall process efficiency and the economic viability of the proposed CCSU process.

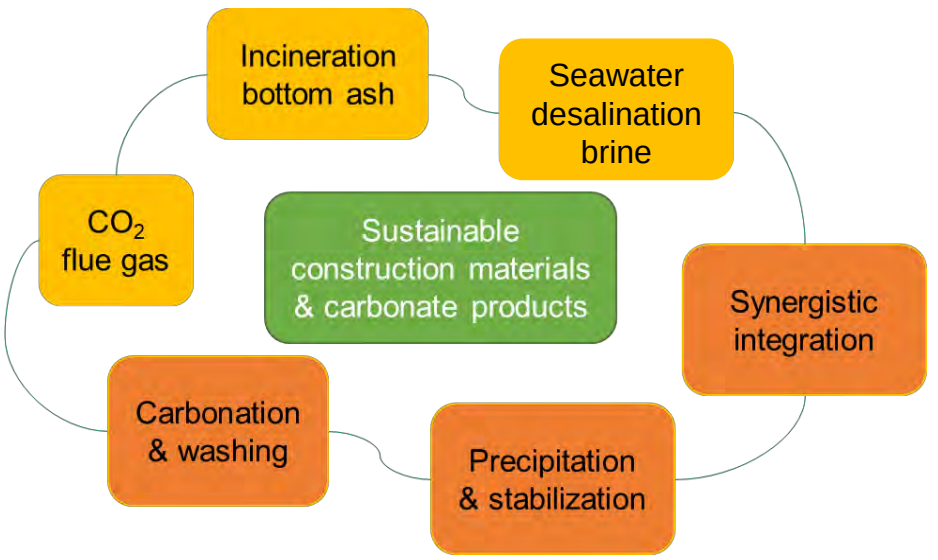
Currently, IBA generated from incineration plants is landfilled at Pulau Semakau (which is estimated to be fully utilized by 2035) while the SDB from desalination plants are discharged without any beneficial use. In this study, treated IBA can be used a potential replacement material of Ordinary Portland Cement (OPC) during concreate production. This way, it is possible to extend the life span of Pulau Semakau by another 40 years, whilst reducing Singapore's reliance on imported construction materials.

In addition, the precipitated carbonates that are produced from the carbonation of SDB will be characterized and customized for commercial applications.

Overall, our approach can contribute to an annual carbon abatement potential of more than 0.6 million tons CO_2.

The potential saving through direct carbon capture, indirect CO_2 abatement (during OPC production) and reutilization of IBA is estimated to be S$ 55 million/yr while the potential revenue from selling the products (treated IBA and precipitated carbonates) is around S$ 98 million/yr, which totals up to a gross annual income of S$150M generated by the integrated process.

References:
Dou, X., et al., Review of MSWI bottom ash utilization from perspectives of collective characterization, treatment and existing application. Renewable and Sustainable Energy Reviews, 2017. 79: p. 24-38.





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RISING TO THE NEXT LONG HAUL CALL:

Singapore Vision on Zero Waste Masterplan and Climate Change Challenges

Contributed by: Mr Bill Ho and Dr Maszenan Abdul Majid

Rising to the next Long Haul Call: Singapore Vision on Zero Waste Masterplan and Climate Change Challenges

Singapore is a unique city state that need to rise for another long haul call. As a city state with limited water resources, Singapore addresses the water challenges by diversifying our water supply taps through sound water supply pricing and regulating policies, adopting recycling and recovery through innovation and technology translation, improving water usage efficiency, and educating the public on sustainability (i.e. use wisely with no wastage). This long haul call was laid by Singapore's government through projects like the Singapore River clean up, tree planting and implementing hefty fines for public littering which create public education and awareness to care for the environment which we live in.

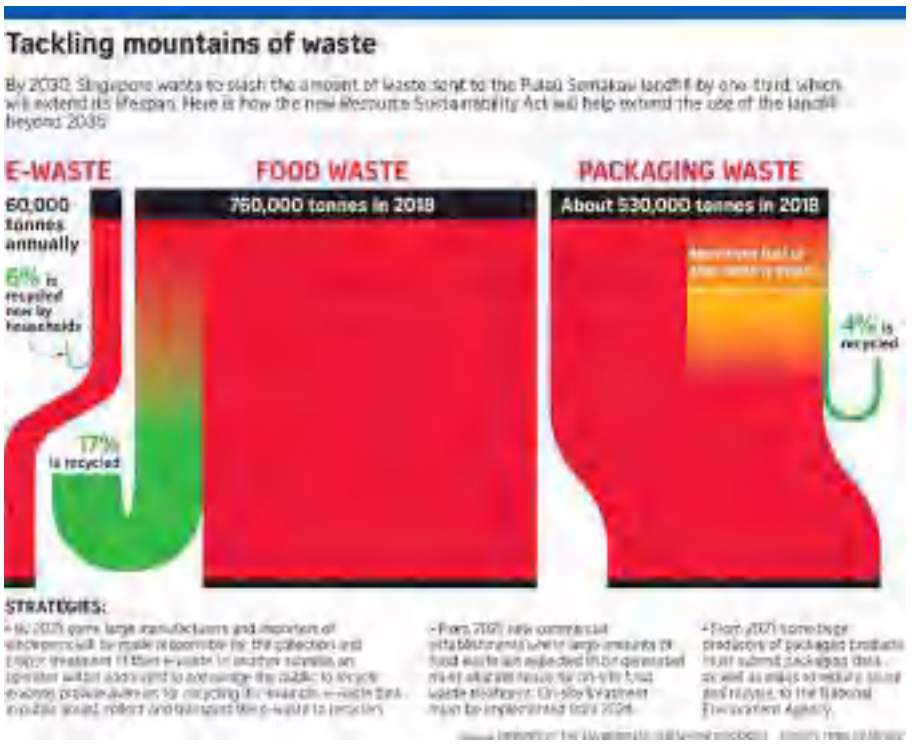
Singapore's next environmental challenge which every metropolis city in the world faces, is the amount of waste generated per daily basis. Due to the island state's size, compounded by competing demand for land scarce Singapore, town planners relocated all landfills and its activities to a reclaimed island offshore known as Pulau Semakau (Semakau island). The Ministry of Environment and Water Resources (MEWR), projected that the island-landfill will be filled by 2045. However, the landfill is fast in filling up due to the increase in waste volume generated. It is estimated that Semakau Island will be completely filled up by 2035. This is not an error in engineering calculation but instead driven by the seven-fold increase in the amount of waste generation; similar to the increase in water consumption in the 70s and 80s. The threat of climate change to small island in the world is very real. The urgency for the government to launch Singapore's Zero Waste Master plan was imminent, and passed the Resource Sustainability Bill in Parliament of Singapore in the first week of September 2019 which aims to:

1. Extending Semakau Landfill lifespan

To extend the life span of Semakau landfill, waste reduction sent to the landfill would have to drop to 30% per day by 2030 (cut down from 0.36kg per capita in 2018 to 0.25kg per capita by 2030). In 2018, its was estimated that each person disposes 800g of waste per day. For the new benchmark, the benchmark for each person lowers to not more 640g of waste disposal per day in 2030.

2. Improving Singapore Recycling rate to 70%, (via public education on recycling properly)

This is to achieve a 70 per cent overall recycling rate by 2030, MEWR unveiled a new design for the blue recycling bins located in housing estates. MEWR introduced new recycling labels in Aug 2019, which convey more explicitly what can and cannot be placed in the blue recycling bins. These labels will make clear that paper, metal, plastic and glass products are permitted, while styrofoam, food-stained items and bulky items are not allowed. Banners stating 'No Food. No Liquids.' will be placed in prominent positions to remind the public to keep the blue recycling bins free from food and liquid waste. It hopes to boost waste recycling from domestic waste, i.e. waste from household and small business which accounts only 22% of Singapore's domestic waste. Another issue in relation to recycling is contamination; 40 per cent of domestic waste thrown into the blue recycling bins is contaminated.



MEWR and the National Environment Agency (NEA) will also focus on improving the public's education, on how to recycle correctly with the #RecycleRight campaign launched in 2019, as part of efforts to push Singapore towards zero-waste. But encouraging proper recycling needs to go beyond public education and motivation for press/media release. Aligning to the master plan, these waste streams will need to be regulated under the Resource Sustainability Bill, 2019, to encourage and motivate more organisations to work towards achieving Nation's Zero Waste goal.

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RISING TO THE NEXT LONG HAUL CALL:

Singapore Vision on Zero Waste Masterplan and Climate Change Challenges

Contributed by: Mr Bill Ho and Dr Maszenan Abdul Majid

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NEWRI is one such research institute that continues to innovate novel discoveries, explore new technology development and translates it for industrial application in an effort to move towards achieving Singapore's Zero Waste Master Plan objectives.

Some examples like the collaboration with PUB, where used water is treated by applying membrane technology developed by NEWRI's SMTC, amongst other technologies to produce NEWater. There are also efforts via public education to have domestic waste segregated at point source as a screening process before treatment. Now, there is mandatory legislation requiring to collect and convert waste into new recycled resources using NEWRI technology for producing recycled polymer resin for plastic and plastic product manufacturing.

Another example of NEWRI's endeavors towards Zero Waste is the Waste to Energy (WtE) Research Facility located at Tuas South that uses the gasification process to generate Syngas for self-sustaining energy consumption with excess connected to power grit line, and test bedding for other potential technologies.

NEWRI is also looking into pyrolysis technology that has the potential to generate pyrolytic oil which has medicinal/therapeutic properties and when blended with other oils has the potential to generate biofuel. Biochar, (which is the side stream product of pyrolysis, generated from pyrolytic action of converting agriculture and horticulture waste) can also be utilized as a substrate for the landscape, plant and flower nursery and horticulture industry. Waste converted into resources holds bountiful potential and goes beyond our imagination. The pursuit of turning waste into valued resource does not just align with sustainable development goals, in the long haul, it may be the solution that saves the planet Earth.

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A CLOSER LOOK AT OUR ANALYTICS

Pitch to NEWRI's Analytical Needs - PARAFAC Analysis of EEM Data

Contributed by: Ms Koh Danyu

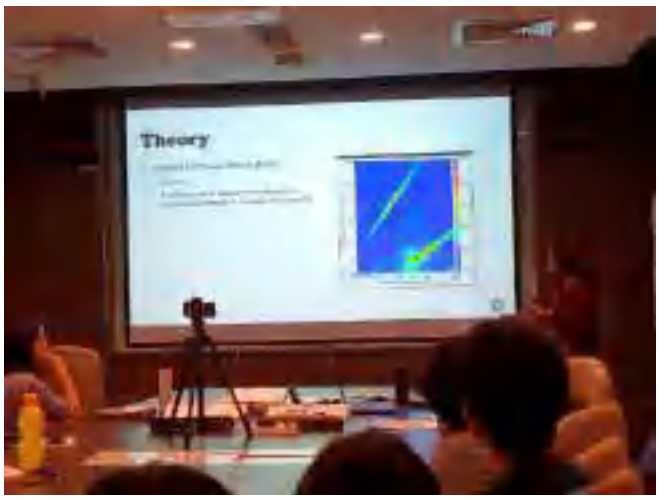
Recognizing diverse types of samples and challenges in sample analysis encountered by NEWRI researchers, NEWRI Analytics Cluster has prepared a series of seminars "Pitch to NEWRI's Analytical Needs" tailored to address the common issues and to offer practical tips to solve the problems.

The third seminar of "Pitch to NEWRI's Analytical Needs" series was presented on 23 August 2019 by Ms Koh Danyu, from NEWRI Analytics Cluster, focusing on elaborating PARAFAC Analysis of EEM Data

Fluorescence spectroscopy is a widely used technique in water quality monitoring. However, it has always been a tedious task to analyse EEM data, which is generated from fluorescence spectrometry measurement, in determining the composition of water sample. Furthermore, overlapping of wavelength adds more complexity to isolation and quantification of individual components.

Statistical computing software that are readily available, for instance MATLAB and R script can become extremely helpful in improving the efficiency and accuracy of analysing EEM data using PARAFAC analysis.

With this in mind, the seminar covered the basis of PARAFAC as well as the workflow of PARAFAC in the two software - MATLAB and R script.



Ms Koh Danyu presenting the seminar on 23 August 2019

Parallel Factor Analysis (PARAFAC) is a statistical modelling method, used to extract individual components from a mixed 3D fluorescence data or from overlapping components. Although the basic integration technique is widely performed it has several disadvantages. To get better, more accurate results in a shorter amount of time when analyzing multiple samples, two of the most commonly used computing software, MATLAB or R script can be utilized to analyse EEM data using PARAFAC.

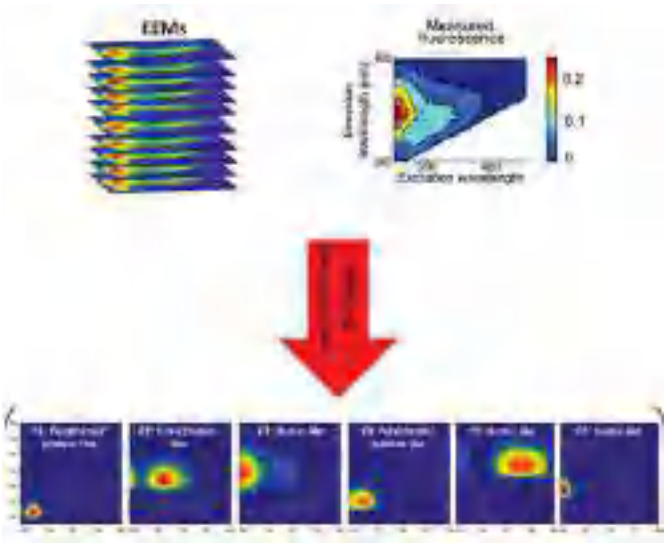
The general workflow of PARAFAC is broken down into 6 parts: Acquiring data measurements, Importing of raw data into software, Pre-processing of dataset, Exploring corrected dataset, Model validation and lastly Interpretation of results.

Acquiring data is simple and also fast. One will acquire 3D fluorescence data using fluorescence spectrometer and absorbance data using UV-visible spectrometer. The data will be collated into a sample log. Light and instrument influences will be corrected before removing any outliers and determining the component model that fits the dataset. The model will be validated using a statistical method called "Split half analysis". Once validated, the identity of individual components can be determined by matching with literature data.

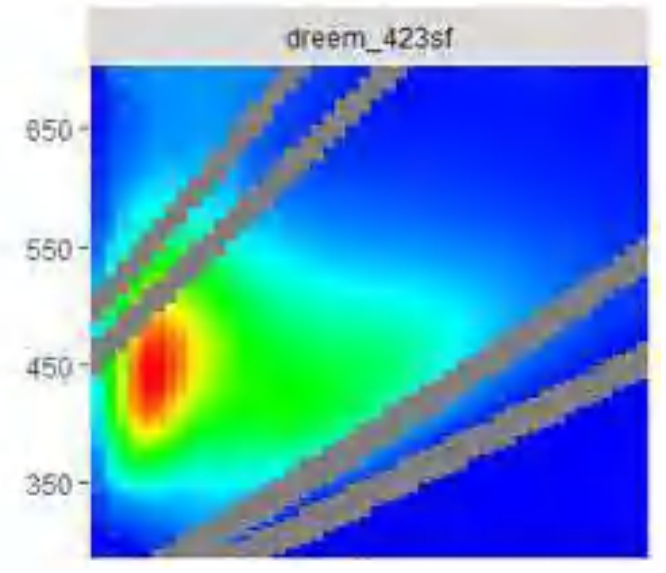
PARAFAC analysis generates quantification results with high level of accuracy and thus is regarded as a good tool when analyzing samples with unique fluorescence properties.

In addition to quantifying Dissolved Organic Matter (DOM) or Extracellular Polymeric Substance (EPS) in water samples, PARAFAC analysis can also be used for other applications where samples containing molecules with fluorescence properties, for instance Organic dyes and Quantum dots, are to be analyzed.

In summary, with PARAFAC analysis, analyzing complex EEM data is made more efficient and more accurate, providing strong support to research findings.



PARAFAC Analysis.



Example of Contour plot (EEM data)

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A CLOSER LOOK AT OUR ANALYTICS

Liquid Chromatography Mass Spectrometry (LCMS) Sample Preparation Techniques

Contributed by: Ms Elvy Riani Wanjaya

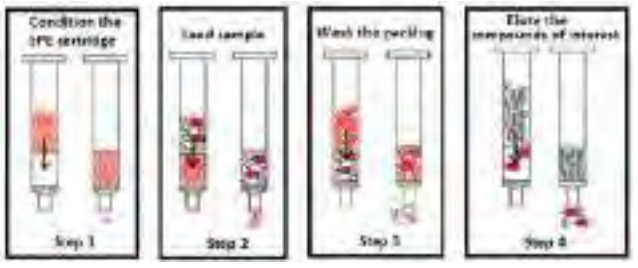
Recognizing diverse types of samples and challenges in sample analysis encountered by NEWRI researchers, NEWRI Analytics Cluster has prepared a series of seminars "Pitch to NEWRI's Analytical Needs" tailored to address the common issues and to offer practical tips to solve the problems.

Ms Elvy presenting the seminar on 14 June 2019

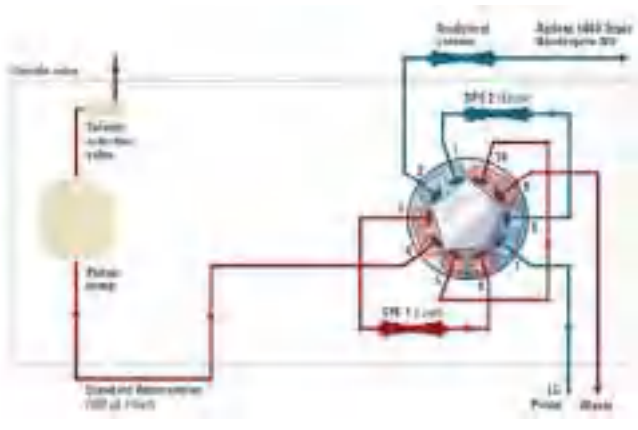
The second seminar of this series which focused on Liquid Chromatography Mass Spectrometry (LCMS) Sample Preparation Techniques – Manual Solid Phase Extraction and Online Solid Phase Extraction was presented on 14 June 2019 by Ms Elvy Riani Wanjaya, who is an Assistant Manager in NEWRI Analytics Cluster.

It has always been a challenge to analyse trace organic compounds in environmental samples due to the low concentration level of analytes and the complexity of sample matrix.

In addition to advanced instrumentation, sample preparation becomes extremely important in order to achieve the desired detection limit. With this in mind, the seminar covered both key principles/concepts and practical steps/tips of sample preparation techniques most suitable for the environmental samples encountered in NEWRI.



Solid Phase Extraction sequence steps.



Online Solid Phase Extraction

Solid phase extraction (SPE) is widely performed for multi-residue extraction of analytes in aqueous environmental samples in order to reduce the matrix effects observed in mass spectrometry, i.e. ion suppression. To perform a good SPE, it is noteworthy that conditioning step is important to activate the packing material of SPE cartridge, while proper equilibration is required to displace the solvent loaded during conditioning step to avoid sample breakthrough.

Optimization of the loading, washing and elution steps are important to achieve high extraction recoveries. One has to allow sufficient time for the analytes to interact with the sorbent such that analytes of interest will be retained, while the interferences can be washed away during washing step. Drying down the SPE cartridge prior to elution step is recommended to break the interaction of analytes with the sorbent for high extraction recovery. During elution step, one has to consider the chemical and physical properties of the analytes of interest to select the most suitable solvent.

Current trends in sample preparation techniques include online solid phase extraction (OSPE), a fully automated online system that integrate extraction, chromatography separation and mass detection in one step. OSPE allows high throughput analysis of samples with reduced manual labour and solvent consumption. In addition, OSPE cartridges can be reused for a few hundreds of samples' injections (depending on the samples matrices), which results in substantial cost saving. On the other hand, OSPE has the limitation of solvent and modifier selection for the washing and elution steps, as it has to be compatible with the LCMS system.

Thus, manual SPE and OSPE complement each other for LCMS applications of diverse environmental samples.

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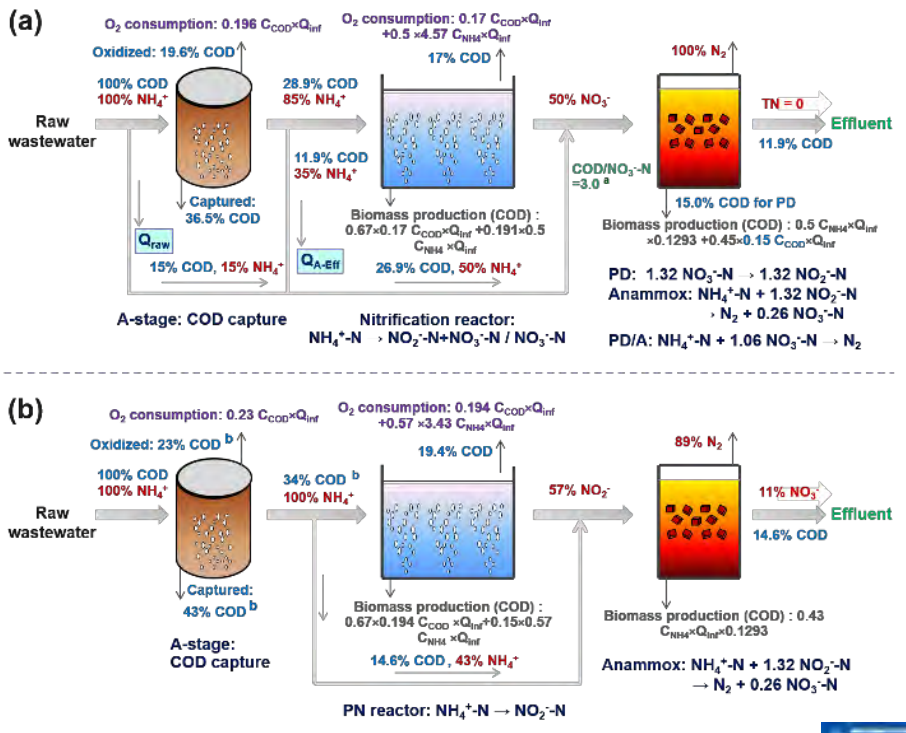
Denitrifies in mainstream anammox processes – competitors or supporters?

Shenbin Cao, Adrian Oehmen, Yan Zhou. 2019

Abstract

The partial nitrification–anammox (anaerobic ammonium oxidation) process (PN/A) was proposed to remove nitrogen from low-strength municipal wastewater. The huge economic incentives are driving researchers and practitioners to make tremendous efforts in order to implement PN/A processes in full-scale systems. However, the typical variations in temperature, nutrients, and organic concentrations create many challenges in PN/A processes treating municipal wastewater.

Instead of producing nitrite through partial nitrification prior to the anammox process, much attention has been paid recently to the formation of nitrite from denitrification as a process alternative. Such process concept shown here appears to be a promising way forward for achieving energy-neutral or energy-positive wastewater treatment. Operating costs and energy recovery are comparable with PN-based anammox processes, while better effluent quality, lower greenhouse gas emissions and long-term stability are achievable with partial denitrification – anammox process. In contrast to the generally accepted viewpoint, the potentially positive role of denitrifiers should be recognized in order to better benefit the stability and robustness of sustainable wastewater treatment plant operation.



Water Research

Volume 161, 15 September 2019, Pages 202-210

Low-temperature-steam activation of phosphorus in biochar derived from enhanced biological phosphorus removal (EBPR) sludge.

Qian Tingting, Li Wang, Le Cheng Cheng, and Zhou Yan, 2019

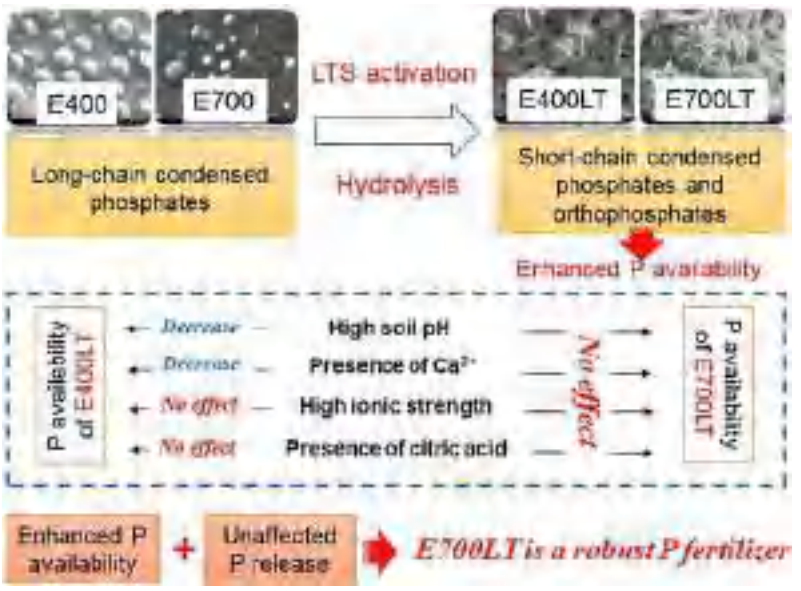
Abstract

The property and release behavior of phosphorus in biochar derived from enhanced biological phosphorus removal sludge (EBPR sludge) were investigated.

A low-temperature-steam (LTS) activation method was developed to increase the P availability in the biochar. The results demonstrate that the P content in the biochar is comparable to that in typical P fertilizers. The biochar contained a considerable portion of fast-release P. Polyphosphates (poly-P) were the predominant P species in the biochar. LTS greatly improved P availability in biochar produced at 700 °C by hydrolyzing insoluble poly-P to soluble pyro-P and ortho-P. In addition, the presence of Ca^{2+} could greatly reduce the P-release from biochar produced at lower temperature, e.g. 400 °C, due to that Ca^{2+} could facilitate the precipitation/adsorption of orthophosohates/pyrophosphates released from the low temperature biochars.

Such phenomena was not observed with high temperature biochar, as the soluble poly-P released from 700 °C biochar could complex with Ca^{2+} rather than precipitated with it. Other environmental conditions, i.e., environmental pH, ionic strength of the soil porewater, and presence of low-molecular-weight acid, only had minor or negligible effects on the P-release of most studied biochars.

This study concludes that LTS-activated-700 °C biochar could be a promising P fertilizer given its high, rapid, and unaffected P-release under various environmentally relevant conditions.



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Research Gate

Article in Journal of Computational Science, February 2019

Feature engineering using homogenization theory with multiscale perturbation analysis for supervised model-based learning of physical clogging condition in seepage filters

Chew. A, Law W.K. Adrian. 2019

Abstract

Aquifer recharge and recovery systems (ARRS), which can broadly be analysed as seepage depth filters, in natural or engineered aquifers are gaining attention worldwide. Engineering predictions of their complex physical clogging behavior, however, continue to be challenging which has hindered the predictive maintenance of these systems for energy and materials savings. To address this problem statement, we leverage the homogenization theory with the multiscale perturbation analysis as the feature engineering step to reduce the complexity of the physical clogging behavior in ARRS. The analytical approach systematically derives a unique homogenized representation which quantifies the clogging condition at the macroscale.

A series of physical parameters are identified from the derived homogenized representation to build a pre-processed input layer into our own multi-layered neural network (NN) architecture for predictive analysis. Measured data extracted from the literature is then used to train and verify the NN model. By far, the trained model yields an average error deviation of 20% between the model's predictions and the respective measurements for an optimized set of hyperparameters tested. We then discuss quantitatively how the trained NN model can be adhered to predict the timing for a concerned ARRS to reach its breakthrough stage for a range of operational conditions. Finally, we also demonstrate how the homogenized representation can be useful to determine an arbitrary filter's critical reaction rate and diffusion coefficient responsible for its breakthrough stage.

Water Research

Volume 131, 15 March 2018, Pages 33-44

An integrated approach with the zebrafish model for biomonitoring of municipal wastewater effluent and receiving waters

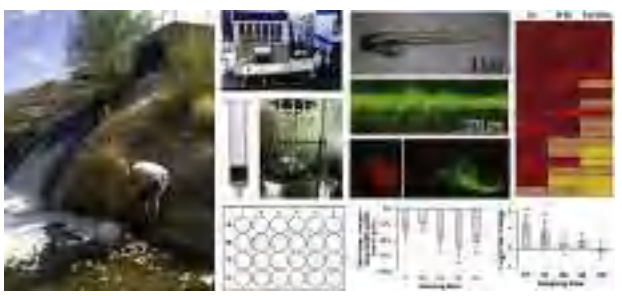
Caixia Li, Qiyu Chen, Xiaoyan Zhang, Shane A.Snyder, Zhiyuan Gong, Siew HongLam, 2018

Abstract

Comprehensive monitoring of water pollution is challenging. With the increasing amount and types of anthropogenic compounds being released into water, there are rising concerns of undetected toxicity. This is especially true for municipal wastewater effluents that are discharged to surface waters. This study was designed to integrate zebrafish toxicogenomics, targeted gene expression, and morphological analyses, for toxicity evaluation of effluent discharged from two previously characterized wastewater treatment plants (WWTPs) in Pima County, Arizona, and their receiving surface water. Zebrafish embryos were exposed to organic extracts from the WWTP1 effluent that were reconstituted to represent 1× and 0.5× of the original concentration. Microarray analyses identified deregulated gene probes that mapped to 1666, 779, and 631 unique human homologs in the 1×, 0.5×, and the intersection of both groups, respectively.

These were associated with 18 cellular and molecular functions ranging from cell cycle to metabolism and are involved in the development and function of 10 organ systems including nervous, cardiovascular, haematological, reproductive, and hepatic systems. Superpathway of cholesterol biosynthesis, retinoic acid receptor activation, glucocorticoid receptor and prolactin signaling were among the top 11 perturbed canonical pathways.

Real-time quantitative PCR validated the expression changes of 12 selected genes. These genes were then tested on zebrafish embryos exposed to the reconstituted extract of water sampled downstream of WWTP1 and another nearby WWTP2. The expression of several targeted genes were significantly affected by the WWTP effluents and some of the downstream receiving waters. Morphological analyses using four transgenic zebrafish lines revealed potential toxicity associated with nervous, hepatic, endothelial-vascular and myeloid systems. This study demonstrated how information can be obtained using adverse outcome pathway framework to derive biological effect-based monitoring tools. This integrated approach using zebrafish can supplement analytical chemistry to provide more comprehensive monitoring of discharged effluents and their receiving waters.



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Emerging Trends in the Water Industry

Inaugural Seminar @ Cleantech One

Contributed by: Dr Pramodh Vallam (NEWRI Business Development)

SWA and NEWRI hosted the inaugural seminar entitled "Emerging Trends in the Water Industry" at Cleantech One (Oct 2019) to provide a platform that brought together various players in the Water Industry, including, technology providers, integrators, researchers, business managers. The workshop participants from government agencies, engineering/procurement/construction companies, consultancies, Institutes of Higher Learning (IHL) were treated to a bevy of speakers about the current trends in the various water domains, including, wastewater treatment, AI, Smart Nation, and many others.

The workshop also provided NEWRI an opportunity to speak about its capabilities and capacities (experimental, simulations, prototyping, testing, etc.) , as well as gaining better insight into industry needs, especially in the frontiers of artificial intelligence and digitisation. The dialogue created plentiful potential for future collaboration (there was interest to collaborate in the field of molecular dynamics, and digitisation and AI efforts with a Canadian start-up), with hopes of putting together another event to reach out to more diverse audiences in the 2nd quarter of 2020, delving into the nexus between our capabilities and recent advances in the waste industry sector of Singapore.

Mr Dinesh Sharma CEO of DNR Solutions (Vice- President (Administration), SWA) with Prof Fang Mingliang (NEWRI)

Prof Shane Snyder (Executive Director, NEWRI) during his opening address and an overview of water problems in South East Asia

Prof Shane Snyder (NEWRI) engages with a guest

Dr Gao Xin (Grundfos) talks about "Smart Filtration Solutions"

Mr Hideyuki Komori (Kurita Asia) gave his talk on "Sensing CS - Waste Water Real Time Monitoring & Chemical Dosing Control"

Mr Dennis Chang (ZH Technologies International) talk was on 'Big Data Era - Sensor Technology and their Application'

Prof Liu Ai Qun (NEWRI, NTU) speaks to a guest interested in his talk about automated online monitoring and detection of waterborne from virus to parasites

Dr Shailesh Kharkwal (Environsens) after his talk about heavy metal toxicity sensing

Dr Benjamin Moy (NEWRI) speaks about NEWRI's experience in water efficiency management for water conservation

Participants were treated to a tour of NEWRI laboratories and got to view membranes in production

Dr Adil Dhalla (START's MD) gave visitors a first hand look at the membrane sheet manufacturing process

In addition to the NEWRI labs, visitors also viewed scaled up membrane sheets for industrial use.

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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 visits; allowing knowledge to diffuse throughout the organisation. Here are some highlights:

"Recycling of Plastic Refuse into High-value Products" (13 Dec 2019)
Dr James L Hedrick , IBM Research – Almaden San Jose, California, United States

"Sustainability of Polymer MaterialsL Renewable and Recyclable" (13 Dec 2019)
Dr Jinwen Zhang, School of Mechanical and Materials Engineering, Washington State University(WSU), United States

"Impact of Dissolved Organic Matter on the performance of UV-based AOPs: Scavenging effect, transformation and production of disinfection by-products " (25 Nov 2019)
Dr Jean-Pilippe Croué, Environmental Science and Engineering, University of Poitiers, France

"Seminar 1 - Gold-carbonyl Group Interactions in the Electrochemistry of Anthraquinone Thiols Self-assembled on Au(111)-surfaces Seminar 2 - Utilisation of Natural Phenols for Energy Storage" (30 Oct 2019)
Dr Michal Wagner, R&D Engineer, IPM – Intelligent Pollutant Monitoring

"Time makes the poison: How time-of-day modulates pharmacotherapy"
(11 Sept 2019)
Asst Prof Robert Dallmann, Warwick Medical School, University of Warwick

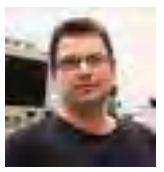
"Pitch to NEWRI's Analytical Needs - PARAFAC Analysis of EEM Data"
(23 Aug 2019)
Ms Koh Dan Yu, NEWRI Analytics Cluster

"Wave interaction with two-body heaving wave energy converter"
(22 July 2019)
Dr Sourav Mandal, Ocean Engineering Division CSIR, National Institute of Oceanography (NIO) Goa, India

"Mettler Toledo Lunch and Learn – Process Instrumentation in Water / Wastewater"
(27 June 2019)
Mr Derek Chan, Senior Application Specialist, Mettler Toledo

"Natural River Hydraulics and Sedimentation Modelling and Applications" (13 Dec 2019)
Dr Jaan H Pu, Faculty of Engineering & Informatics, University of Bradford, United Kingdom

"Atmospheric Plasma Applications in Sustainable Manufacturing and the Environment" (6 Nov 2019)
Dr PJ Cullen, University of Sydney, School of Chemical and Biomolecular Engineering



"Chemistry of 2D materials and their energy and environmental applications"
(27 Nov 2019)
Professor Zdenek Sofer, University of Chemistry and Technology Prague, Czech Republic

"Integrated Technology Enhanced with Membrane Separation (ITEMS)"
(13 Sept 2019)
Dr Avijit Dey, Vice President of Water Technologies, Advisian

"How to mimic Nature in Peroxide Catalysis: NewTAML activators with hydrogen peroxide for destroying micropollutants in municipal wastewater"
(2 Sept 2019)
Prof Terrence J Collins, Teresa Heinz Professor of Green Chemistry & Director, Institute for Green Science, Carnegie Mellon University

"Micro Pollutants In The Aquatic Environment And The Challenge To Deal With Them"
(27 Aug 2019)
Prof Klaus Kummerer, Institute for Sustainable Chemistry and Environmental Chemistry, Leuphana University Luneburg, Germany

"Reuse & Recycling of Granular Waste Materials in Geotechnical Engineering Applications: An Australasian Prospective" (4 July 2019)
Dr Gabriele Chiaro, Snr Lecturer Geotechnical Engineering, Dept of Civil and Natural Resources Engineering, University of Canterbury, New Zealand

"Pitch to NEWRI's Analytical Needs - LCMS Sample Preparation Techniques - Manual SPE and Online SPE"
(14 June 2019)
Ms Elvy Riano Wanjaya, NEWRI Analytics Cluster

Missed it?
NEWRI seminars & workshops reminders
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The Singapore National Day Awards are a means of recognising various forms of merit and service to Singapore. This year, a total of 4,985 individuals in 21 award categories received National Day Honours. Dr Shi Lei (SMTC – NEWRI) was one of 577 whom received "The efficiency medal", which is awarded to persons for exceptional efficiency or exceptional devotion to duty or for work of special significance

Congratulating our award winners whom have done us proud!

Mr Lee Wen Jie (NEWRI-ECMC) was presented the Best Poster Presentation Award for his entry entitled "*Hybrid Catalytic Ozonation-Ceramic Membrane Filtration Process for Micropollutants Degradation*" at the 14th International Conference on Catalysis in Membrane Reactors (ICCMR14), University of Technology, Eindhoven, Netherlands.

STUDENT LIFE

NEWRI is an incubator for promising researchers with advanced facilities that enable individuals to conduct research independently; with professional technicians providing powerful analytical support; professors and colleagues are always there to lend their help. Students enjoy their study here and grow tremendously. Find out what's floating their aspirations and is driving their academic pursuits.

Nesting in the greenery of Jurong Eco Garden, NEWRI is a place where you can share your research thoughts with the morning breeze. With smooth and efficient management, administrative operation flows quietly like a joyful stream down the valley. Colleagues and friends from diverse background form the colorful sunset glow which you are going to miss at the end of every day.

Working alongside with helpful peers and supportive supervisors, we are not fighting a battle alone. Indeed, we are well-equipped and supplied by the constant facility upgrades and laboratory skill trainings. Industrial collaborations, on the other hand, mean that realistic scenarios are laid in the exercise training ground.

Chen Rongfen - Currently 3rd year (AEBC)
Current research area - Membrane Biofilm Reactor Integrated with Anammox Processes.

INQUIRIES?
AskNEWRI@ntu.edu.sg
(65) 6513 7359

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NEWRI RUNNERS CLUB NEWS

NEWRI's own running club participated in NTU Staff Run 2019, and managed an overall 7th place (118 points in total), with our own Dr Yan Wangwang (AEBC) clinching the 2nd Runner Up for women category. The running club brings staff from all over NEWRI together in a weekly healthy activity. You're cordially invited to join!

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