Tools, techniques, and technologies for pollution prevention, control, and resource recovery

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Population growth, urbanization, and climate change are posing serious threat to a sustainable future of human societies. Population growth and urbanization demand large amounts of natural resources to be mined and processed to create products that are essential for various infrastructures that are the backbones of day-to-day life. This leads to numerous new industries to be developed. While all the above activities make the standard of living as well as the life expectancy to increase significantly, this is accompanied with significant adverse effects such as decrease in natural resources, contamination of air, water, and soil, some of which eventually contribute to climate change. Transforming current cities to future cities, their adaptability to the increase in population growth, new designs which will manage solid and liquid waste to energy in decentralized systems are some of the many challenges tackled by researchers all over the world to mitigate the adverse effects caused by human activities and to contribute to a sustainable future.

This special issue contains 21 articles selected from the 9th annual international conference on “Challenges in Environmental Science and Engineering,” CESE-2016, that was held in Kaohsiung, Taiwan from November 6–10, 2016. There were 232 delegates from 17 countries who participated in CESE-2016. The conference covered 5 themes namely, (i) application of membrane technology and nanotechnology, (ii) water and wastewater: pollution prevention and treatment, (iii)

resources and wastes: management and recovery of materials and energy, (iv) air pollution: prevention and treatment, and (v) sustainable catchments and renewable energy. While cleaner production should be considered essential and given priority, it is also necessary to consider developing novel concepts, tools, techniques, technologies, and applications to keep the environment clean. Thus, the purpose of the CESE conference series is to bring scientist and engineers together to showcase their research on tools, techniques, technologies for pollution prevention, control, and resource recovery.

In this special issue, six themes namely, (i) controlling industrial chemicals, (ii) pollution control by adsorption, (iii) pollution control by biodegradation, (iv) other pollution control methods, (v) resource recovery, and (vi) soil remediation have been covered by the 21 manuscripts.

Companies belonging to chemical industries produce more than 70,000 products from raw materials such as water, metals, minerals, air, oil, and natural gas. The industrial revolution coincided with the birth of heavy chemical industries that produce chemicals in large quantities. Sulfuric acid was one of the first chemicals to be produced in large amounts in 1736. Bleaching powder production increased from 52 tons in 1799 to almost 10,000 tons five years later. In 1870, Britain produced 200,000 tons of soda ash annually (https://en.wikipedia.org/wiki/Chemical_industry). Those were the early stages in the production of numerous chemicals which were yet to come to the market in the subsequent centuries. The effluents from almost all chemical factories contain chemicals which are harmful to humans and the environment if discharged without proper treatment. The treatment processes we apply in pollution control and resource recovery could either destroy those chemicals or recover them for reuse.

Three articles of this special issue deal with specific industrial chemicals and novel treatment techniques and analysis, namely (i) in situ remediation of chlorinated solvent-contaminated groundwater using zero-valent iron (ZVI)/organic carbon amendment in China: field pilot test and full-scale application, (ii) analysis of chromium (Cr) status in the

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revegetated flora of a tannery waste site, and microcosm accumulation studies using *Easina fetida*, a species of earthworm, and (iii) treatment of tannery effluent by passive uptake-parametric studies and kinetic modeling.

Although adsorption is an old process that assists in capturing dissolved pollutants, finding novel adsorbents and their effectiveness in adsorbing specific dissolved compounds, preparing and characterizing adsorbents, understanding the competition among different species in occupying the adsorption sites of the adsorbent, types of adsorption and mechanisms, and regenerating the spent adsorbents are still continuously studied by researchers to apply adsorption effectively in full-scale treatment systems. This special issue has four articles on adsorption covering some of the abovementioned aspects. One article deals with the preparation, characterization, and testing dye removal using activated carbon prepared from palm oil mill wastes (palm kernel shells). The second article characterizes ferromagnetic sludge-based activated carbon and applies it in catalytic ozonation of *p*-chlorobenzoic acid. The third article explores the bio-regeneration of spent mercury bearing sulfur-impregnated activated carbon adsorbent. The fourth article evaluates the importance of inherent inorganic species such as carbon dioxide (CO₂) in improving copper (Cu) uptake by biochar when it is pyrolyzed under CO₂ rich atmosphere.

Treating organic and inorganic pollutants from effluents through biological processes is also dating back to early 1900s when the activated sludge process was invented in 1913 and a full-scale activated sludge treatment plant was installed at Worcester, England in 1916 (https://en.wikipedia.org/wiki/Activated_sludge). A microbial consortium, composed of bacteria, protozoa, and rotifers, present in the activated sludge degrades organic compounds into CO₂ and water under aerobic conditions and methane (CH₄), hydrogen sulfide (H₂S), and fatty acids under anaerobic conditions. They also convert inorganic compounds into different forms under aerobic and anaerobic conditions. While some chemical species act as electron donors, others act as electron acceptors to convert the original chemical species present in the wastewater into the end-products. This special issue contains five articles which explore different aspects of biological treatment, such as (i) using lignocellulosic biowastes as carrier material and slow release electron donors for sulfate removal from wastewater in an inverse fluidized bed bioreactor, (ii) evaluating the effect of carbon to sulfur (C/S) ratio and salinity stress on sulfate reduction in the BES1® process, (iii) finding the effect of coexisting BDE-47 on the migration and biodegradation of BDE-99 in different river-based aquifer media recharged with reclaimed water, (iv) developing the vertical distribution of the archaeal community associated with anaerobic degradation of pentabromodiphenyl ether (BDE-99) in the river-based groundwater recharge with reclaimed water, and (v) understanding the antibacterial mode of action of violacein from *Chromobacterium violaceum* UTM5 against *Staphylococcus aureus* and methicillin resistant *S. aureus* (MRSA).

Other pollution control methods such as electrochemical treatment, photocatalytic oxidation in combination with membrane filtration, hybrid forward osmosis-membrane distillation systems are also effective in treating effluents that are hard to treat by biological systems. Three articles of this special issue cover the technological aspects of these treatment systems namely, (i) the application of ruthenium (IV) oxide/Ni (RuO₂/Ni) foam electrodes for the remediation of ibuprofen in soil matrix- the effect of electrokinetic parameters, (ii) treatment of secondary effluent by sequential combination of photocatalytic oxidation with ceramic membrane filtration, and (iii) the exploration of an innovative draw solution for a forward osmosis-membrane distillation desalination process.

Considering a sustainable future, it is essential to recover chemicals whenever possible. Since liquid and solid wastes contain a large number of chemical species, recovering and reusing them will conserve the available resources. When we consider food, there is enough food produced in the world to feed everyone. However, one third of all the food produced is lost or wasted (around 1.3 billion tons of food), costing the global economy close to \$940 billion each year. For example, the food waste costs Australia 20 billion dollars annually (<http://www.ozharvest.org/fightfoodwaste/food-waste-facts/>). Thus, food waste is starting to pose serious threats in many parts of the world and serious steps should be taken to address this problem. This special issue contains two articles on this emerging topic: (i) resource recovery of food waste through continuous thermophilic in-vessel composting and (ii) agricultural waste derived fuel from oil meal and waste cooking oil.

The last section of this special issue has four articles that covers different aspects of soil remediation. The major concern with soil pollution is the health risk that could be posed to humans and deterioration that could affect the flora and fauna. How heavy metals and organic pollutants could adsorb onto soils and marine sediments, preventing the transport of contaminants in different soil environments, and evaluating suitable remediation methods are essential factors which should be continuously investigated. In this special issue, the following aspects have been discussed through four articles: (i) using polyglutamic acid as a soil washing agent to remediate heavy metal contaminated soils, (ii) remediation and cytotoxicity study of polycyclic aromatic hydrocarbon-contaminated marine sediments using synthesized iron oxide carbon composites, (iii) biogeochemical and engineered barriers for prevention of the spread of contaminants, and (iv) effect of pH and organic matter on the adsorption and desorption of pentachlorophenol by soils.

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successfully. Last, but not the least, our sincere appreciation to all the reviewers for providing critical reviews, comments, and feedback on manuscripts that were submitted for this thematic special issue. The guest editors would also like to thank the MS, PhD students, and staff members from National Kaohsiung Marine University (Taiwan) for their assistance and support in organizing the CESE-2016 conference in Kaohsiung.

We hope you enjoy reading the manuscripts presented in this special issue and sharing the issue with your colleagues and friends as much as we have enjoyed bringing it to you.

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Eldon R. Rene is a senior lecturer of Resource Recovery Technology at UNESCO-IHE, Institute for Water Education (Delft, The Netherlands). His research majorly focuses on the development of biological treatment processes for wastewater and waste gas treatment, non-point source pollution prevention, resource recovery from waste gases, the use of artificial intelligence tools for environmental monitoring, environmental process control, and eco-industrial parks. He

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Dr. Li Shu is the Managing Director of LJS Environment (Australia) and a guest Professor at Shandong Normal University (China). She was a senior researcher at RMIT University (Australia), until December 2016. Dr. Li Shu has more than 150 publications in forms of book, book chapters, journal papers, and refereed conference papers. She obtained her Bachelor degree from Qingdao University of Science and Technology (China), Master degree from

Asian Institute of Technology, Bangkok (Thailand), PhD from University of New South Wales, Sydney (Australia). She with her students and colleagues were the first to document images of water clusters taken by a microscope. They also proposed the structure of water, which will be published soon. With the proposed structure of water, the mysterious behavior of water could be explained. The research group reported that the pH of neutral salt was not 7.0 and the neutral salt was corrosive. Dr. Li Shu proposed that strong electrolytes such as sodium chloride (NaCl) existed in water as aggregates in 2005. The concept has been supported using a Nanosizer (Malvern) and important results of this research were published in 2013 and 2017, respectively. Dr. Li Shu's research interest is in water and wastewater treatment using membrane filters: resource recovery and zero liquid discharge. Her research team has also tested various membranes and nanoparticles for water and wastewater reclamation. She taught Water and Wastewater Systems to undergraduate and post graduate students. She is one of the founders of the international conference series on “Challenges in Environmental Science and Technology (CESE)” and has been the co-chair of the conference since 2008. She is an editorial board member of Austin Environmental Sciences and *SM Journal of Environmental Chemical Engineering*. She is a guest editor of the journals: Bioresource Technology, Desalination and Water Treatment, International Biodeterioration and Biodegradation, Water, Air and Soil Pollution: Focus, Reviews in Environmental Science and Bio/Technology, as well as Membrane Water Treatment.

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