News Article for RISUD Strategic Focus Area (SFA) Scheme

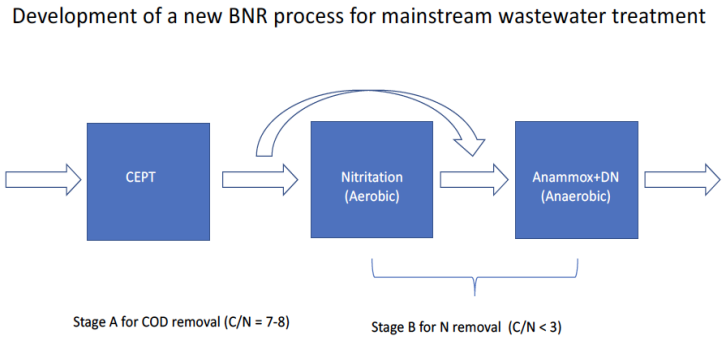
		Name	Department
1.	**Principal Investigator**:	Li Xiangdong	CEE
2.	**Name of SFA:**	**Type A:** SFAs with established strength and a constant stream of external funding to sustain a strong research programme;	
3.	**Project Title:**	New Paradigm of Integrated Urbanwater Management	

4. **First/Second/Third Year Progress/Achievement (***in layman's language, no more than two A4 pages, pls attach a few figures***)**

Application of a prototype BNR process (FMBR-Anammox) in a local sewage treatment works for mainstream wastewater treatment

One set of prototype partial nitritation-Aanmmox (PN-Anammox) system developed by us was applied in a local sewage treatment works and its on-site operation has demonstrated that (1) the sewage treated by a CEPT process in SCISTW can be further treated in our PN-Anammox system to remove nitrogen successfully; (2) the digested sewage sludge from CEPT process can produce a biogas containing 70% methane to generate electricity through an innovative Solid Oxide Fuel Cell (SOFC) process with a higher energy conversion efficiency than conditional CHP processes; (3) elemental sulphur can be recovered from the biogas of digested sewage sludge as a value-added material; and (4) a new species of bacteria was identified in our study as one of new anammox bacteria which is suitable for saline sewage treatment. This project has successfully delivered an efficient, green and energy-producing system, which consists of pilot-scale mainstream Anammox fluidized-bed membrane bioreactor (FMBR), laboratory-scale meso-digester, laboratory-scale twin hydrogen sulfide (H_2S) scrubber and pilot-scale solid oxide fuel cell (SOFC) for conversion of wastewaters into electricity.

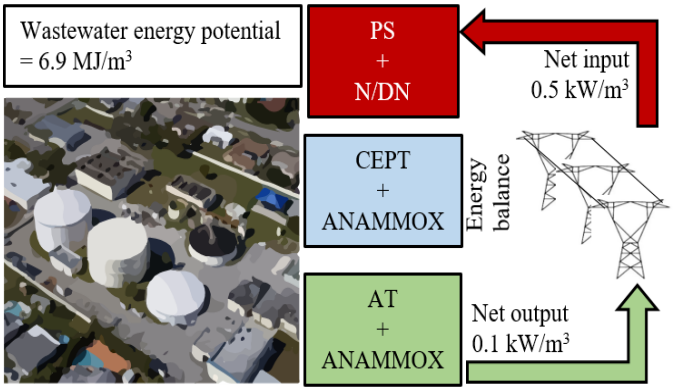
Further development of a separated PN and Anammox/denitrification reactor system with a bypass flow design for mainstream wastewater treatment



A separate partial nitritation (PN) and Anammox reactor system including a PN reactor for partial nitrification and an anammox reactor for anammox/denitrification was successfully set up and has been operated for more than two years. The PN reactor was operated at an aerobic/anoxic condition to biologically oxidize ammonia to nitrite and nitrate affected by several operating conditions of hydraulic retention time (HRT), dissolved oxygen (DO), pH, aeration strength and pattern. Performance efficiency was evaluated by a few KPI parameters including ammonia removal efficiency (ARE) > 90%, ammonia removal rate (ARR), and nitrite accumulation ratio (NAR) >50%. There are main two groups of bacteria, ammonia oxidation bacteria (AOB) and nitrite oxidation bacteria (NOB) in the PN reactor. To achieve a high NAR, the key challenge is to suppress NOB as mush as possible. The experiments demonstrated an optimized operating condition including DO at 0.5-1.0 mg/L, pH at 8.5-9.0, and a short HRT of 5-6 hours. In addition, the intermittent aeration pattern, free ammonia (FA) concentration and free nitrous acid (FNA) concentration could also enhance the suppression of NOB. However, our study found that variation of the operating condition such as DO, pH, HRT etc, the NOB growth is more sensitive than AOB which is beneficial to resulting in good NAR performance, but NOB could gradually adapt the new operating condition and resulted in a recovery of the NOB activity after a few days. In this study, bacteria community was examined at different operating conditions by PCR and sequencing analyses to understand the bacteria composition and variation accordingly for a deep understanding of this PN reactor performance. The experiment results indicated that the variation of operating condition in the PN reactor can only improve its performance for a short time and an alternative sludge treatment is needed to maintain a AOB dominated environment in the PN reactor. The experiment was further conducted by adding a side-stream sludge treatment facility to treat the sludge of PN reactor with high FA concentration (around 250 mg/L-N) at a high pH of 9 for 24 hours. The bacteria activities of AOB and NOB were examined before and after the sludge treatment. It was found that NOB activity was reduce more than 50%, while AOB activity was only reduced < 30%. The sludge after this treatment was returned to the PN reactor to treat mainstream wastewater and a higher NAR was achieved to be 50-80%. However, the activity of NOB could gradually be recovered from the inhibition after one week. Therefore, we suggest that a sludge treatment process at a side stream is necessary to be conducted periodically in order to maintain an AOB dominated environment in the PN reactor. In this study, bacteria community was examined at different operating conditions by PCR and Sequencing analysis methods to

understand the bacteria composition and variation accordingly for a deep understand the performance of this PN reactor.

Analysis of energy balance in wastewater treatment plants towards energy neutrality



To reduce operational costs and carbon footprint, the achievement of energy neutrality in municipal wastewater treatment plants (WWTPs) is a highly promising approach. Over 100 nitrification/denitrification (N/DN) and anaerobic ammonia oxidation (ANAMMOX)-based wastewater treatment systems were reviewed in this study. The energy consumption performance of N/DN systems ranged from 0.3 to 4 kWh/kg-COD and 5 to 15 kWh/kg-N; while those of ANAMMOX-based systems ranged from 1 to 5 kWh/kg-COD and 0.5 to 1.5 kWh/kg-N. Based on an energy balance analysis of typical domestic wastewater (COD = 500 mg/L;TN = 50 mg/L) treatment, the conventional N/DN process averagely consumed 0.5 kWh/m^3 (1.78 MJ/m^3) more energy than was recovered from its sludge digestation and incineration. However, if wastewater is pretreated by a chemically enhanced primary treatment (CEPT) or anaerobic treatment (AT), the subsequent ANAMMOX-based wastewater treatment systems may realize WWTP energy autarky or even output electricity up to 0.17 kWh/m^3. In such a nexus of energy recovery, the biogas generation from the AT or sludge digestion would be an effective manner of recovering energy, while the incineration of dewatered digestates was an energy-negative process. The combination of early-stage COD capture and ANAMMOX is a promising approach to achieve sustainable performance of WWTPs.

To be a Hong Kong-wide, world-leading platform for the development and implementation of technologies and systems for smart/sustainable cities through collaborations among the three sectors of universities, government departments and the industries, a University-Government-Industry (UGI) Consortium for Sustainable Urban Development was launched by RISUD in 2017 (i) to identify topics of common interests for collaborative research through exchanges among Consortium members; (ii) to undertake collaborative research to address the key challenges faced by Hong Kong; (iii) to facilitate the implementation of research outcomes in practice; and (iv) to support the export of Hong Kong's expertise to high-density cities in the Chinese mainlined and beyond. So far three workshops have been annually and successfully conducted on 4 March 2017, 28 April 2018 and 22 June 2019, respectively, until a pandemic difficulty occurring in 2020. We are planning to hold the next UGIC

Forum in June 2022, at which a session entitled “Urban Water” will be arranged. A number of collaborative R&D projects have been conducted by following up the previous UGIC forum events among the universities, the government departments and local industries. The these collaborative research has also resulted in three patent applications of one US patent and two China patents as follows:

- Energy-efficient mainstream anammox system (China invention patent application number: 201910321295.5)
- Energy generation from carbonaceous and nitrogenous pollutants via ammonium, methane, and carbon dioxide reformation (U.S. patent serial No. 62/353,137)
- An algorithm model, method, real-time monitoring device and system for sulfide removal from biogas with microaeration (China invention patent application No. 202010353493.2)