ABSTRACT

The high energy-consuming existing wastewater treatment systems require larger footprints, which hinders its application in treating aquacultural wastewater. The integrated microbial fuel cell (MFC)-membrane bioreactor (MBR) and moving bed biofilm (MBBR) assisted MBR based systems were developed and assessed for treating aquacultural wastewater. Different cathode catalysts were synthesized in this work, like TiO2/Activated carbon photo-cathode catalyst, which if exposed to ultraviolet (UV) radiation showed enhanced efficacy of integrated MFC-MBR system, which was further improved by omitting the necessity of UV by synthesizing the visible light excited photo-catalyst Bidoped TiO2 nano-powder. The catalysts based on carbon nanotubes (CNTs) co-doped with Fe or Co and nitrogen, synthesised to achieve electrocatalytically active oxygen reduction reaction (ORR) to improve the bio-electricity recovery from MFCs. Further research showed the multi-walled carbon nanotube (MWCNT) and carbide-derived carbon (CDC) supported metal (Fe and Co) phthalocyanines with FePc-CDC (8.26 W/m3) being the best in comparison to the popularly used costly platinum (8.76 W/m3). The anode material based on the graphitized coconut coir and loofah sponge were found to be superior than bare carbon felt based anode because of higher specific surface area as well as better biocompatibility to achieve efficient wastewater treatment as well as higher energy recovery from MFCs. Moreover, in-situ suppression of methanogenesis by employing fish market wastewater was witnessed assuring the elimination of re-occurrence of methanogens in long-term application of MFC.

The proton exchange membrane (PEM) also played a crucial role in MFC. The comparable performance with far less expenditure as compared to the Nafion advocates the applicability of polyvinyl alcohol (PVA) based TiO2-Si as low-cost PEM. The electrochemical membrane bioreactor (EMBR) was then developed with polymer derived ceramic made bifunctional membranes with hierarchical pore structures, which inhibit the migration of dissolved oxygen along with showing the hydrophilic behaviour, which helps in retaining the water molecule in the membrane structure similar to Nafion. Hence, when suction pressure is applied from the cathodic side (10-20 kPa) of EMBR, it can filter the anolyte. An anaerobic ultrafiltration membrane bio-fuel cell (UFMFC) was also developed to reduce the footprint of treatment with longitudinal vibration technique to mitigate the biofouling of flat sheet ultrafiltration membrane placed at the anodic chamber of UFMFC, which drastically reduces the footprint of the wastewater treatment regime and improves the treatment efficiency of fish processing wastewater.

Lastly, a pilot-scale packaged wastewater treatment plant was fabricated and conceptualized, merging MBBR and MBR technologies in a single module, which can be functioned as a decentralised treatment scheme for four to five house-holds with effluent quality good enough for non-kitchen purposes, such as

gardening, horticulture, vehicle washing, floor cleaning, aesthetic enhancement, re-circulatory aquaculture system etc.

Keywords: Cathode catalyst; Fish processing wastewater; Membrane bioreactor; Microbial fuel cell; Moving bed biofilm reactor; Proton exchange membrane