ABSTRACT

Considering the ever-depleting freshwater reserves all over the globe, there is a constant need to find an alternative source of water to fulfil the daily water demands. In this regard, treated municipal wastewater can be a potential source for various non-potable applications. Now-a-days even municipal wastewater is laden with emerging organic contaminants (EOCs) that pose a serious threat to the local ecosystem and human beings if exposed for a prolonged duration. Secondary biological wastewater treatments are incapable of removing such EOCs, which demands the development of tertiary treatments for their removal. However, some of the newly developed advanced secondary treatments, such as anodic treatment in microbial fuel cell (MFC) and electrically conductive bio-filters demonstrated effective removal of organic matter (60%), while simultaneously achieving partial removal of surfactant (sodium dodecyl sulphate SDS, 80%).

Also, nutrient removal from municipal wastewater is necessary, for this the application of moving bed sequencing batch reactor (MBSBR) was explored for the simultaneous removal of organic matter and nitrogen. The optimized MBSBR having an initial 60 min of anaerobic treatment with an overall cycle time of 6 h, bio-carrier filling volume of 30%, and C/N ratio of ~7 achieved COD, total nitrogen, and SDS removal of 64, 65, and 81%, respectively. Similarly, electrically conductive bio-filters, which function as attached growth treatment achieved a similar wastewater treatment efficiency (COD, total nitrogen, and SDS removal of > 60, > 55, and > 90%) in the lab- and pilot-scale bio-filter operated under an applied OLR of 115 – 130 g COD/m^3.day.

Even then a follow-up treatment is necessary for removing pathogens and remaining EOCs from secondary treated wastewater. As a low-cost and less chemical- and energy-intensive treatment option, MFC-based advanced oxidation processes (bio-electro-Fenton and photo-electro-catalytic oxidation) were implemented for the tertiary treatment of wastewater and removal of SDS, which demonstrated above 90% removal of SDS. A comparative life cycle assessment of bio-electro-Fenton oxidation with biological treatment and electrochemical oxidation also suggested that the environmental impacts of the bio-electro-Fenton process were the lowest; thus, suggesting bio-electro-Fenton as a preferred treatment strategy.

Even after understanding the importance of advanced secondary and tertiary treatments, secondary biological treatments are considered as low-cost treatments and are the backbone of wastewater treatment. Biological sludge management is a major limitation of such biological treatments. Thus, valorisation and reutilization of wastewater sludge in wastewater treatment in the form of adsorbent for adsorption and electrode in electrochemical oxidation (EOX) can be a possible way of achieving a circular economy. Based on this, the wastewater sludge-derived activated hydrochar exhibited a surface area of 1119 m^2/g with a maximum methylene blue (MB) adsorption capacity of 192.7 mg/g; whereas, the wastewater sludge-biochar derived cathode in EOX demonstrated above 90% of MB decolourisation under an optimal applied current density of 10 mA/cm^2 at neutral pH, with simultaneous cathodic *in-situ* H_2O_2 production capability. Overall, such integrated treatments in futuristic wastewater treatment plants will generate treated effluent as a prime resource, which can be utilized for any non-potable contact uses; thereby can reduce the dependency on ever-depleting freshwater and aid in achieving environmental sustainability.