Abstract:

Rapid urbanization has led to an increase in the production of domestic wastewater there by putting enormous pressure on the existing centralized sewage treatment plants. Upgrading the existing treatment plants is not easy due to various technical challenges and high costs. Decentralized wastewater treatment systems are therefore emerging as one of the alternative strategies for wastewater treatment at the point sources. Most of the available technologies commonly employ separate treatment processes for the removal of organic matter and nutrients from the waste waters. Moreover, they are also not equipped with resource recovery capabilities. The available waste water treatment processes are either energy or chemical intensive, costly, and suffer due to operational complexity. The development of decentralized integrated systems based on multiple processes is anticipated/hypothesized to address some of these issues. In this context, we tested a decentralized wastewater treatment system based on the integration of drip hydroponics and microbial electrochemical technologies not only for waste water treatment but also for resource recovery in the form of plant cultivation and energy production. In a proof-of-principle design, the integrated system consisted of ten reactor units, and each unit housed a graphite anode embedded in the cocopeat support media bed, a graphite air cathode, and Cymbopogon citratus grass (common name: lemongrass). The system was operated in a semi-continuous drip-hydroponics mode. Various wastewater treatment parameters, which include COD, BOD, ammonia, nitrate, phosphate, coliforms, pH, and conductivity along with the electricity output in terms of cell voltage were monitored continuously for evaluating the performance of the system. At 3 h hydraulic retention time (HRT), the integrated hydroponics-microbial electrochemical system achieved 72% COD, 80% phosphates and 35% ammonia removal efficiencies. In addition to the wastewater treatment, the presented system produced low levels of electricity output and allowed simultaneous cultivation of commercially important plants. Up to 30.9 mW/cm^2 and 31.6 mW/m^2 power outputs were obtained with a serially and parallelly connected microbial fuel cell units in these systems, respectively. At longer HRTs of 6 h or 12 h, more than 85% COD and N & P nutrients removal efficiencies were observed. As hypothesized the innovative integration in a single system allowed the exploitation of activities of multiple biological components such as aerobes, anaerobes, exoelectrogens, plant roots and rhizosphere microbiota for the removal ofdifferent pollutants present in domestic wastewater. The proof-of-principle study demonstrated the feasibility of the integrated system for efficient domestic wastewater treatment with simultaneous electricity generation and commercially important plant cultivation. Other unique features of the proposed system include easy operation, no chemicals, no foul odor, and CO_2 sequestration by plants.