An Innovative Membrane Bioreactor Process for Achieving Sustainable Advanced Wastewater Treatment

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Chemicals of concern (COCs), such as pharmaceutical chemicals, steroid hormones, and pesticides, have been found to be widely distributed in water and wastewater. Conventionally operated wastewater treatment plants do not provide an effective barrier against the release of these COCs to receiving waters. An alternative to conventional activated sludge reactors for the treatment of wastes containing COCs is the use of membrane bioreactors (MBRs) because the solids retention time (SRT) can be easily manipulated to enable enrichment of slower-growing strains of microorganisms to degrade such compounds. The goal of this research is to determine the efficacy of a gravity-flow Biomass Concentrator Reactor (BCR) for the removal of COCs at trace level concentrations (10 μg/L). The BCR is equipped with a membrane having a pore size ranging from 18 to 28 μm, which presents a significant advantage over conventional MBRs with ultrafiltration membranes requiring vacuum or pressure to effect solids-liquid separation. In the BCR, water permeates by gravity with a head differential of less than 2.5 cm. The BCR performance in removing COCs is being studied under conventional aerobic conditions and as a hybrid system with nitrification, where organic carbon and ammonia are oxidized and, at the same time, nitrate is reduced to dinitrogen in a separate anoxic compartment. Two reactors are operated in parallel and fed with medium-strength municipal wastewater fortified with an estrogen ethinyl estradiol, a progestin progesterone, an androgen testosterone, nonylphenol, triclosan, caffeine, atrazine, and carbamazapine. Both BCRs operating at 6 days SRT have successfully reduced the concentrations of 8 of the 10 COCs by > 90% (mostly by > 95%), and higher removals (up to 99+%) occurred at 15 days SRT. The 2 COCs that were partially reduced were atrazine and carbamazapine. Based on the demonstrated performance of the BCR, we have proposed the hybrid design for treatment of municipal wastewater to levels that allow water reuse. Further improvements would result in wastewater treatment for producing safe drinking water sustainably.

Key words: membrane bioreactors, biomass concentrator reactor, biological wastewater treatment, biological nutrient removal, chemicals of concern, sustainability