Removal of pharmaceuticals in pre-denitrifying MBBR – Influence of organic substrate availability in single- and three-stage configurations - DTU Orbit (16/08/2019)

Removal of pharmaceuticals in pre-denitrifying MBBR – Influence of organic substrate availability in single- and three-stage configurations

Due to the limited efficiency of conventional biological treatment, innovative solutions are being explored to improve the removal of trace organic chemicals in wastewater. Controlling biomass exposure to growth substrate represents an appealing option for process optimization, as substrate availability likely impacts microbial activity, hence organic trace chemical removal. This study investigated the elimination of pharmaceuticals in pre-denitrifying moving bed biofilm reactors (MBBRs), where biofilm exposure to different organic substrate loading and composition was controlled by reactor staging. A three-stage MBBR and a single-stage reference MBBR (with the same operating volume and filling ratio) were operated under continuous-flow conditions (18 months). Two sets of batch experiments (day 100 and 471) were performed to quantify and compare pharmaceutical removal and denitrification kinetics in the different MBBRs. Experimental results revealed the possible influence of retransformation (e.g., from conjugated metabolites) and enantioselectivity on the removal of selected pharmaceuticals. In the second set of experiments, specific trends in denitrification and biotransformation kinetics were observed, with highest and lowest rates/rate constants in the first (S1) and the last (S3) staged sub-reactors, respectively. These observations were confirmed by removal efficiency data obtained during continuous-flow operation, with limited removal (<10%) of recalcitrant pharmaceuticals and highest removal in S1 within the three-stage MBBR. Notably, biotransformation rate constants obtained for non-recalcitrant pharmaceuticals correlated with mean specific denitrification rates, maximum specific growth rates and observed growth yield values. Overall, these findings suggest that: (i) the long-term exposure to tiered substrate accessibility in the three-stage configuration shaped the denitrification and biotransformation capacity of biofilms, with significant reduction under substrate limitation; (ii) biotransformation of pharmaceuticals may have occurred as a result of cometabolism by heterotrophic denitrifying bacteria.

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