Effective Removal of Contaminants of Emerging Concern by Biologically-Active Filters

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Background/Objectives. Contaminants of emerging concern (CECs) have been widely found in the water cycle, including the influents and effluents of wastewater treatment plants (WWTPs), surface water, drinking water, and even groundwater. Their prevalence has led to studies to better understand their removal through a number of treatment processes including ozonation, granular activated carbon (GAC), and advanced oxidation. Some limitations of these treatment processes include by-product formation, adsorbent breakthrough and regeneration, and excessive energy requirement. Recently, biologically active filters (BAFs) have received increasing attention in their application to treat a variety of water contaminants including CECs; their treatment effectiveness has been studied as a function of operational factors, such as filter media, pretreatment process, empty bed contact time (EBCT), and temperature. In this study, we investigate the effectiveness of BAFs in treating 16 indicator compounds that represent CECs that are widely used, detected with significant frequency in the water cycle, persistent in the environment, and recalcitrant to treatment. As the key players, microbial communities in BAFs are unveiled using the high-throughput Next Generation Sequencing. Multivariate statistical tools is used to exploit the key operational variables that regulate the CEC-degrading biofilm in BAF systems. Specific degraders of selected CECs (e.g., sulfamethoxazole) are identified and isolated using conventional dilution-to-extinction method.

Approach/Activities. Eight columns were set up to evaluate CEC removal in the BAFs with four columns dedicated to an individual BAF media: two with pre-ozonation and two without (each column run in duplicate). Two types of filter media included the GAC media and the anthracite/sand dual media. Sixteen CECs belonging to 11 types of classes based on usage and therapeutic categories were selected as indicator compounds, including acetaminophen and ibuprofen (analgesics); erythromycin, sulfamethoxazole, and trimethoprim (antibiotics); carbamazepine (antiepileptic); atenolol (β-blocker); gemfibrozil (blood lipid regulator); TCEP (fire retardant); cotinine (nicotine metabolite); aminotriazole, atrazine, and DEET (pesticides); caffeine (psychomotor stimulant); 17β-estradiol (steroid); and, iopromide (x-ray contrast agent). Spiked concentrations in the source water were based on environmentally relevant concentrations and their reported removal in treatment processes.

Results/Lessons Learned. GAC BAFs were found to be highly efficient in treating CECs. At an EBCT of 18 min, only iopromide was removed at <75% (59%). With the application of pre-ozonation at a dosage of 3 mg/L (i.e., ozone demand), all the CECs including iopromide were removed by >75%. At a 10?min EBCT, the number of CECs removed by >75% decreased to seven. Dual media showed limited and reduced removals with less than four of the compounds removed by >75% without pre-ozonation. Detrended correspondence analysis demonstrated media materials predominantly governed the structures of the acclimated biofilm in BAFs as they provide direct attachment surface. This is in line with the higher microbial activity and better treatment performance exhibited by GAC BAFs compared to the dual media BAFs, corroborating the importance of filter media selection to promote the acclimation of active and robust biofilm for efficient CEC removal. Putative CEC degraders are predicted based on their dominance in the media and degradation capabilities reported in previous literature. Isolation and characterization of CEC degraders is in the process.