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A Laboratory Batch Study

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Removal of Organic Micropollutants from Wastewater by Ozone Activated Carbon Filtration and Porous Cyclodextrin Polymers Adsorption: A Laboratory Batch Study

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Introduction

Organic micropollutants (OMPs) are present in all compartments of the water cycle. A specific case is the presence of pharmaceuticals in wastewater. Removal of pharmaceuticals by traditional wastewater treatment plants is limited, which necessitates the application of advanced treatment processes. A new adsorption process concerns the use of porous cyclodextrin polymers (P-CDPs) as an alternative for activated carbon. Insoluable polymers of β-cyclodextrin, an inexpensive, biobased macrocycle of glucose, are of interest for removing micropollutants from water by means of adsorption. This study explored the use of a mixture of positively and negatively charged P-CDPs for the removal of pharmaceuticals from real wastewater, and compared the results with the removal by activated carbon filtration and ozone-activated carbon filtration as mature processes.

Methodology

Treated effluent from the secondary clarifier of the wastewater treatment plant Horstermeer was spiked with a mixture of 14 OMPs (6 positively, 2 negatively, 6 neutrally charged) at individual compound concentrations ranging between 0.29 and 47 µg/l.

P-CDP batch adsorption experiments were performed with a 50%/50% mixture of a positively and negative charged P-CDP obtained from CycloPure USA (Dexsorb) at dosages of 0.5-2-5-10-30-50 mg/l at 72 h contact time. Experiments were performed in demi water and in Horstermeer wastewater effluent.

In the ozone-activated carbon experiments the Horstermeer wastewater effluent was first ozonated at ozone dosages 0.2-0.4-0.8-1.4 gO_3/gDOC, followed by batch experiments with pulvarized GAC (Cabot GAC 612WB) at carbon dosages 0.5-2-5-10-30-50 mg/l. As a reference same experiments with GAC were carried out without pre-ozonation. All GAC adsorption experiments applied 48 h contact time.

Results & Discussion

Ozone-activated carbon experiments

The removal of the target compound with pulverized GAC is shown in Figure 1. Combining GAC with O_3 increased the removal efficiency.

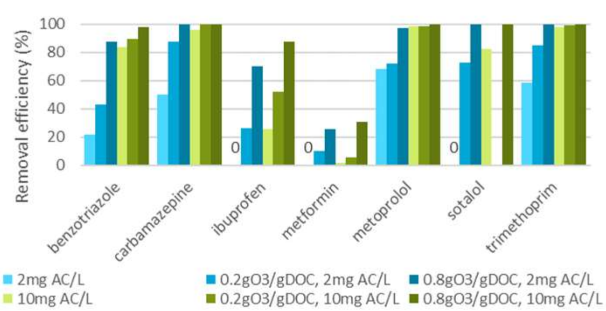

Figure 1: Ozone + pulvarized GAC removal efficiency for Horstermeer wastewater effluent

P-CDP adsorption experiments

Figure 2 shows the removal efficiency in demi water and Horstermeer wastewater effluent.

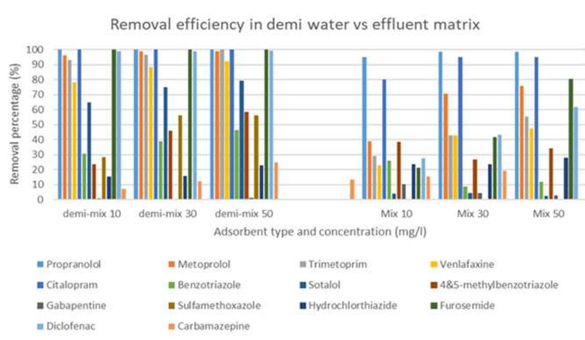

Figure 2: P-CDP Mix removal efficiency in demi water (left) and Horstermeer wastewater effluent (right)

Removal in demi water using P-CDP Mix met expectations of predicted outcomes based on previous research. At 30 mg/l mix, all 8 positively and negatively charged OMPs were removed to greater than 70%, with 6 of the OMPs removed in excess of 90%. Those 6 OMPs were removed to 90% at the lowest dosing of 10 mg/L. Removal of neutrally charged compounds lagged across all dosing levels. Comparing removal efficiencies in demi water and Horstermeer wastewater effluent, it appeared that the effluent matrix affects the removal efficiency.

Figure 3 shows the removal efficiency for P-CDP Mix compared to pulverized GAC in the Horstermeer wastewater effluent. Matrix effects seem to influence adsorption by P-CDP more than adsorption by pulverized GAC.

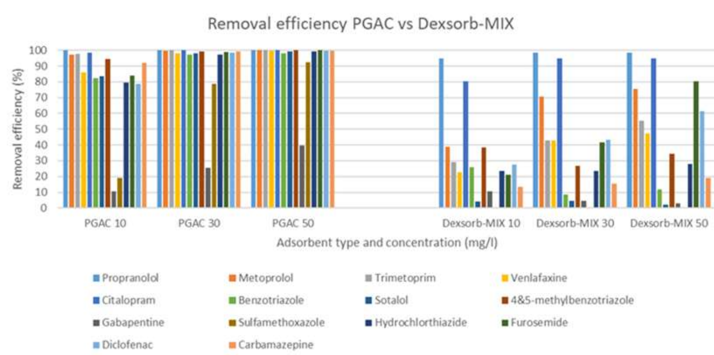

Figure 3: P-CDP Mix (right) and pulverized GAC (PGAC) (left) removal efficiency for Horstermeer wastewater effluent

Conclusions and further perspectives

In Horstermeer wastewater effluent, pulverized GAC and O3-GAC outperformed P-CDP, especially for neutrally charged OMPs. However, P-CDP may be attractive for its fast kinetics and easy, on-site regeneration with methanol. In contrast to the energy intensive and degradative regeneration processes of GACs, P-CDPs are easily regenerated by rinsing with methanol at room temperature. Additional experiments will be performed with higher P-CDP dosages.