Influence of Microplastics on Gravity-driven Membrane Filtration of Wastewater

Graduate

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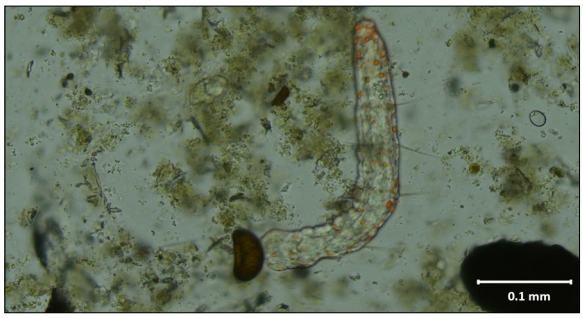
Introduction: The inadequate treatment and disposal of domestic wastewater remains a significant environmental problem in Iceland. The discharge of untreated wastewater into the oceans carries risks such as eutrophication, the occurrence of micropollutants and microplastics as well as waterborne pathogens. To meet the wastewater disposal standards of the Icelandic Water Framework Directive, it is necessary to develop reliable decentralized wastewater treatment processes. Gravity-driven membrane (GDM) filtration is considered as an energy-efficient and cost-effective decentralized wastewater process, especially for remote locations. However, the transport and mitigation of microplastics in the GDM systems are still unclear.
Therefore, the aim of this thesis was to investigate the effects of microplastics on the GDM performance.

Approach: The microplastic beads with different sizes and amounts were dosed into both clear water and wastewater, which were used as feed water for the GDM systems.
Five experimental conditions were carried out, and the membrane performance (water flux, resistance distribution) and water quality (total suspended solids, BOD5, pH and conductivity) were examined. Furthermore, the cake layer foulant characteristics were analysed and the specific cake resistance was calculated to illustrate the cake fouling mechanism.

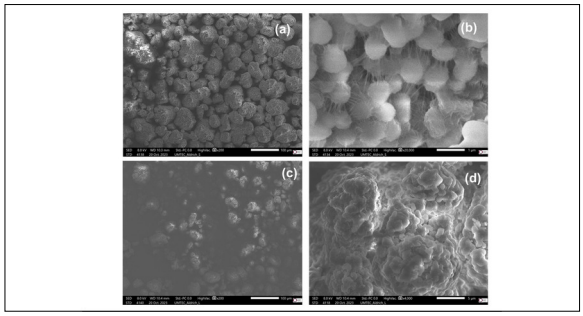
Conclusion: The presence of microplastics in the feed had no major influence on the permeate water quality. Both TSS and BOD5 removal ratios met the requirements by the Water Framework Directive under all tested conditions.
Increasing size and amount of microplastics in clean water led to an increased contribution to the total resistance. The presence of a mixture of different sized microplastic beads led to a greater reduction in the flux than single sized microplastics. In the presence of microplastic beads, cake layer fouling was largely dominant during GDM filtration of wastewater. The specific cake layer resistance was higher in the control GDM system than those with dosed microplastics. Increasing concentration of microplastics in the feed water led to a decreased specific cake resistance, which indicated a more porous cake layer (because the beads would create more space between the biofoulants).
The microscopic analysis of the cake layers on the GDM with wastewater showed the accumulations of prokaryotes and eukaryotes in the cake layers. Meanwhile, the small-sized microplastics tended to aggregate to increase their sizes.

GDM filtration is a promising method for the purification of municipal wastewater in remote areas. However, it would be interesting to investigate the influence of microplastics during periodic cleaning process of GDM systems. In addition, the effect of microplastics on heavy metal removal in GDM systems would be worth investigating in more detail.

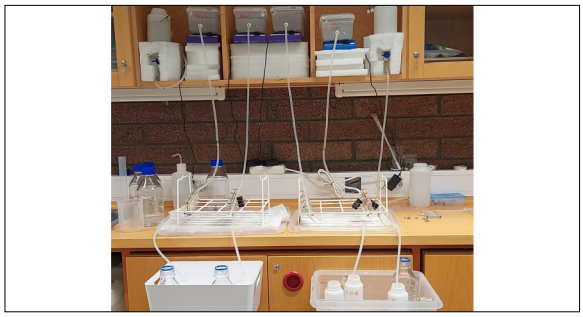
The image of the foulants after ~25 days with dosed small-sized 0.1 g/L microplastics in wastewater under a microscope
Own presentment



The scanning electron microscope (SEM) images of (a-b) S-MP and (c-d) L-MP used in this study.
Own presentment



Experimental setup
Own presentment



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Subject Area
Water treatment