Submerged Gravity-Driven Membrane Reactor for Municipal Wastewater Treatment

Graduate

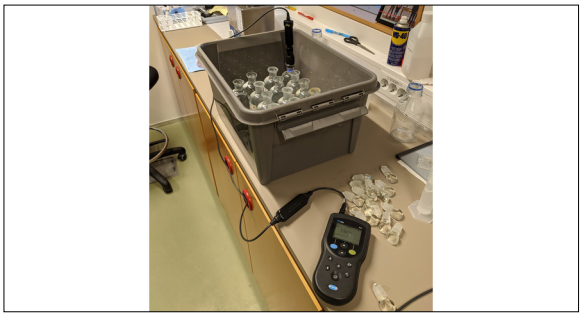
Nicola Landolt

Introduction: In Iceland, wastewater treatment is not as advanced as economic progress would suggest compared to other northern European countries. Currently, in a large part of Iceland wastewater is only treated with a first treatment stage, and in some cases it is not treated at all. The discharge of untreated wastewater into nature entails risks such as eutrophication, occurrence of micropollutants and microplastics or waterborne pathogens, which must be avoided at all costs. Therefore, solutions are needed in Iceland to improve wastewater treatment. For cold temperatures, low water volumes in remote areas and discontinuous inflow, gravity-driven membrane technology (GDM) offers an alternative to standardised methods thanks to simple and low-energy operation.
The bachelor thesis was about comparing three different membrane types (polyethersulfones, 35-40nm pore size & silicon carbide ceramic, 100nm pore size) at different operating conditions. In addition, one membrane had a layer of granular activated carbon upstream and the effluent of one reactor was pre-treated with lava stones.
The membrane performance and permeate quality were examined.

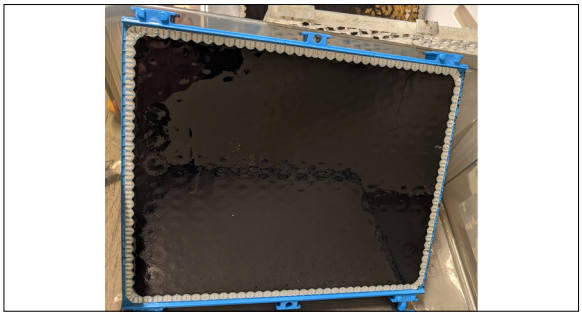
Approach: The experiments were conducted in three phases of 20 days each. In the first phase, one of each membrane type (total of four) was placed in a tank at transmembrane pressure (TMP) 0.05 bar and the wastewater was treated by the membranes. In addition, two more membranes (one polyethersulfone and one ceramic) placed in a smaller tank (TMP: 0.03 bar) of treated wastewater that had already been pre-treated by sedimentation over lava stones. In the second phase, chemical cleaning was carried out periodically during operation. In the third phase, the membranes were rearranged. Thus, in the large tank, two identical membranes made of polyethersulfone, but one with an additional GAC layer were tested at different water levels. In the small tank, two ceramic membranes were investigated to see if the geothermal brine could also be used for periodic cleaning. At the end of each phase, physical and chemical cleaning was carried out.
To compare the membranes, the following parameters were measured to assess the water quality: Flux, pH, Conductivity, Biochemical Oxygen Demand in five days (BOD5) and Chemical Oxygen Demand (COD). Total nitrogen and total suspended solids were also measured for further analysis.

Conclusion: The flux stabilisation phenomenon typical for GDM could be observed. The flux stabilised at the value of 1.7 l/m2*h for all membranes (except the one with additional GAC layer). This was independent of the transmembrane pressure or the pore size. Periodic cleaning did not result in a constant increase of the flux. The flux stabilized at low level within a very short time after cleaning. All membranes managed to degrade BOD5 by at least 80% on average compared to the feed, with the PES-2 variant showing the best degradation capacity. However, the ceramic CEM membrane also showed potential for future use, as it also degrades BOD5 by more than 80% and is less susceptible to possible physical exposures such as backflushing due to its robust material.

BOD5 measurement in the laboratory
Own presentment



Membrane fouling on the PES-1 membrane
Own presentment



Experimental setup
Own presentment

Examiner
Prof. Dr. Michael Burkhardt

Co-Advisor
Bing Wu, University of Iceland, Reykjavik

Subject Area
Water treatment