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Influence of Organic Matter on Membrane Efficiency

Wastewater from the food industry is polluted by dissolved organic compounds. Wastewater treatment through membrane technology may offer promising cost savings. Recirculating systems with membrane technology are cost-saving solutions. With increasing organic load, filtrate flux, permeate flux and membrane selectivity are reduced. In order to upgrade dairy farm wastewater with a COD of 984 mg/l, microfiltration combined with reverse osmosis sufficiently fulfils the minimum restrictions for disposal into surface waters and attains a water quality which allows reuse as process water. The treatment of slaughterhouse wastewater (COD = 1737 mg/l) however requires a second stage of reverse osmosis.

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Keywords

Wastewater treatment, membrane technology, microfiltration, ultrafiltration, reverse osmosis

In the processing of fruits and vegetables (washing, peeling, sorting, blanching, cooling, cleaning and disinfection, with an increasing demand in recent years, a lot of organically polluted wastewater is produced. Efficient cycling processes by means of membrane technology may save money and are therefore of great interest for many producing enterprises with a high water consumption. However the deposition of organic material (Fouling) on the membrane surface reduces the efficiency of the membrane [1]. Studies on wastewater discharged by municipalities [2], vegetable industry [3] and drinking water conditioning [4] have shown that low concentrations of organic compounds have only little effects on filtrate flux, permeate flux and the selectivity of the membrane. According to these results, there are promising ways to treat low polluted wastewater by membranes and to reuse the upgraded wastewater as process water. This article describes the influence of dissolved organic matter on the efficiency of different membrane technologies during the treatment of wastewater.

Microfiltration (MF)

For all experiments applying membrane filtration, special attention was concentrated on clogging which should be prevented. Therefore, deposable solids were removed from the wastewater before membrane filtration started. Experiments were performed on a technical scale (UFI-TEC GmbH Oranienburg, Germany) with exchangeable modules and membranes. The experimental system was operated by a recirculation pump. During the treatment of dairy farm wastewater (COD = 984 mg/l) by microfiltration through a ceramic Al_2O_3 membrane (cut-off: 100 nm) at a pressure of 2 bar, there was a strong decline of the filtrate flux during the first two hours, when the inflow concentration level was constant. The decline in filtrate flux is caused primarily by a layer of non-deposable inorganic and organic compounds in the wastewater, which covers the surface of the membrane with its pores (scaling und fouling). The discharge of the filtrate increases the concentration of the wastewater, leading to a further decline of filtrate flux until it reaches a constant flux rate after about five hours. The following overflow of the membrane is sufficient to prevent an ongoing coating of the membrane (*Fig. 1*). Due to the overflow an equilibrium is achieved between the production and the removal of the clogging layer. For this type of dairy farm wastewater, a mean filtrate flow of 219 l/m^2•h was recorded. In comparison to the use of a Al_2O_3 membrane, the filtrate flow of carrot washing water (1382 mg COD/l) shows a similar pattern when a membrane of SiC is used, which has the same cut-off and a pressure of 2 bar (*Fig. 1*). However, the mean filtrate flow is only 188 l/m^2•h.

Wastewater from slaughter houses is still higher loaded with organic matter (1737 mg COD/l), compared to dairy farm wastewater and carrot washing water. Consequently the permeability decreases and the mean filtrate

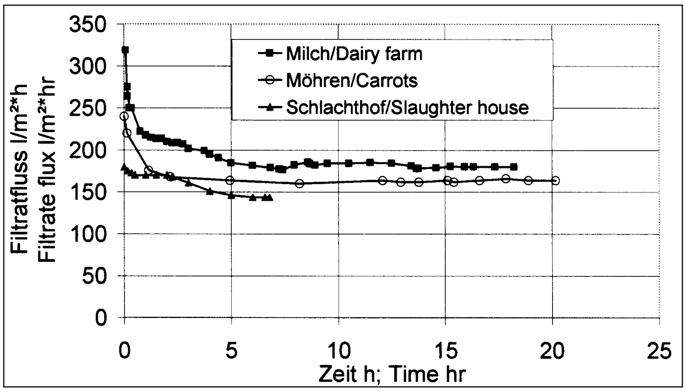

Fig. 1: Filtrate flux during microfiltration of different wastewaters after processing milk and carrots as well as slaughterhouse wastewater (cut-off: 100 nm; pressure: 2 bar)

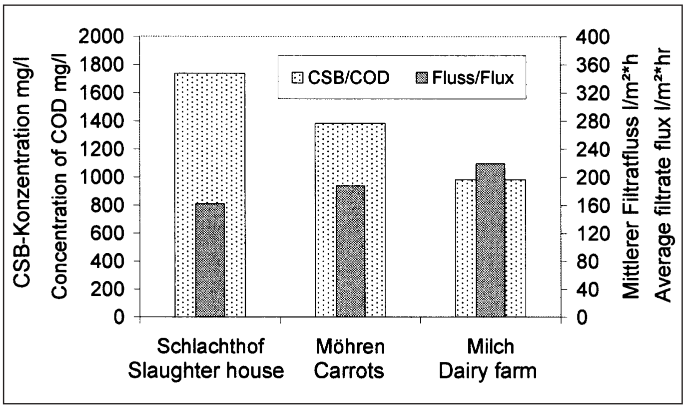

Fig. 2: COD concentration in the feed and average filtrate flux of slaughterhouse wastewater as well as of other wastewater from processing of carrots and milk (cut-off: 100 nm; pressure: 2 bar)

flow is reduced to 162 $l/m^2 \cdot h$ (Fig. 1). Calculations of mean filtrate fluxes of the three types of wastewater were related to the experimental period of the slaughterhouse wastewater. Mean filtrate fluxes of the types of wastewater under study can be related to their COD concentrations (*Fig. 2*).

Ultrafiltration (UF)

The same washing water of carrots, which was treated by MF was also treated by UF. Furthermore vegetable wastewater was used. For both trials a ceramic SiC membrane with a cut-off of 50 nm and a transmembrane pressure of 1 bar was applied. Thus, an influence of different membrane materials as in the MF trials could be excluded. The results confirmed the relationship between filtrate flux and organic pollution of the wastewater.

Reverse osmosis (RO)

In the case of RO membranes organic compounds affect the permeate flux as well as the retention of dissolved compounds. Since there is a concentration polarisation at the membrane, the selectivity of compound held back decreases, resulting in a greater pollution of the permeate.

Combination of micro-/ultrafiltration and reverse osmosis

For relatively low COD concentrations MF followed by RO is sufficient to turn e.g. dairy farm wastewater to a water quality which meets the minimum requirements for the discharge into a surface water. This process water is also suitable to be used for intra-farm cleanings. As a safety step a disinfection by UV however has to follow. Treating wastewater of a slaughterhouse in the same way is not sufficient. Therefore a second step of reverse osmosis is needed to fall below all limiting values.

Conclusions

The experimental results were obtained from different studies performed on a pilot-scale. To find a cost-effective technology for the treatment of a special type of wastewater, a set of reproducible data from long-term experiments is needed. Then a full-scale equipment of a membrane plant can be designed. Besides the lifetime of the membranes, additional information is needed about pre-processing, cleaning intervals and cleaning agents in order to assess the interactions between membranes and wastewater compounds. This is required for the control and maintenance of the efficiency of the whole treatment system.

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