Control of Organic Fouling in UF of Secondary Effluent by Bio-filtration

4th Scientific Meeting
UNESCO-IHE
Delft, Netherlands
4 - 7 October 2009

X. Zheng*, M. Ernst**, M. Jekel*

* Technische Universität Berlin, Chair of Water Quality Control,** Centre for Water in Urban Areas
Sekr. KF 4, Straße des 17. Juni 135, D-10623 Berlin, Germany,
e-mail: xing.zheng@tu-berlin.de, mathias.ernst@tu-berlin.de, martin.jekel@tu-berlin.de

Summary

Ultrafiltration (UF) can be used as a promising process filtering secondary effluent to produce reuse water. However, membrane fouling caused by macromolecular organic compounds is a general drawback. In the present work, slow sand filtration is used to reduce fouling potential of secondary effluent prior to UF. The results show that it can remove particles, colloids and dissolved substances and improve the performance of a conjuncted UF significantly. Lab-scale membrane filtration tests show that biopolymers detected using LC-OCD are major organic foulants. Pilot-scale UF experiments verified this conclusion. Within slow sand filters the removal of biopolymers is observed to take place in the upper active sand layer. The sustainable elimination of biopolymers is mainly attributed to biological processes.

Background

Due to the presence of macromolecular organic compounds, direct UF of secondary effluent results in always severe fouling [1]. As a simple and effective process, bio-filtration can be used to remove foulants from secondary effluent prior to UF and improve its performance [2]. Although the evaluation of fouling control effect can be conducted by comparing the performance of UF, for a better understanding of fouling mechanisms and selecting of suitable fouling control strategies it is necessary to identify and quantify major foulants. Based on quantified results, the investigation of foulant removal mechanisms within biofilters and factors impacting its performance can be further carried out.

Methods

Slow sand filter

Filter material:
silica sand
grain size 1-2 mm

Filtration layer:
0.7 m

Filtration rate:
0.25 and 0.5 m/h

➡ Pilot-scale slow sand filter and UF plant

UF membrane

Membrane material:
hydrophilized
polyethersulfone (PES)

Molecular weight cut-off:
100 to 150 k Da

Filtration mode:
dead-end

➡ Lab-scale Amicon ultrafiltration cell

Separation of DOC components in terms of molecular weight

UV detector @ 254 nm

Photochemical oxidation of organic compounds

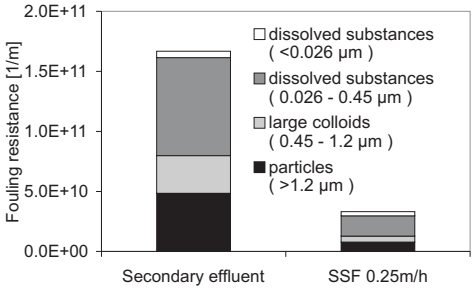
Infrared detection of CO_2

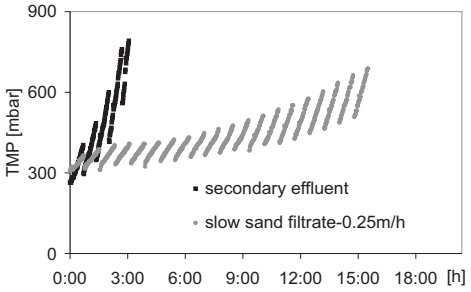
ON detector @ 220 nm

➡ Liquid chromatography with on-line organic carbon, UV and organic nitrogen detectors (LC-OCD)

Results

1. Fouling Control Effect using Slow Sand Filtration:

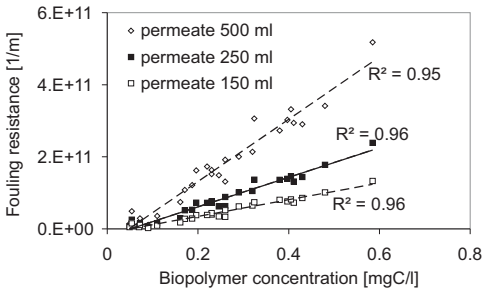


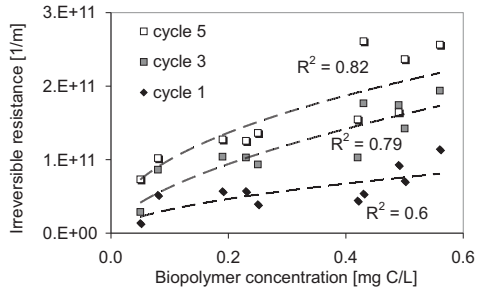


➡ Slow sand filtration can remove particles, colloids and dissolved substances [3]

➡ Filtering slow sand filtrate leads to a much slower TMP increase

2. Identification and Quantification of Major Organic Foulants:

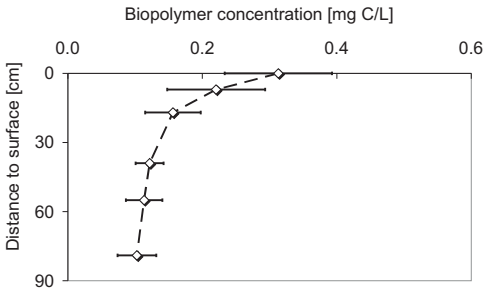


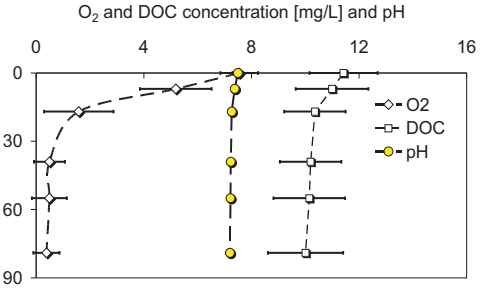


➡ Biopolymer concentration impacts the fouling resistance proportionally

➡ Biopolymer content influences the irreversible resistance significantly

3. Removal of Biopolymers within Slow Sand Filter:





➡ The removal of biopolymers takes place mainly in the upper active sand layer

➡ The removal is related to biological processes

Conclusions

➡ Slow sand filtration can remove particles, colloids and dissolved substances, the performance of the subsequent conjuncted UF can be improved to a large extent.

➡ The biopolymers detected using LC-OCD are major organic foulants. The removal of them in bio-filtration is mainly due to biological processes.

[1] Haberkamp, J., Ruhl, A.S., Ernst, M. and Jekel, M., 2007, Impact of coagulation and adsorption on doc fractions of secondary effluent and resulting fouling behaviour in ultrafiltration. Water Research 41(17), 3794-3802.
[2] Zheng, X., Mehrez, R., Ernst, M. and Jekel, M., 2009, Effect of slow sand filtration of treated domestic wastewater as pre-treatment to UF. Desalination (in press)
[3] Zheng, X., Ernst, M. and Jekel, M., 2009, Identification and quantification of major organic foulants in treated domestic wastewater affecting filterability in dead-end ultrafiltration. Water Research 43(1), 238-244