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Elimination of emerging pollutants in membrane bioreactors (MBR) and soil-aquifer-treatment (SAT)

A. Tiehm[1], P. Lipp[1] , N. Schmidt[1], M. Stieber[1], F. Sacher[1], S. Meuler[2], S. Paris[2], F. Bischof[3]

1 Water Technology Center, Karlsruher Str. 84, 76139 Karlsruhe, Germany (E-mail: tiehm@tzw.de)

2 Hans Huber AG, Industriepark Erasbach A1,92234 Berching, Germany

3 University of Applied Science, Kaiser-Wilhelm-Ring 23, 92224 Amberg, Germany

SMART

Introduction

In regions with lack of fresh water resources the reuse of wastewater becomes an important issue. Anthropogenic trace compounds such as pharmaceuticals, endocrine disrupters and x-ray contrast agents have been detected in wastewater, surface water, and groundwater already. As reuse of wastewater may result in the accumulation of anthropogenic trace organics it is necessary to eliminate these compounds during suitable treatment processes. As part of the SMART Jordan Valley project, MBR technology combined with consecutive subsoil conditioning for groundwater recharge is studied with respect to the removal of anthropogenic trace compounds and pathogenic organisms.

Batch tests

Method

Using the in- and outflow of a conventional treatment plant two active and one control batch tests (< 4°C) were setup. 2-5 µg/L of different pharmaceuticals and endocrine disrupters were added. The active batches were supplied with activated sludge from the treatment plant as inoculum and incubated under aerobic conditions at room temperature.

Results

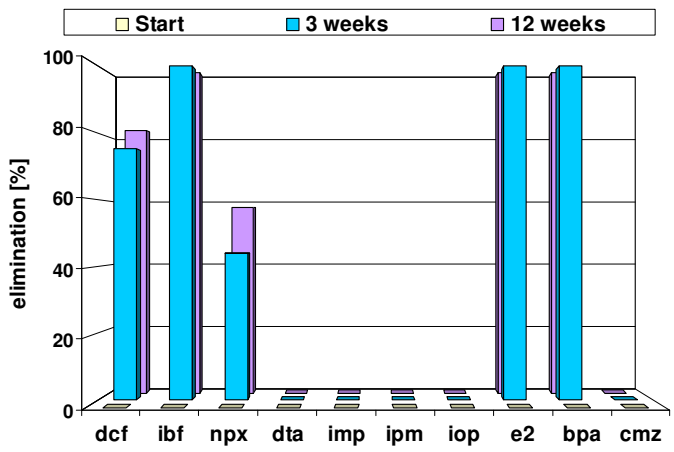

Fig. 1: Biodegradation of different anthropogenic trace pollutants

- Endocrine disrupting compounds (17-β-estradiol (E2), bisphenol A (bpa)) were eliminated by 100% within the first 3 weeks
- Diclofenac (dcf), ibuprofen (ibf) and naproxen (npx) showed removal rates of 82 %, 100% and 58 % respectively
- X-ray contrast agents (diatrizoic acid (dta), iomeprole (imp), iopamidole (ipm) and iopromide (iop)) did not show significant elimination
- Carbamazepine (cmz) was not eliminated during the three months test

Outlook

Unsaturated column experiments are conducted to study biodegradation under vadose zone conditions (fig. 3). Four columns of stainless steel, filled up with natural vadose zone soil, are irrigated with treated wastewater from a CWWTP.
By comparing leachate concentrations of biologically inhibited (cooled down to 2°C) and bioactive columns (20°C), biodegradation of the trace organics during soil passage will be assessed.

Fig. 3: Soil columns

Subsequent to batch and column studies in the laboratory, field experiments are intended, combining wastewater treatment by MBR with groundwater recharge at test sites in the Jordan Valley.

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Elimination in MBR and CWWTP

Method

The MBR pilot plant consists of a process tank (volume 800 L) in which two different plate and frame membrane modules of 2 m² membrane area each were studied simultaneously (fig. 2).

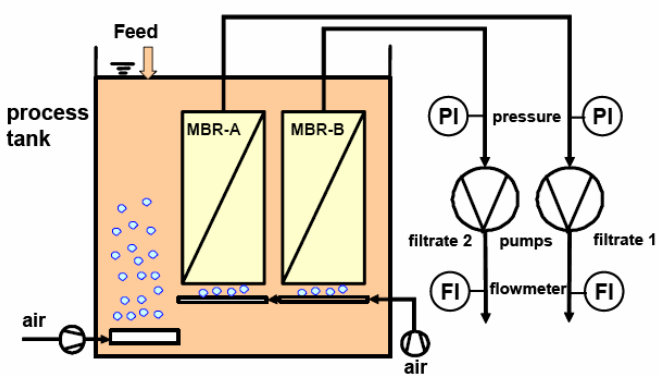

Fig. 2: Process scheme

Results

Tab. 1: Elimination of anthropogenic trace compounds

	Elimination [%]		
Compound	CWWTP	MBR-A	MBR-B
Bezafibrate	80	91	91
Gemfibrozil	66	97	97
Fenofibric acid	52	96	96
Diclofenac	53	56	56
Ibuprofen	89	99	99
Naproxen	80	95	95
Atenolol	57	57	60
Bisoprolol	42	75	75
Metoprolol	24	23	30
Sotalol	0	-15	-20
Carbamazepine	-10	11	11

Samples from the MBR pilot plant and the conventional wastewater treatment plant (CWWTP) have been analysed for 30 anthropogenic trace organics, including analgesics, betablockers , lipid regulators and one antiepileptic (tab. 1).

- Some substances showed a better elimination rate in the MBR than in CWWTP (tab. 1)
- The comparison of data showed no difference between the two ultrafiltration membranes operated with the MBR
- Ibuprofen and bezafibrate were almost entirely removed, diclofenac and metaprolol showed only moderate removal
- The increased removal is thought to be the result of the higher sludge age and total suspended solids content in the MBR as compared to the conventional WWTP

Conclusions

Groundwater recharge with reused wastewater bears the risk to accumulate persistent trace pollutants. Therefore, the elimination of such compounds represents a key factor in integrated water resources management in arid regions.
Our first results indicate an increased elimination of trace organics in MBR as compared to CWWTP. Aerobic biodegradation of endocrine disrupting compounds and pharmaceutical residues was demonstrated in batch tests.
More specific studies will be performed to identify the most efficient degradation processes of single compounds, depending on the presence of auxiliary substrates (co-metabolic degradation) and redox conditions (e.g. aerobic/anoxic degradation).