SANIRESCH

Research Project SanitaryRecycling Eschborn (SANIRESCH)
Project component: Operation and Monitoring

1. Background

This project component of the research project SanitaryRecyclingEschborn (SANIRESCH) was responsible for the operation and monitoring as well as the optimisation of the three plants. This included monitoring with remote control, error control, regular inspections, as well as the maintenance of the equipment. Furthermore wastewater parameters of yellow-, brown- and greywater were analysed, data was evaluated and consumables for continuous operation were supplied.
The optimisation included improvement of the plant operations, the settings of the chemical process and the associated basic parameters and procedures.

2. Approach

2.1 Structure and functioning of the urine precipitation plant

Urine, collected by waterless urinals and separating toilets, is first saved in one of four collecting tanks, with a respective capacity of 2 m^3. By hydrolysis of urea (Equation 1), the pH (> pH 9) and ammonium concentration increase.

$$CH_4N_2O + 2\,H_2O \rightarrow NH_4^+ + HCO_3^- + NH_3 \qquad \text{Equation 1}$$

In the precipitation plant developed by HUBER SE, 30-50 l urine can be treated per precipitation cycle. Low-cost technical magnesium oxide, with a ß-factor of 1.5, is used as precipitant. After the addition of magnesium oxide by a dosing unit, a stirring period with alternating stirring and pause intervals, each 30 s for 3 min., follows. The dosage of magnesium oxide causes the following precipitation reaction (equation 2):

$$Mg^{2+} + NH^4+ + PO_4^{3-} + 6\,H_2O \rightarrow MgNH_4PO_4 \bullet 6\,H^2O\downarrow \qquad \text{Equation 2}$$

The sedimentation process requires 90 min. The generated MAP (MgNH4PO4 • 6 H2O, struvite) is collected in the cone of the funnel-shaped precipitation area. After sedimentation the treated urine is discharged into polypropylene filters, with a pore size of 10 µm (see Figure 1).

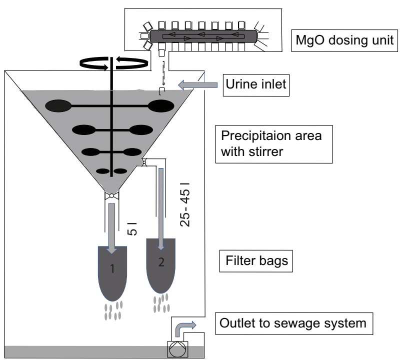

Figure 1: Schematic drawing of the MAP precipitation reactor.

2.2 Mode of operation of the membrane bioreactors

The MBRs were usually operated with a constant low sludge loading of 0.1 kg COD kg^{-1} TS d^{-1}. The necessary permeate (filtrate) volume was calculated based on the measured concentration of COD in the inlet and the biomass concentration in the activate sludge tank. By this mode of operation the transmembrane pressure varied between 45 and 75 mbar for the greywater plant and between 37 and 68 mbar for the brownwater plant. Due to the highly fluctuating characteristics of the influents it was intended to create a trouble-free and stable operation.

Usually membrane bioreactors operate with biomass concentrations (TS levels) of approximately 12 g l^{-1}. For reasons of operational stability, both MBR were operated with a constant TS of 4 g l^{-1} (greywater) and 8 g l^{-1} (brownwater).

3. Results and discussion

3.1 Mass balance of the precipitation reaction

The mass balance of one storage tank (2000 l) shows that 97% of dissolved phosphate can be recovered by MAP precipitation with analytical MgO (see Figure 2) (Röhricht et al., 2012).

However by using low-cost, technical MgO the yield decreases to approximately 65%. Technical magnesium oxide was used for regular operation of the precipitation reactor for cost reasons. The price for 1 kg of analytical MgO is approx. 500 Euro, whereas technical MgO is available for only 20 Euro.

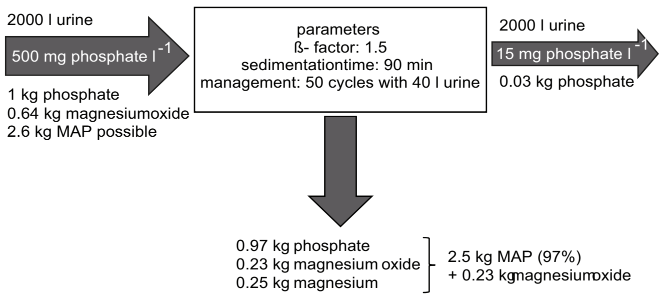

Figure 2: MAP mass balance of a storage tank (2000 l), precipitation with analytic MgO.

In the present project 0.7 to 1.3 g MAP could be recovered per litre treated urine with technical MgO as precipitant.

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3.2 Analytic and process parameters of the membrane bioreactors

The nutrient ratio C:N:P of the greywater was usually 100:2:1, the ratio of brownwater was 100:9:1. The composition of the wastewater flows largely correspond to those who are described in literature. The greywater MBR reached a COD purification efficiency of 96%, the brownwater MBR of 97%. Chemical parameters of the inlet flows and permeates of the grey- and brownwater membrane bioreactors are compared in Table 1.

Table 1: Chemical parameters of the inlet flows and permeates of the grey- and brownwater membrane bioreactors (greywater: average of 50 samples; brownwater of 45 samples)

			Greywater		Brownwater	
			inlet	permeate	inlet	permeate
COD	[mg l^{-1}]	ø	647	28.5	803	23.0
		min	329	17.2	238	13.8
		max	1455	39.5	1439	39.8
TN_b	[mg l^{-1}]	ø	15.6	12.5	69.8	72.9
		min	5.36	5.4	13.4	24.9
		max	35.8	25.7	190	170
P_t	[mg l^{-1}]	ø	21.5	15.6	24.2	22.0
		min	2.84	3.4	6.93	3.82
		max	60.4	29.2	48.5	59.4

Membrane bioreactors are usually operated with flux values of 20 - 30 l m^{-2} h. The MBRs in this project were operated with an average flux of 6.6 l m^{-2} h^{-1} for greywater and 10 l m^{-2} h^{-1} for brownwater. The low loading of the membrane was due to the need for operating stability. Occasionally there was also a shortage of greywater. The average throughput of the greywater MBR was 324 l d^{-1}, corresponding to a retention time of 37 h. The average throughput of the brownwater MBR was 542 l d^{-1}, corresponding to a retention time of 36 h.

3.3 Classification of the permeate into quality criteria

The reuse of water is the main motivation for grey- and brownwater treatment. The specific hygiene quality requirements depend on the intended use. Usually the BOD_5 concentration (storage capacity), turbidity (aesthetic concerns) and the microbiological load (health risks) are considered as relevant quality parameters (for details see also factsheet "Quality of products").

Table 2: Comparison of values and quality requirements for toilet flushing water, irrigation water and drinking water with the average values of the permeates of grey- and brownwater

	fbr H 201	DIN 19650	EU drinking water directive	greywater[3]	brownwater[3]
COD [mg l^{-1}]	-	< 60	-	28.5	23.0
BOD_7 [mg l^{-1}]	< 5	< 10(BSB_5)	-	1.5	1.6
O_2 conc. [mg l^{-1}]	> 50%	-	> 5	8.8	8.3
Turbidity [NTU]	-	-	< 1	0.4	0.5
Total coliforme	< 100/ml	-	0/100 ml	1.1/ml	2/ml
E.coli	< 10/ml[1]	0-2000/100 ml[2]	0/100 ml	0.4/ml	0/ml

[1] applies to faecal coliforms [2] depending on qualification level [3] average values (for details see also Table 1)

According to fbr note sheet 201 both permeates comply with the requirements for toilet flushing water. Furthermore the permeates are useable as irrigation water. According to DIN 19650 four qualification levels are distinguished. Although both permeates do not comply to level 1, they can be used for the irrigation of sport facilities and public parks as well as for products not intended for human consumption, fruits, vegetables for preservation and vegetables until two weeks before harvest (DIN 19650).

4. Conclusion

The project demonstrated that a decentralised and separated wastewater treatment in an office building with limited space available is technically feasible. The phosphorus precipitation from human urine is a promising way to recover phosphorus. It has been shown that the process is possible on an industrial scale and continuous operation. The water quality of purified brown- and greywater allows the reuse as toilet flushing and irrigation water.

5. Major references

Röhricht, M., Hartmann, M., Heynemann, J., Winker, M., Paris, S.(2012): Phosphate recovery from urine by MAP-precipitation, book of Abstracts on Ecotechnologies for Wastewater Treatment 2012, IWA International Conference, Santiago de Compostela, June 2012.

6. Acknowledgements

This research was realised within the research project SanitaryRecycling Eschborn (SANIRESCH) and supported by the BMBF (Federal Ministry for Education and Research), fund No. 02WD0950. The authors thank the BMBF for the financial support.

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October 2012