Factsheet
Pilot plant

Process chains for the treatment of sewage plant effluents to meet different service water qualities

At the waste water treatment plant (WWTP) in Nordenham (Lower Saxony) MULTI-ReUse operates a pilot plant to treat effluent for water reuse. The focus lies on the membrane processes ultrafiltration and reverse osmosis. They can be combined modular with other processes such as flocculation, powdered carbon dosage, activated carbon filtration and UV-disinfection. Main purpose is the production of defined water qualities for different purposes of use (Fit-for-Purpose).

Raw water for water reuse

Local waste water that is intended to be used for water reuse first undergoes the classical treatment at the waste water treatment plant. Thereby the following substances are removed from the water:

- undissolved substances (grease separator, sedimentation, sand filtration)
- the majority of solved nutrients, mainly BOD, COD or DOC (biological stage)
- compounds of nitrogen and phosphate (biological stage, precipitation)

In the water remains:

- some turbidity and colouration
- microorganisms (e.g. bacteria, fungi, viruses)
- dissolved organic carbon (DOC), among them microcontaminants that can be harmful (industrial and household chemicals and pharmaceutical products, among other things)
- dissolved salts (ions)
- residual contents of dissolved nutrients and nitrogen and phosphate compounds

Therefore, for the reuse of effluent water a further treatment is necessary. In the following, the different service water qualities produced at the pilot plant are introduced (see table 1) and the applied process combinations described.

Figure 1: MULTI-ReUse pilot plant in Nordenham

Service water type 1

Water quality and use

The water is free of undissolved substances and pathogenic germs but still contains dissolved nutrients and organic trace substances. It can be used industrially for washing processes (e. g. street cleaning) or for cooling processes with little requirements (e. g. regarding the concentration of dissolved salts). The nutrient content can affect the water storage and distribution though.

Treatment technology

The main treatment process is ultrafiltration (UF) with a porous polymer membrane (see figure 1), where all undissolved waterborne substances (particles, larger colloids) that are bigger than the pores of the membrane (medium pore size 0.00002 mm = 20 nm, process parameters see table 2) are removed. This also includes microorganisms up to the size of viruses. Dissolved substances such as nutrients, salts and anthropogenic trace substances are not removed. For an optimized operation of the UF a pre-filter and flocculation are used as pre-treatment: The sieve cloth with a mesh size of 0.2 mm keeps large substances away to protect the ultrafiltration membrane from damage. Following, iron- or aluminum salts are added that develop insolvable micro-flocs in the water (iron/aluminum hydroxides). This is done for more than one purpose: The hydroxides attach themselves to particles and colloids as well as to the membrane surface. That creates a high water permeability of the membrane and the during the filtration process growing coating layer on the one hand. On the other hand a direct contact and adhesion between particles and membrane can be largely avoided, which makes it easier to remove them during the back-flush. You can find more details about UF in the factsheet about ultrafiltration. A downstream disinfection with UV-light guarantees the microbiological safety of the service water.

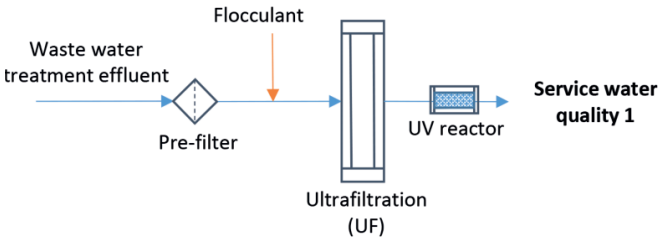

Figure 2: Process chain to produce service water quality 1

Service water type 2

Water quality and use

The water is free of undissolved substances and pathogenic germs. The concentration of nutrients is considerably reduced compared to water quality 1. This increases the microbiological stability of the water (lower growth potential during storage and distribution). It also contains much less organic trace substances of anthropogenic origin. It can be used for industrial cleaning or cooling processes with higher quality requirements, for urban or agricultural irrigation purposes or for groundwater recharge.

Treatment technology

The water undergoes the UF process (like the water type 1) but additionally is treated with an activated car-

Parameter	Raw water	Service water quality		
		1	2	3
pH-value	6.9	6.9	6.8	5.5
Conductivity [µS/cm]	1240	1240	1240	30
TOC [mg/l]	12	9	6.4	0.2
DOC [mg/l]	11	8.2	–	–
Turbidity [FNU]	9.1	< 0.1	0.1	0.1
Manganese [mg/l]	0.4	0.4	0.1	0.0
Iron [mg/l]	0.6	0.0	0.0	0.0
KFU at 22°C [KFU/ml]	7800–25200	0.001–8	–	2
KFU at 36°C [KFU/ml]	2700–29500	0.001–5	–	9
COD [mg/l]	39	27	19	< 15
Total suspended solids [mg/l]	8	–	–	–

Table 1: Medium quality of the raw water (effluent) and the produced service waters

bon filter (see figure 2). The granulated activated carbon (GAC, grain diameter 0.6 to 2.4 mm) has a large inner surface which is suitable for the adsorption of organic components in the water, such as e. g. pharmaceuticals and pesticides. Furthermore, GAC is also a carrier material for microorganisms and therefore facilitates the further removal of biodegradable organic substances from the water. If there is manganese in the influent, a manganese removal filter (sand) should be used in addition to prevent damages through the sedimentation of manganese. A downstream disinfection with UV-light after the activated carbon filter enhances the microbiological safety of the service water. You will find more details about the procedure in our factsheet about the activated carbon filtration.

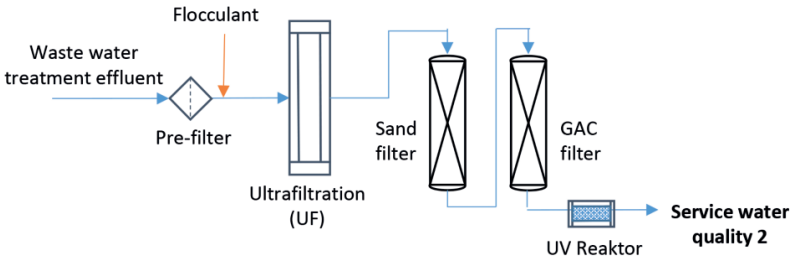

Figure 3: Process chain to produce service water quality 2

Service water type 3

Water quality and use

The water is free of undissolved substances and pathogenic germs. By using the process chain with reverse osmosis (RO) the majority of the dissolved ions and molecules in the water is held back. Compared to the other two water qualities a maximum of microbiological stability and a minimum in the concentration of salts and organic trace substances is obtained. As a low-ion water, it can be used as process water for a broad spectrum, e. g. for the production of ultrapure water or as mixed water for dilution purposes. The low concentration of ions and the free carbon dioxide can lead to the water having a corrosive effect on certain metallic materials. This has to be considered when choosing the materials for water storage and distribution. Alternatively the water can be adjusted by buffering and pH value correction.

Treatment technology

The main treatment process is the RO with a membrane (see figure 3 and table 2), which is identified as dense because the medium pore size is only 0.0000005 mm (= 0.5 nm) and therefore only slighter larger than a water molecule. Consequently the water is diffused through the membrane under pressure. Purpose of the RO is the retention of monovalent ions (sodium, chloride, nitrate) or bivalent ions (calcium, magnesium, sulphate) as well as dissolved organic carbon (DOC). Furthermore, low molecular organic trace substances are held back especially when they are charged (ionic). For the protection of the non-flushable RO membranes and their maximum efficiency the combination of UF and flocculation (see service water type 1 treatment) as well as the addition of antiscalants (to prevent the precipitation of salts) is an optimal pretreatment. This can be intensified by additionally using a dosage of powdered activated carbon (PAC) prior to flocculation and UF, to eliminate organic substances through adsorption and therefore to support the stability of the membrane processes (RO and UF). A disinfection with UV-light after the RO guarantees the microbiological safety of the service water.

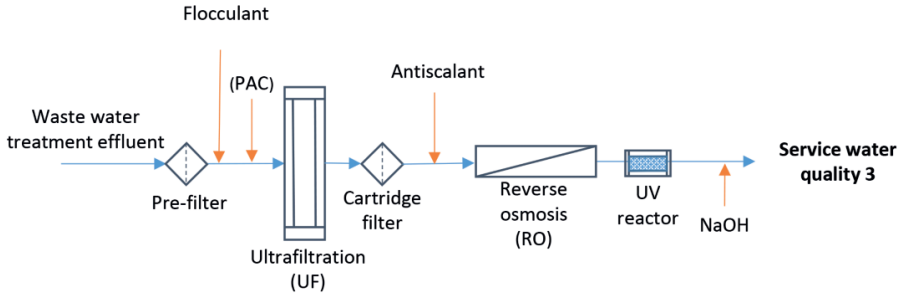

Figure 4: Process chain to produce service water quality 3

Table 2: Main parameters of the pilot plant processes UF and UO

Prozessparameter der Pilotanlage	UF	RO
Membrane surface per module [m²]	80	7.9
Number of modules	1	3
Flow [m³/h]	5.60	0.67
Flux [l/(m²h)]	70	20.0
Transmembrane pressure filtration [bar]	0.3–0.8	13.9
Transmembrane pressure backflush [bar]	0.5–1.5	
Backflush flux [l/(m²h)]	230	
Recovery rate [%]	90–93	75
Salt retention [%]	–	98
Min. flux filtration [l/(m²h)]	40	
Max. flux filtration [l/(m²h)]	140	
Min. flux backflush [l/(m²h)]	200	
Max. flux backflush [l/(m²h)]	333	

Short description of the MULTI-ReUse project

Treated wastewater is an important part of the water cycle. It usually is fed into rivers, something that is acceptable from an environmental point of view but for the use in agriculture or industry the water often is unsuitable. MULTI-ReUse closes this gap by developing and implementing of new procedures for the reuse of service water. The aim of MULTI-ReUse therefore is the development, demonstration and evaluation of a modular water treatment system, in order to offer service water in different qualities and quantities for the different purposes and to competitive prices.

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