MULTI ReUse

Ultrafiltration in wastewater treatment for water reuse

Water and water based fluids are an essential part of our everyday lives – no matter if in the private sector or in industry. Over the course of time new technologies for water treatment were developed to adapt the quality of filtered water to human requirements. Ultrafiltration (UF) is a relatively new technology that revolutionized water treatment worldwide and uses membranes based on high-tech-materials.

Technology

Ultrafiltration is a low pressure operated membrane procedure used to completely eliminate particles. The patented Multibore® membranes made of modified polyethersulfone (mPES) have seven honeycombed capillaries and a filter surface with the defined pore size of 0.02 µm.

With this pore size the UF reliably keeps particles and microorganisms, such as bacteria (> 9 log distance) and even viruses (> 4 log distance) on the inside of the capillaries during the filtration process and only releases clean water to the other side. Mono- and multivalent ions as well as other dissolved and anthropogenic trace substances are not held back (see figure 1). Over time a fouling layer of the held back substances forms inside the capillaries. Because of this fouling layer the pressure increases and with it the energy input to transport clean water to the filtrate side. To remove the fouling layer the flow direction of the water is changed after some filtration time: while the water usually flows from the inside out of the membrane during the filtration process (see figure 2), it is being pressed from the outside to the inside during the so called backwash. The backwash water with the particle load can be collected and disposed. For more stubborn contamination caustic soda followed by acid is added to the backwash water for a so called „CEB“ – Chemically Enhanced Backwash in certain time intervals. As soon as all contamination is removed the membrane has a 100 % filter performance again. That is how a constant amount of water is produced at a constant pressure level (transmembrane pressure) permanently.

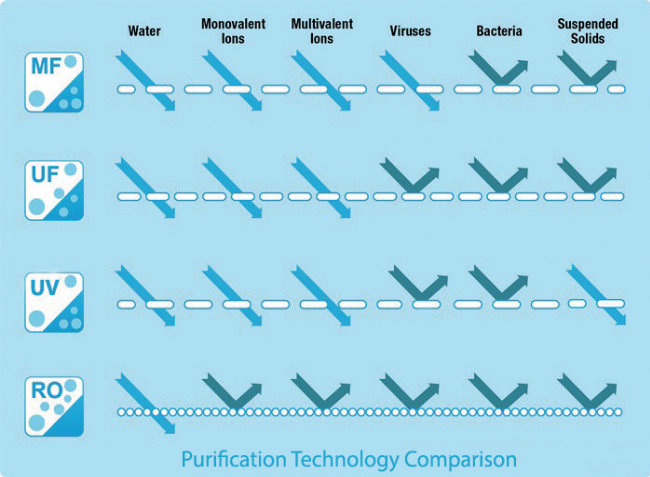

Figure 1: Different filtration technologies (Source: https://www.bestrowaterpurifier.in/wp-content/uploads/2018/09/water-purification-technology-comparison.jpg from 24.10.2018)

Pre-treatment

The pre-treatment of the inlet water for the UF depends on the quality of the raw water. In principal the use of a pre-filter with the size 300 µm or smaller is recom-

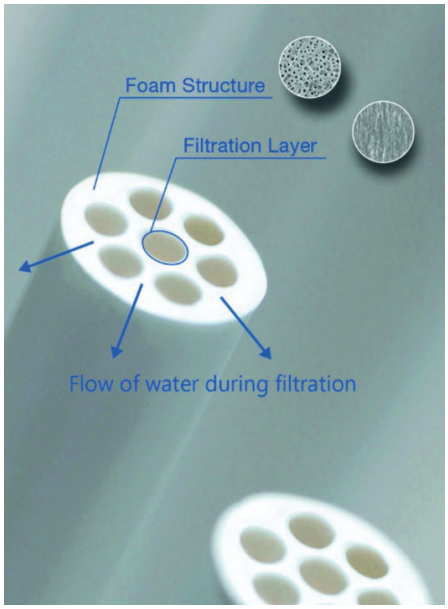

Figure 2: Presentation of In-to-Out filtration with inge® membranes

mended to protect the membrane from damage through larger or sharp particles. “Simple” water with small organic and particle load (for example aquifer water) often can be treated with UF without any further pre-treatment. If a certain turbidity or the presence of organic particles is expected in the water (e. g. in surface, sea or WWTP effluent water) a further pre-treatment step is recommended: the inline-coagulation. Here an aluminium or ferrous coagulant is added to the inlet water, resulting in a porous coating layer on the membrane surface. This is easier to remove during backwash than the more compact fouling layer that would occur without coagulation.

Figure 3: inge® modules in a large-scale plant

Advantages of UF during the treatment to service water

A comparison with other filtration technologies is difficult, because the UF with the ability to reliably hold back viruses is unique. Nonetheless, an alternative conventional water treatment method the UF often is compared to is the sand filter. Here the UF is not only convincing because of the smaller space requirement but also because of the performance data. To reach a comparable low turbidity with a sand filter, the use of coagulants and possibly flocculating agents is necessary. The maximum turbidity that can be reached is 0.1 NTU. The UF produces a filtrate with a turbidity significantly under 0.1 NTU (inge® < 0.03 NTU, see figure 4) – without the use of chemicals and independent of the inlet water quality.

Consequently there is a higher retention of bacteria and viruses during the UF too. That is not only relevant if the UF filtrate is used directly but also for possible following treatment steps. The UF is the perfect pre-treatment for reverse osmosis because of the excellent retention of particles and microorganisms, the low SDI15 (Silt Density index) values of < 3, and an expected removal of organic particles of at least 40 % if combined with an inline coagulation process.

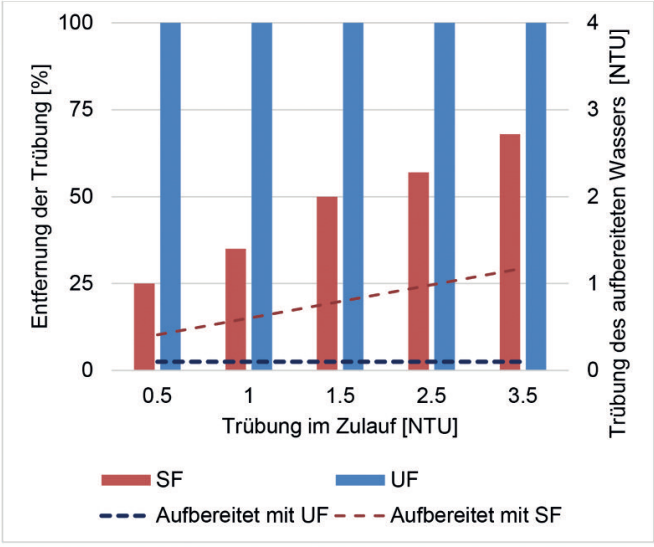

Figure 4: Dependency of the removal of turbidity with the sand filter (SF) compared to UF (Abbasi-garravand, Mulligan, & Laflamme, 2015)

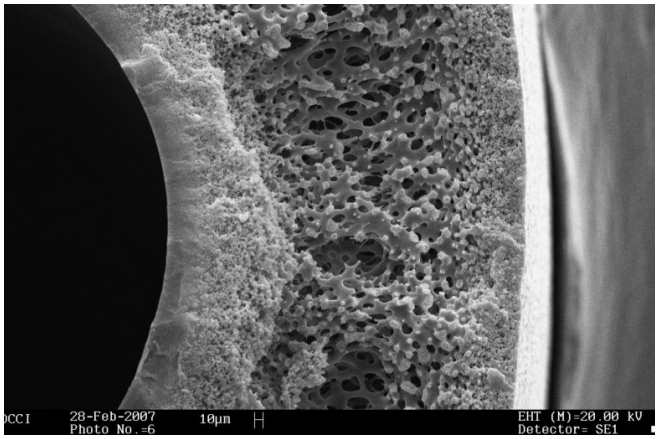

Figure 5: Cross-section image with a scanning electron microscope

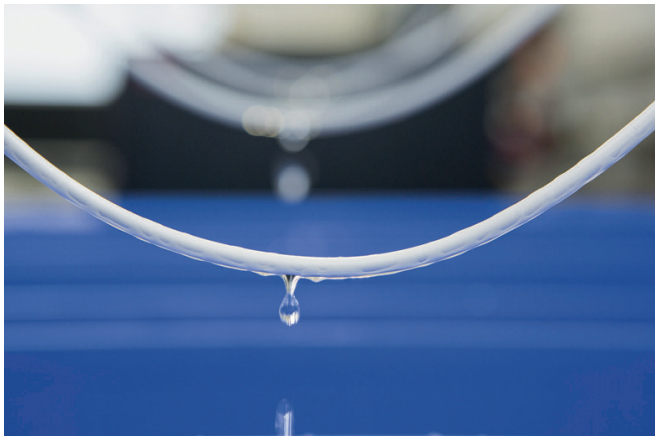

Figure 6: Quality check

Parameters	Unit	Value
Flux	L/(m² h)	70
Filtration time	Minutes	40
Backflush time	Seconds	45
Frequence of chemically enhanced backwash (CEB)	1/d	1
Recovery rate	%	90–93

Table 1: Typical UF construction for the operation with a WWTP effluent. During the chemical cleaning usually NaOH with a pH value of 12, followed by a cleaning with sulphuric or hydrochloric acid (sulphuric acid within MULTI-ReUse) with a pH value of 2.3 is used. Both chemicals are applied for about 15 minutes each.

Examples for the production of service water with inge® UF membrane plants

Jamnagar, India: 456,000 m³/Day

One of the biggest inge® UF-projects: The process water for the largest petrochemical industrial complex is obtained from sea water and desalinated with reverse osmosis (RO). As preparation for this procedure inge® modules and T-Rack systems are used.

Dalian, China: 36,000 m³/Day

The CNPC Dalian Petrochemical Company treats urban waste water from the secondary stage via ultrafiltration and reverse osmosis for reuse.

Conclusion

Over the last two decades Ultrafiltration (UF) has become the most used method for the retention of turbid matter and microorganisms. UF delivers a reliable and constant high water quality, independent from the quality of the inlet water. Therefore, UF doesn't just produces water of high quality but also preserves the following treatment steps (e. g. reverse osmosis) and contributes to the improvement of the performance and life span.

Literature

Abbasi-Garravand, E., Mulligan, C. N., & Laflamme, C. B. (2015). Using Ultrafiltration and Sand Filters as Two Pretreatment Methods for Improvement of the Osmotic Power (Salinity Gradient Energy) Generation Process, (1570124407), 1–12

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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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