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Indirect potable reuse via groundwater recharge offers a multibarrier solution for safe production of drinking water

Site Information

Location:
Koksijde, Belgium

Capacity:
2 x185 m^3/h

Purpose:
Produce infiltration water for an artificial ground-water recharge in eco-logically sensitive dune area

Time in Operation:
Since July 2002

Performance:

- Stable permeate flow and salt rejection
- Low operational cost
- Higher groundwater levels and better drinking water quality

Pressure vessels housing reverse osmosis elements at the water treatment facility
(Photo courtesy of Intermunicipal Water Company of the Veurne Region)

Introduction

The Torreele water plant in Belgium, operated by the Intermunicipal Water Company of the Veurne Region (IWVA) since July 2002, reuses municipal wastewater effluent to produce infiltration water for an artificial groundwater recharge in St-Andre dune water catchments. This aquifer is used to extract potable water for nearby communities. Throughout the years, the levels of the ground water were decreasing and as the location is close to the Flemish coast, salt water intrusion presents a threat for continuation of the process. Without the artificial recharge with treated waste water, the use of catchments would no longer be possible.

The choice for membrane filtration, ultrafiltration (UF) and reverse osmosis (RO), was based upon the quality parameters set for the infiltration water. As this water is recharged in a dune area, which is of high ecological value, the infiltration water must have low levels of salts and nutrients. Reverse osmosis is the only technique currently capable of achieving these goals in one step.

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The plant uses FILMTEC™ BW30LE-440 elements with enhanced membrane chemistry allowing lower pressure operation compared to the standard FILMTEC BW30-400. The BW30LE-440 element also provides higher productivity due to an increased surface area of 440 square feet (41 m^2) per element. The rate of membrane fouling therefore remains low, allowing for higher flow rates over time and prolonged element service life.

The productivity advantages of the FILMTEC BW30LE-440 element can be utilized in the design of new systems that produce the desired flow rate while operating at significantly lower feed pressures. This will result in savings due to lower energy consumption. The high surface area of the FILMTEC BW30LE-440 element permits designs of new RO systems that meet productivity targets with fewer elements than standard 8-inch elements resulting in lower installed system cost by reducing the number of system components and lower installation expense.

Water Treatment Process

The Torreele plant was built on the premises of the existing Wulpen waste water treatment plant operated by Aquafin, which treats domestic waste water with high salt and nutrient content as presented in Table 1. The existing treatment process consisted of a primary settlement, predenitrification, aerobic treatment followed by a clarifier. As the rainwater is collected in the same sewer system, the effluent water quality can vary largely.

Table 1. Feed water analysis

Parameter	Unit	Average	Minimum	Maximum
Temperature	°C	15.3	9.8	22.3
pH	—		7.06	7.88
Total organic carbon	mg/L	8.8	4.8	13.7
Total nitrogen	mg/L	12.1	2.6	37
Total phosphorous	mg/L	1.2	0.3	2.7
Suspended solids	mg/L	3	<1	15
Chemical oxygen demand	mg/L	33	<21	49
Biological oxygen demand	mg/L	<5	<5	9

Data courtesy of Intermunicipal Water Company of the Veurne Region

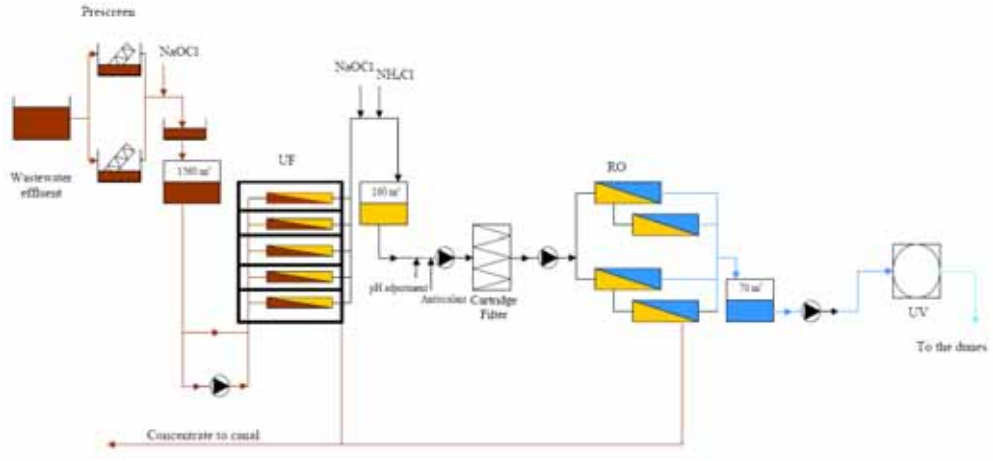
Based on several pilot trials with different MF/UF and RO systems the final effluent treatment includes submerged ultrafiltration (UF), cartridge filtration, two stage reverse osmosis (RO) and ultraviolet irradiation (UV) as presented in Figure 1. The UV irradiation was discontinued in the mid 2004 due the constantly low bacteria counts in the RO permeate.

The process flow diagram (Figure 1) features:

- Municipal waste water effluent pre-screening
- NaOCl and NH4Cl pH and antiscalant adjustment
- Five UF pre-treatment trains
- Cartridge filter with 15µm pore size
- Two RO skids, with 36 vessels each. Of those, 30 are loaded with six BW30LE-440 elements each, two are loaded with six BW30LE-440i elements each (since 2005)
- The capacity of both skids can be enlarged by filling and using the remaining four pressure vessels
- Two-stage configuration 21:6 pressure vessels in the first pass and 11:6 pressure vessels in the second pass
- 15,744m^2 of active RO membrane area
- Design capacity: 2 x185 m^3/h

Water Treatment Process, cont.

Figure 1 Process scheme of the plant

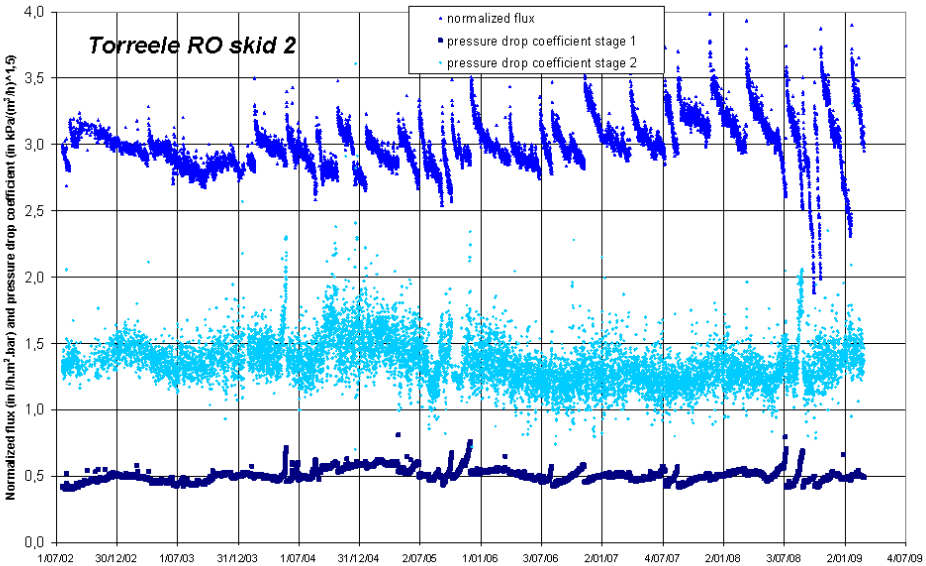


The water produced at the Torreele facility is recharged to the aquifer under the St-Andre dunes, approximately 2.5 km from the site. The infiltration pond has an area of 18.200 m^2 and the minimum residence time is 30 days. The extracted groundwater is further treated with aeration and rapid sand filtration and UV treatment prior to distribution as drinking water.

System Performance

The reverse osmosis system has been performing consistently since the beginning of operation as can be seen from the Figure 2, showing the normalized permeate flow and pressure drop coefficient over time. This performance is related to the moderate design recovery of 75 percent and excellent operation of the plant. Good pretreatment and sufficiently performed cleanings (every two-three months) have enabled a long membrane life time even with high fouling potential feed water. No RO membrane replacements were needed for the first six years of operation.

Figure 2. Normalized permeate flow and pressure drop



System Performance, continued

Reused waste water directly or indirectly intended for human consumption has to meet very strict quality parameters. The Torreele facility control program ensures that the UF and RO permeate as well as the final recharged water meet the quality parameters for the infiltration water. The produced water has constantly been of excellent quality as shown in the Table 2.

Table 2. Recharge water quality

Parameter	UF Filtrate	RO Filtrate	Infiltration Water
Conductivity (µS/cm)	1,148 (481 – 1,474)	23 (10 – 39)	43 (16 - 94)
pH	7.67 – 8.39	5.47 - 6.37	6.26 – 9.13
Total Organic Carbon (mg/l)	8.4 (4.3 – 11.8)	< 0.2	< 0.2
Total hardness (mg/l as $CaCO_3$)	27.9 (13.3 – 37-6)	< 1	< 1
Total alkalinity (mg/l as $CaCO_3$)	22.3 (9.0 – 31.2)	< 1	2.3 (1.3 – 4.7)
Chloride (mg/l)	204 (74 – 286)	2.9 (< 1 – 5.0)	2.9 (1.5 – 4.6)
Total Nitrogen (mg N/l)	8.0 (3.0 – 14.9)	< 2	
Nitrate (mg NO_3/l)			2.4 (< 1 – 6.3)
Ammonia (mg NH_4/l)			< 0.10 (< 0.05 – 0.23)
Total Phosphorous (mg P/l)	0.7 (0.2 – 1.7)	< 0.1	< 0.1
Silica (mg SiO_2/l)	19.0 (9.5 – 25.1)	0.25 (< 0.1 – 0.4)	0.23 (0.1 – 0.3)
Sodium (mg/l)	144 (50 – 197)	3.7 (1.4 – 6.4)	10.3 (3.7 – 16.5)
Total Coliform (counts /100ml)	0	0	0
E. Coli (counts / 100 ml)	0	0	0
Heterotrophic plate count (22°C)	8 (0 - 31)	< 1 (0 – 1)	< 1 (0 – 20)

** Mean values are presented with minimum and maximum values provided in parentheses.*

*** Infiltration water consisted of RO filtrate to which sodium hydroxide was dosed.*

Data courtesy of Intermunicipal Water Company of the Veurne Region

Aquifer recharge with highly treated waste water has increased the quality of the final drinking water over the years. The conductivity of the extracted water has gradually decreased by 60 percent and decline has been observed in organic content, iron and manganese concentration.

Sustainability

The project described here has long history. Local environmentalists have objected aquifer extraction as early as the 1970's and problems in drinking water supply during hot summers obliged IWVA to look for alternative, sustainable sources to meet the demand for drinking water. The water reuse scheme described here produces infiltration water on average 2.063.000 m^3/year, which equals to 40 percent of the local drinking water demand. As a result of the multi barrier treatment, the drinking water quality has significantly improved in terms of hardness and color. Furthermore, the natural groundwater extraction has been reduced by 30 percent or one million m^3/year, enhancing the natural values of the dune areas. Thus, the reuse scheme addressed both the drinking water shortage and environmental concerns by enabling a sustainable management of the dune area. As a result of IWVA's efforts to share the project details concerning the planning, the implementation and finally the results to public, the end user acceptance has been very high.

Summary

Torreele facility is a prime example of indirect potable water reuse in Europe. This treatment scheme can be leveraged to many regions, where it can help solve problems with inadequate water supply. In Torreele's case, the combined membrane treatment has proved to be a state-of-art technique continuously providing an excellent quality of infiltration water.

The moderate design of the RO, good pretreatment and sufficiently performed cleanings have enabled stable operation and long membrane life time even with very high fouling potential feed water. The permeate production, salt passage and pressure drop (ΔP) are all within or exceeding the expected values.

Literature

Van Houtte, E. and Verbauwhede J., *Torreele's water re-use facility enabled sustainable groundwater management in the Flemish dunes (Belgium)*, 6th IWA Specialist Conference on Wastewater Reclamation and Reuse for Sustainability, Antwerpen 2007.

FILMTEC™ Membranes
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