

Sustainable groundwater management of a dune aquifer by re-use of wastewater effluent in Flanders, Belgium

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Abstract

In July 2002 the Intermunicipal Water Company of the Veurne Region (IWVA) started with the production of infiltration water by the re-use of wastewater effluent. This new treatment plant, called 'Torreele', contains the following treatment steps: pre-screening, microfiltration (MF), cartridge filtration, reverse osmosis (RO) and ultraviolet irradiation (UV). The 'Torreele' plant is designed to produce $2,500,000\text{m}^3\cdot\text{yr}^{-1}$ of infiltration water, this is 40% of the current drinking-water demand. The flowchart is shown in Fig. 1. The whole project was developed to create a sustainable groundwater management of the existing dune water catchment. Because of the presence of salt water north and south of these dunes, the drinking-water production capacity was limited – increased production could cause saline water intrusion into the dune aquifer – and by the end of the 1980's the IWVA was unable to further satisfy the increasing demand of drinking-water. Artificial recharge of the sandy unconfined dune aquifer was chosen as the best alternative: the production capacity could be increased and still the natural groundwater extraction could substantially be lowered. Pilot tests using membrane filtration techniques showed that, although stringent quality standards were set, wastewater effluent could be used as the source for the production of infiltration water. This presentation will describe the results of infiltration in the dunes, a period that will cover over three years. The infiltration water recharges the sandy unconfined dune aquifer, the residence time of the recharged water in the aquifer is minimum 40 days.

Keywords: Re-use; Membranes; Infiltration; Groundwater management.

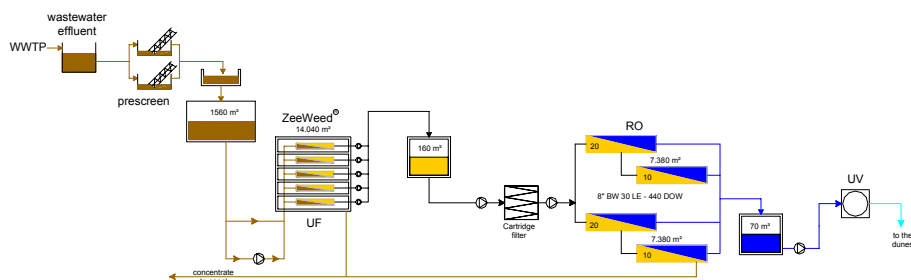


Fig. 1. Flowchart of the 'Torreele' plant.

Introduction

In the western part of the Flemish coastal plain, the options to obtain groundwater for potable water supply are limited to the unconfined aquifer under the dune belt. This dune region is of great ecological value, and as the Intermunicipal Water Company of Veurne-Ambacht (IWVA) historically produced potable water out of dune water, there has been a conflict of interests.

To comply with the ever increasing demand, not only the groundwater extraction increased but since the seventies of the previous century the IWVA took water from neighbouring companies, especially during the summer period when the demand is greater due to tourism. Fifteen years ago the IWVA started investigating alternative drinking-water production. This resulted in an infiltration project in St-André (Fig. 2). The infiltration water is produced in the newly built 'Torreele' plant, where wastewater effluent is used as the source and membrane filtration as the treatment technique.

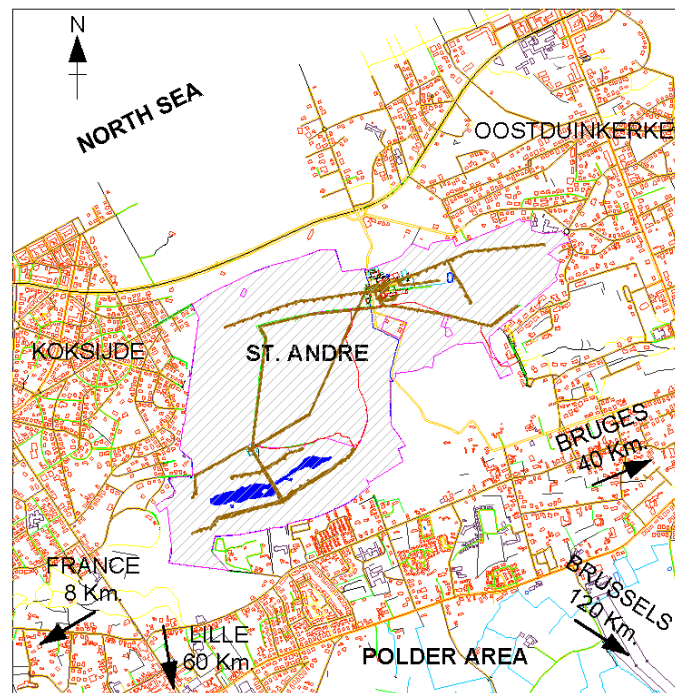


Fig. 2. Localisation of St-André and the infiltration project.

History of dune water extraction at the Flemish western coast

During World War I, the Belgian Army developed a water catchment in Cabour. In 1924 the infrastructure was taken over by the IWVA. As the company expanded, in 1947 a second dune water catchment, St-André, was started. Twenty years later a third water

catchment, the Westhoek in De Panne, was needed to fulfil the increasing drinking-water demand (Fig. 3).

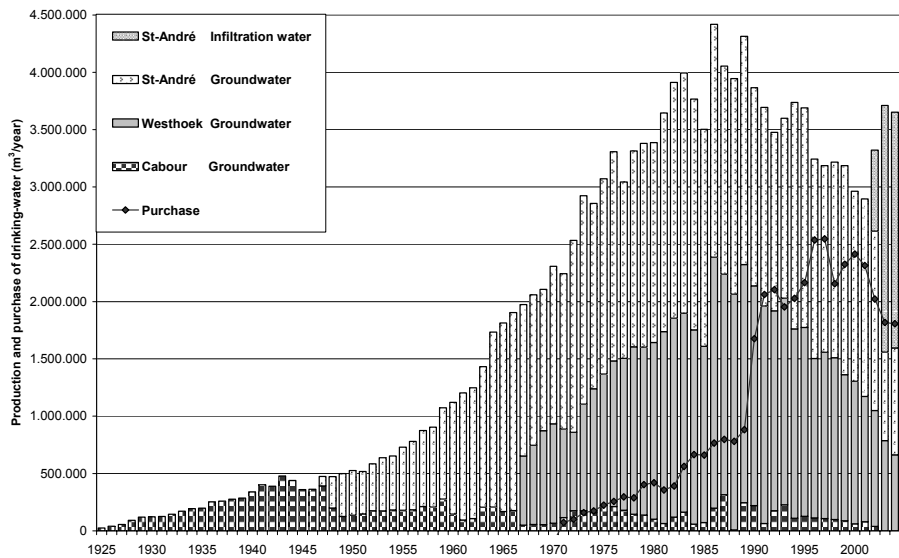


Fig. 3. Evolution of production and purchase of drinking-water by the IWVA.

The Flemish coastal dunes, that covered an area of 6,000ha in 1900, gradually declined. Nowadays only 3,400ha of these coastal dunes are left; 330ha or almost 10% are owned by the IWVA. The company played a role in preserving dune areas when St-André (125ha), initially planned for residential use, was purchased parcel by parcel. No opposition to dune water extraction is known in that period; economy prevailed.

The world changed after 1968: ecology suddenly became an important issue and this was translated into law. Today all IWVA dunes have to be preserved according to the EU Bird Directive and EU Habitat Directive.

From the beginning, the IWVA was confronted with the limits of the dunes as a source for drinking-water production. By the presence of salt water north and south of the dunes (under the sea and under the 'polder area'), too much extraction resulted into saline intrusion. In Cabour the salinity of the produced potable water increased in the nineteen-thirties and since the nineteen-fifties the extraction was limited to a maximum of $200,000\text{m}^3\cdot\text{yr}^{-1}$. St-André never had a problem with salinity. On the contrary, in the Westhoek the salinity increased rapidly since the nineteen-eighties. First the most saline wells were closed and starting in 1996 the extraction was gradually decreased. However by then the IWVA had already changed its policy and aimed, following the 1992 conference in Rio de Janeiro, for a sustainable groundwater extraction in its dunes. Artificial recharge of the unconfined dune aquifer, enabling a decrease of natural groundwater extraction, and related to ecological management of the dunes, was planned.

Ecological management of St.-André

In 1994 an ecological management plan for the dunes of St-André was launched. This plan was based on proposals of the Institute of Nature Conservation (Provoost *et al.*, 1993), an administration of the Flemish government. The goal was the restoration of the dunes as they were in the beginning of the 20th century when extensive pasture was done. To achieve this so-called ‘Massart landscape’, Shetland ponies were introduced after part of the Sea buckthorn was removed. Other measures taken were the removal of exotic trees (*e.g.* Wild rum cherry, Silver leaf poplar) and the conversion of a *Pinus* bush into an indigenous bush.

Besides those ‘ecological actions’, the recreational part of the area was re-managed. The many paths crisscrossing the area were reduced to one central path with a small inner circle within the area. Hiking with horses was also limited to one path situated at the border of the water catchment. A visitor’s centre was opened in 1996.

An ecologist, hired since 1995, is responsible for the execution of the management plan and the functioning of the visitor’s centre. Education plays an important role with a focus on the value of water and the rational use of it, and on the ecological importance of the area. During the last years the scientific evaluation of the management plan has also become an important part of the ecologist’s job.

The vegetation is monitored in 21 zones of 20 by 20m on a yearly basis. Those zones are spread over the water catchment of St-André in a way to have a good indication on the evolution in the area. The Institute of Nature Conservation is involved.

Besides specific plants are monitored all over the area. For the fauna the same is done for dragonflies, grasshoppers and butterflies. During the summer and migration period of birds, they are ringed to get an evolution on the number, age and sex of the birds.

All this information is used for the evaluation and adjustment of the ecological management. In 2003 and 2004 some valuable species (*e.g.* Bristle Club-rush, Blue pimpernel, Blunt-flowered rush, Pond weed, Brookweed) have been monitored around two bombing wells near the infiltration pond. They are the indication that the infiltration project offers opportunities for natural development in the area.

Artificial recharge in St.-André

After many years of pilot testing, the full scale plant treating wastewater effluent for the production of infiltration water, started on July 8th, 2002 (Van Houtte and Verbauwheide, 2003). This plant, called ‘Torreele’, according to the area where it has been built, is situated near the wastewater treatment plant (WWTP) of Wulpen, 3km south of St-André. The WWTP Wulpen, operated by Aquafin, treats domestic wastewater from the IWVA distribution area.

Based on the experience of the pilot tests, the IWVA has chosen the following steps to further treat the effluent: microfiltration (MF), cartridge filter, reverse osmosis (RO),

ultraviolet irradiation (UV). The RO filtrate, which had a low salt content, initially was mixed with 10% of MF filtrate for partial re-mineralization. Since half May 2004, this is no longer done and RO filtrate is directly re-mineralized by dosing chemicals. This water is recharged in the sandy unconfined dune aquifer. After a residence time in the aquifer of minimum 40 days, the water is recaptured by wells with filter elements between 8 and 12m depth. After aeration and sand filtration, to remove the iron and manganese, potable water is produced.

The infiltration area has been located in a zone where infrastructure was present (Fig. 2). No 'virgin' dune areas had to be accessed. Stringent standards were set for the quality of the infiltration water, especially concerning nutrient content (Table I). The infiltration water should be totally recaptured. For this reason, the wells surround the infiltration area and the extraction volume is 1.4 the volume of infiltration.

Table I. Standards for infiltration water and average quality of infiltration water

Parameter	Standard	7/2002 – 5/2004	6/2004 - 5/2005
pH	>6.5 and <9.2	5.62 – 7.67	6.05 – 7.16
Temperature (°C)	25	15.5	15.2
Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	1,000	148	48
Totale hardness (°F)	< 40	3.6	<1
Sodium ($\text{mg Na}\cdot\text{l}^{-1}$)	150	17	11
Total phosphorous ($\text{mg P}\cdot\text{l}^{-1}$)	0.4	<0.2	<0.1
Nitrate ($\text{mg NO}_3\cdot\text{l}^{-1}$)	15	6.8	2.1
Ammonia ($\text{mg NH}_4\cdot\text{l}^{-1}$)	1.5	0.31	0.19
Sulphate ($\text{mg SO}_4\cdot\text{l}^{-1}$)	250	10	<1
Chloride ($\text{mg Cl}\cdot\text{l}^{-1}$)	250	21	2.5

Benefits of artificial recharge

The IWVA is allowed to infiltrate $2,500,000\text{m}^3\cdot\text{yr}^{-1}$. The infiltrated volume should be totally re-extracted. An extra $1,000,000\text{m}^3\cdot\text{yr}^{-1}$ of natural groundwater can be extracted in the infiltration area (ZP2), and $700,000\text{m}^3\cdot\text{yr}^{-1}$ in another zone of St-André (ZP1). This volume is a reduction for natural groundwater extraction by $300,000\text{m}^3\cdot\text{yr}^{-1}$ compared to the pre-infiltration period. In the Westhoek the natural groundwater extraction had to be reduced by $700,000\text{m}^3\cdot\text{yr}^{-1}$ to a maximum of $1,000,000\text{m}^3\cdot\text{yr}^{-1}$.

The first years of infiltration showed that the quality of the infiltration water was very good (Table I). The nutrient and salt content are far below the standards and it even improved when MF filtrate no longer was used to produce infiltration water.

The first important action taken by the IWVA after infiltration started in July 2002, was to stop the production in Cabour. This is an old and small dune ridge 3.5km inland.

In the Westhoek, where groundwater extraction was reduced since almost 10 years, the extraction could further be reduced to $750,000\text{m}^3\cdot\text{yr}^{-1}$ in 2004 (Fig. 3). It resulted in a

substantial rise of groundwater levels (Fig. 4) within the catchment itself (UG32 and WP5.2), but also in the neighbouring nature reserve, where more wet zones were reported over the past years. There is a net outflow of groundwater out of the dunes which will on the longer term restore the quality of the dune aquifer.

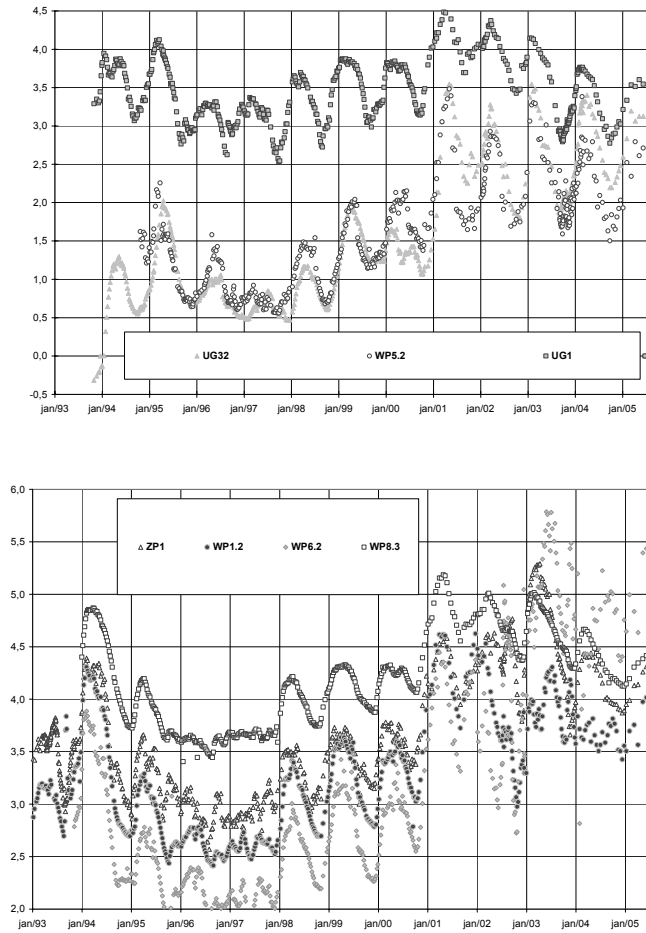


Fig. 4. Groundwater levels (in mTAW) in the Westhoek (upper chart) and St-André (lower chart).

In St-André, the extraction of natural groundwater was reduced since the start of infiltration (Fig. 3) and this resulted in an increase of groundwater levels (Fig. 4). The level at the centre of the infiltration area (WP6.2), near the infiltration pond, is about the same as in Ter Yde, a dune area 3km east of St-André uninfluenced by groundwater extraction. The groundwater in that zone is close to ground level creating opportunities for phreatophytes. North of St-André (WP8.3) there is also a relative increase of groundwater levels, which means that more dune water is running off towards the sea,

indicating the extraction of groundwater is sustainable. Groundwater samples taken from different wells in and around the infiltration area showed that the infiltration water is totally recaptured.

Since the infiltration started, the drinking-water produced in St.-André is soft. This is an important progress for the customers (comfort) and for the environment. Individual softeners are no longer needed, saving on the consumption of water, energy and chemicals. Also less soap should be consumed.

Long term vision on groundwater management

The IWVA opted for a status-quo in St-André but will further reduce the groundwater extraction in the Westhoek. From currently $1,000,000\text{m}^3.\text{yr}^{-1}$ allowed to a maximum of $500,000\text{m}^3.\text{yr}^{-1}$ in 2010. It means that the overall production capacity in 2010 would be $4,700,000\text{m}^3.\text{yr}^{-1}$, $2,200,000\text{m}^3.\text{yr}^{-1}$ being natural groundwater. This is a reduction of 40% compared to 2002, before infiltration started. These volumes guarantee a sustainable groundwater extraction assuring the good quality of the dune water on the long term. As the extraction is limited to restricted areas it will further benefit to the natural development of those dunes and in this way the EU Bird and Habitat Directives would be respected.

Conclusion

The authors are well aware that it will never be possible to convince all environmentalists, but they believe that the IWVA made substantial efforts to reconcile ecology and economy in its dunes. Thanks to infiltration and reduced groundwater extraction, the groundwater levels already restored considerably and will further do, especially in the Westhoek. This guarantees the preservation of specific habitats in the dunes. The income from drinking-water sponsors the natural management of the dunes and the education of the visitors. Without this, the government should have to spend more money to respect the Bird and Habitat zones they defined.

Ten years of natural management in St-André resulted already in an opener landscape. Some important species (flora and fauna) are more abundant or did come back in the dunes.

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