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OVERVIEW AND BACKGROUND OF WATER REUSE PRACTICE IN FLANDERS, BELGIUM

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SUMMARY

The reclamation of effluent from wastewater treatment plants to be applied as an alternative water source is usually linked to reasons of water scarcity in the sense of unmatched temporary or structural water demand. Uneven spatial distribution and seasonal variations in water demand and in the hydrological cycle make the semi-arid coastal planes and islands of the Mediterranean particularly indicated for the use of reclaimed water as a useful drought-proof conservation measure. In the moderate climates of northern Europe, however, at first sight, one may think that there should be sufficient amounts of water available to support all possible water uses. However, the reuse of water in northern Europe can be an important asset to preserve or improve the quality of the existing water bodies. In simplified terms, 'reuse' of water in Northern Europe is dictated by quality aspects rather than by quantity. The main reason for the use of reclaimed water today is to conserve good quality (ground)water resources to applications requiring high-quality water such as the make-up of potable water. The water management in Flanders, the northern region of Belgium, is a good example of this situation, and will be discussed in the following paper.

Keywords: domestic waste water; cooling water; water reuse.

INTRODUCTION

In the 'First Water Management Brief', issued by the Flemish Coordination Commission on Integrated Water Management (2005), and supported by the Regional Minister of Environment, we can read the following:

"A conclusive supply management

Water supplies are extremely valuable for our society. To restore the water balance it is of the utmost importance we handle the existing supplies economically. The basic rule is that water of a high quality is only used for applications that require this quality: this is what we call diversification of the water source. Reuse and the use of alternative water sources are cornerstones of this approach. (…………) In industry the use of greywater (rainwater and treated effluent water) as an alternative to groundwater will be encouraged. Therefore the Flemish government plans to subsidize the construction of greywater circuits in regions where the aquifers are threatened."

The reasons why the aquifers in Flanders are threatened can be explained as follows:

- High population density: Population distribution and density are key factors influencing the availability of water resources. Increased urbanization concentrates water demand and can lead to the overexploitation of local water resources. Belgium is one of the most densely populated areas in Europe, as can be seen from Table 1. Flanders, the northern part of Belgium, with its 434 inhabitants per km² is even the most densely populated area in Europe.

Table 1. Population density in Europe (1996)

Country or region	Density Inhabitants /km²
Spain	78
Belgium	332
Flanders (Belgium)	434
Denmark	122
Germany	229
Greece	79
France	107
Ireland	51
Italy	190
Luxemburg	160
The Netherlands	373
Austria	96
Portugal	108
Finland	15
Sweden	20
United Kingdom	240
Eur 15	**115**

Source: http://www.kuleuven.ac.be/facdep/social/soc/Belgodata/ebevolking.html

- Scattered dwellings: In Flanders, 18% of the land surface is used for buildings or building related activities. Housing and small agricultural areas are distributed evenly throughout the country. As a consequence, diffuse pollution is substantial.

- Still low waste water treatment percentage: In 1990, only 28 % of the domestic waste water was treated in WWTP's. Today, this amounts up to 65 %. In 2008, still 20 %, mainly disperse pollutant sources in rural areas, will remain untreated.

- Low water availability and high renewable water resource exploitation: The water availability in Belgium is one of the lowest in Europe, less than 2.000 m³/inhabitant/year. The Renewable water resource exploitation is one of the highest in Europe (see Figure 1). 75 % of the renewable water resources are withdrawn annually.

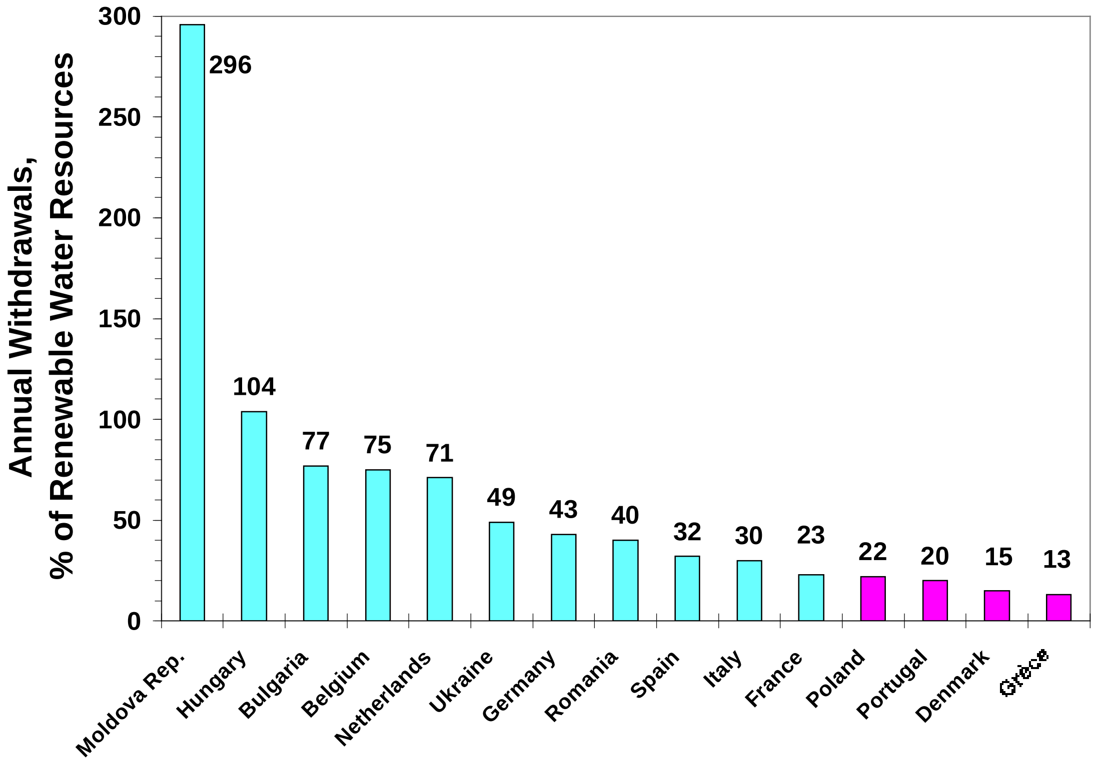

Figure 1. Renewable water resource exploitation in European countries (Angelakis, 2003).

On top of that, Flanders is highly industrialized and its agriculture is intensive, putting a severe stress on ground and surface waters. The pressure on the environment can be demonstrated further by e.g. indicators such as 'ecological footprint' or 'ecological deficit'. The ecological deficit of a country measures the amount by which their footprint exceeds the locally available ecological capacity. It is calculated by subtracting the footprint from the available ecological capacity. Negative numbers indicate a deficit, positive numbers show the still existing remaining ecological capacity. (M. Wackernagel et al.1997). From Figure 2, it can be concluded that the overall stress on the environment in Belgium is significant.

SECTORAL WATER USE AND REUSE

There is a clear difference in sectoral water use when comparing different regions in Europe. Whereas the main water use in Western Central Europe is for energy, in Western Southern Europe, the main water use is in agriculture. The amount of water used for irrigation in Italy and Spain is about 10 times higher than in the central EU countries combined. (UNEP/DEWA/GRID-Europe 1998-2005).

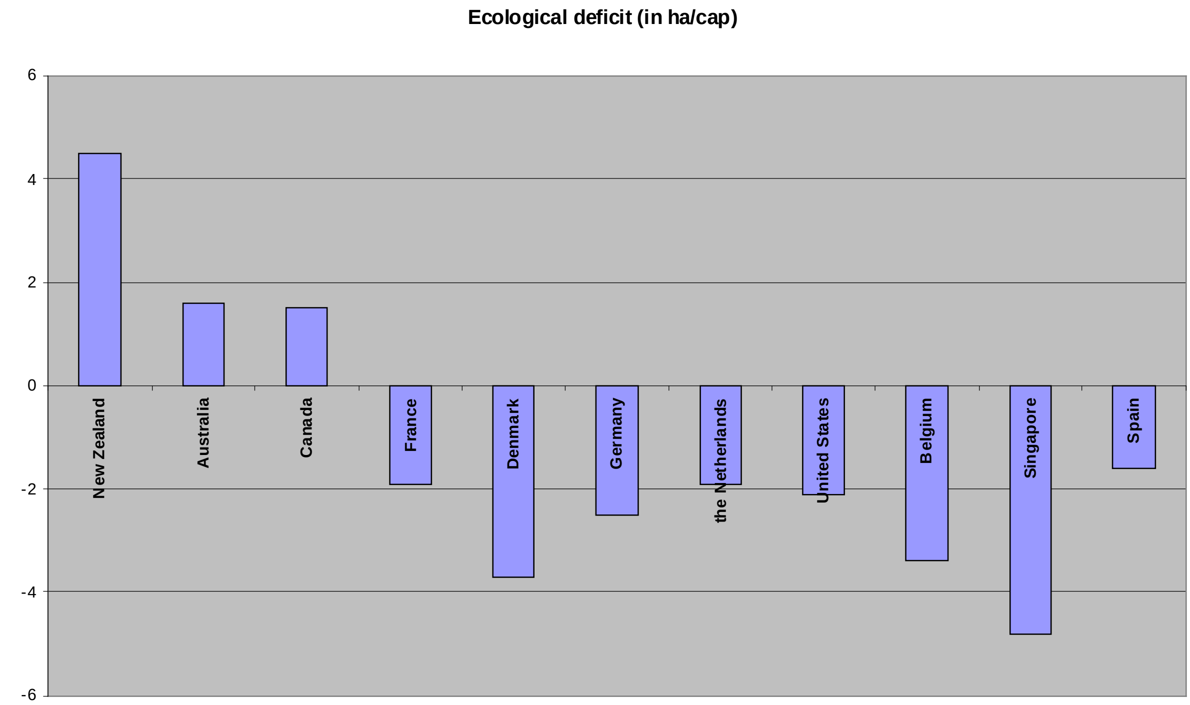

Figure 2. The ecological deficit for a selection of nations (M. Wackernagel et al., 1997)

Cooling water make-up is one of the largest water demands in the European Union. In some countries such as France and Germany, cooling water accounts for over 60 % of the national demand; in Belgium and the Netherlands, it reaches over 80 % (Bertini, A., 2005). If the pressure on the water resources is to be alleviated by water reuse, it is obvious that this would have more impact when applied in irrigation in Southern Europe, but rather in cooling or industrial applications in the Northern European regions. This is reflected in Figures 3 and 4, showing the water use and reuse practice in Europe, divided by sector, respectively.

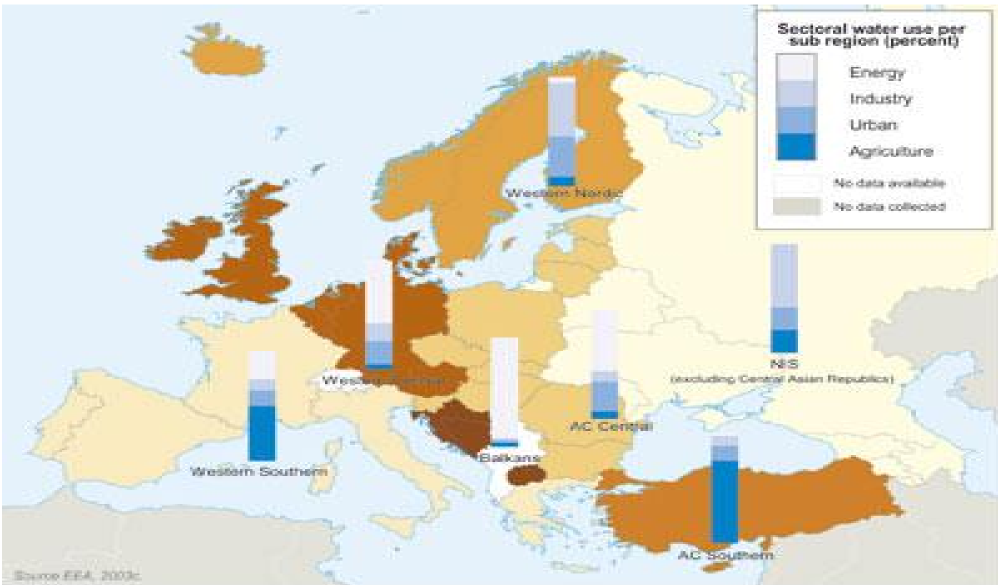

Figure 3. Sectoral water use by sub region (source: (http://www.grid.unep.ch/product/publication/freshwater_europe/consumption.php)

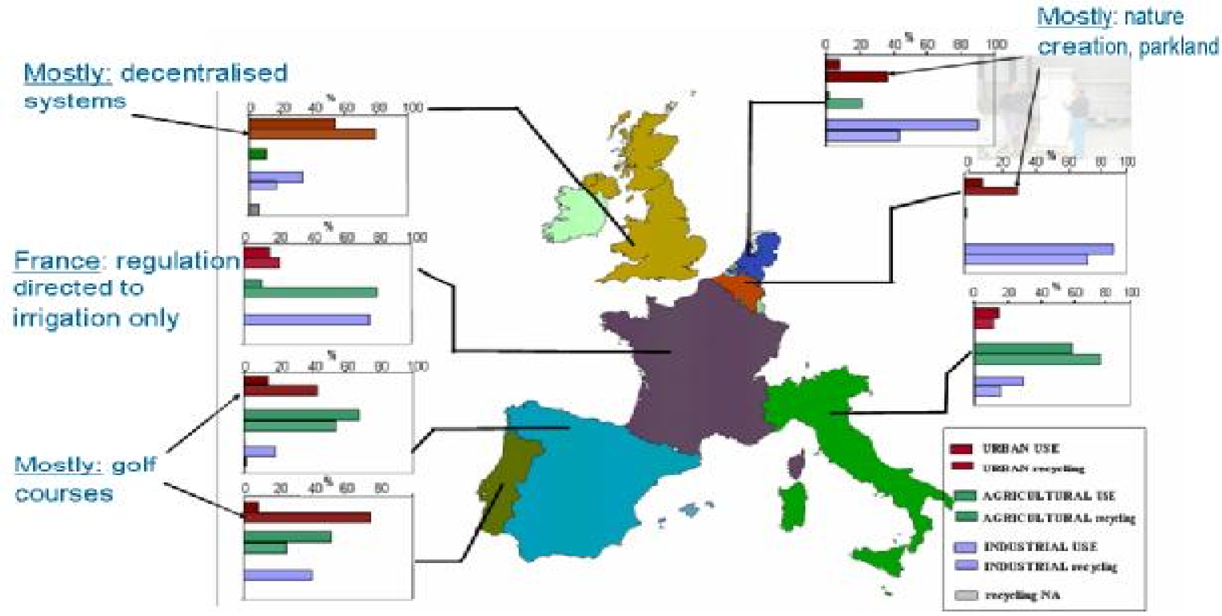

Figure 4. Sectoral water use for conventional water (EEA, 1999) and distribution of reclaimed water projects in Western Europe according to the Aquarec mapping study (Bixio and Thoeye, 2005)

WATER REUSE IN FLANDERS

In 1990 the Flemish government established the utility company Aquafin to accelerate the realisation and operation of the sewage treatment infrastructure in Flanders. To date, 65 % of the domestic waste water is treated and after completion of the investment programme in 2008, 80 % will be treated. The majority of the plants are designed for nutrient removal, as the whole area of Flanders was designated sensitive area under the Urban Waste Water Treatment Directive.

Reuse practice in Flanders has been adopted by Aquafin ever since its start-up. However, as the focus in the first decade of its existence was on the implementation of the investment plans, reuse was rather the result of occasional opportunities, than of dedicated targeted prospecting .

The interest in reuse as a means of upgrading the primary ‘product’ of Aquafin, purified water, resulted in amongst others, the participation in AQUAREC, a DG Research sponsored research project under the 5th Framework Programme, and recently in a 6th Framework research project with the acronym of RECLAIM WATER.

The objectives of AQUAREC are:

- The provision of policy guidelines and water quality standards for municipal wastewater reclamation and reuse.
- The collection and validation of best management practices
- The development of reference manuals and step by step guides for future end-users
- The evaluation, selection and standardisation of technological concepts and components for
- Wastewater recycling
- The integration of various activities towards sustainable wastewater recycling world-wide

The project RECLAIM WATER aims at developing hazard mitigation technologies for water reclamation, providing safe and cost effective routes for artificial groundwater recharge. The project will assess new and improved water reclamation and re-use technologies for the removal of microbial and chemical contaminants. New analytical methods to monitor emerging chemical contaminants and pathogens will be developed. Knowledge, concepts and models for the natural processes occurring in subsurface systems will be generated.

ECONOMIC CONSIDERATIONS

In many cases, the decision to change to alternative water resources is dictated by economic considerations. Therefore it is important to highlight the financial driving forces concerning water (re)use :

Levies for groundwater, surface water and effluent abstraction

The levies for groundwater abstraction are often higher than the cost for effluent reuse. This is the consequence of the regional water management policy: The levies for effluent reuse are comparable to the ones charged for surface water abstraction. The levies for groundwater abstraction increase with increasing abstraction volumes, defavourising large groundwater consumers. (see Figure 5). In addition, if abstracted water, be it surface water or recycled water, is returned at 100 % to the surface water, only 75 % of the levies are charged. This in order to prevent local depletion of surface waters as a result of evaporation through cooling.

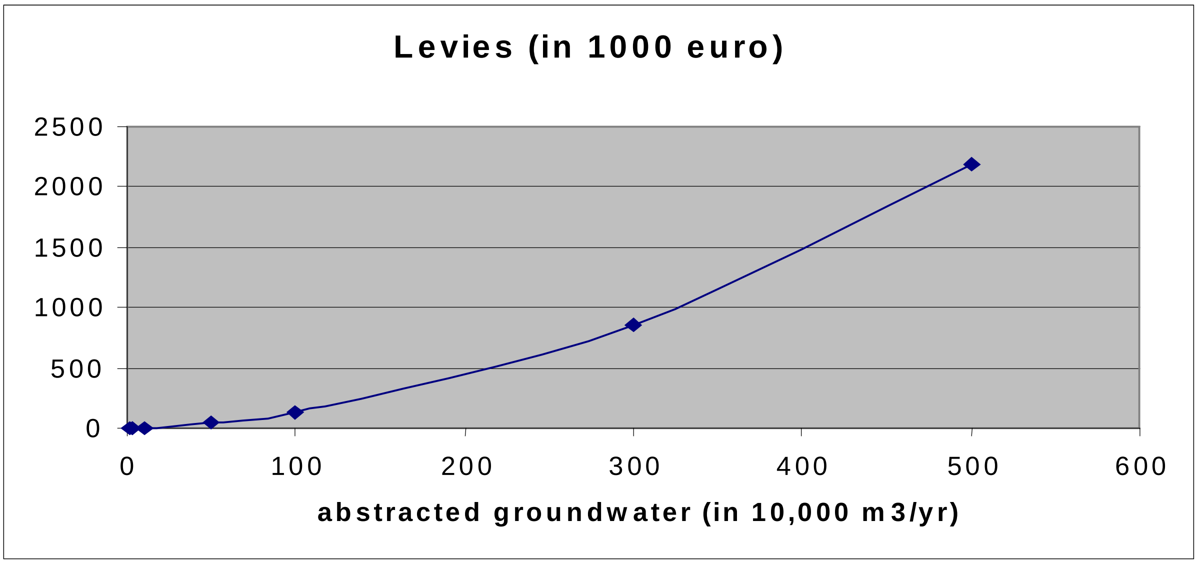

Figure 5. Levies charged for groundwater abstraction

Price Calculations

Until now, no active prospecting has been done for the promotion of the reuse of WWTP effluent. The reuse projects so far have been realised in response of spontaneous demands from customers. Lately, this demand is increasing, mainly because of the favourable price/quality ratio in comparison to the alternatives: groundwater, potable water and surface water. The price calculation for the supply of effluent is based on the following:

1) a compensation for the "tapping" of the effluent. This compensation is now set equal to the abstraction fee for surface water, and is transferred to the government
2) A compensation for "extra costs" and "possible risks"

Extra costs derive from investment and operation costs. On these costs, a case specific margin is added. Possible risks can result from e.g. non-compliance with standards or specifications, from insurance costs, from unpaid invoices or other possible risks. The risks are budgeted differently whether untreated effluent is supplied or further treatment to particular specifications is needed, and they are calculated case by case.

DOMESTIC WASTE WATER REUSE PROJECTS IN FLANDERS

Following the demographic characteristics of Flanders, the Flemish treatment plants are widely scattered. At the end of 2004, Aquafin was responsible for the operation of 202 wastewater treatment plants (WWTPs), 832 pumping stations and 3810 km of sewerage. The medium plant size is around 20,000 p.e. Figure 6 shows the location of the WWTP's in Flanders.

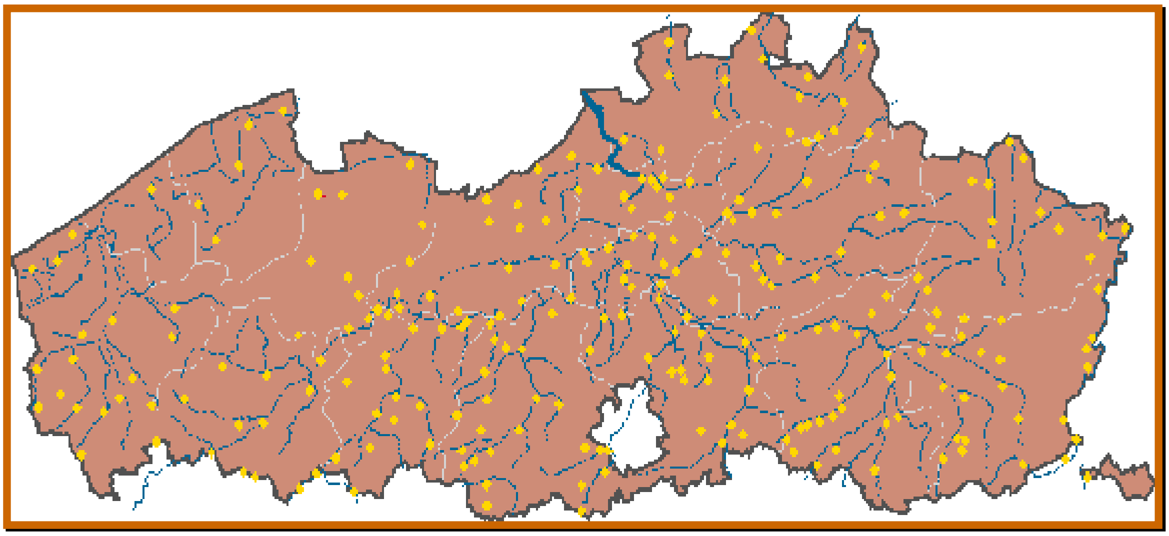

Figure 6. Wastewater treatment installations in Flanders

In the above, a framework is developed in which we can situate the reuse projects in Flanders:

- Water use in Flanders is most intensive in industry, and more in particular in cooling water
- For cooling water, there is a demand for continuity of supply of often large amounts of water of relatively low quality
- WWTP's can offer large volumes of water with a relatively low but constant quality
- There are relatively large WWTP's distributed throughout the Flemish region, offering the opportunity of a nearby alternative water resource
- If needed, more advanced treatment can be provided and included in the ongoing investment and operation programmes.

The reuse projects of domestic WWTP effluent in Flanders are listed in Table 2.

Table 2. Municipal wastewater reuse projects in Belgium

End-use	Size (m^3/yr)	Start-up
Nature enhancement/recreational (bird watching)	11,979,000	1999
Drinking water aquifer recharge	2,500,000	2001
Industrial cooling water	2,500,000	2003
Industrial cooling water	340,000	2000
Industrial cooling water	80,000	1997
Industrial cooling water	70,000	2004
Industrial cooling water	35,000	2003
Industrial washing	5,000	2004
Polder irrigation	Different plants	? - occasionally

Project A: Industrial Cooling

In this project, 2,500,000 m^3/yr, almost the entire effluent flow, is reused for industrial cooling in a nearby factory. The secondary effluent of a nutrient removal WWTP is treated with ozonation for disinfection and prevention of regrowth in the cooling circuit. If needed, sand filtration was considered as an option for further treatment. Reuse practice has been operational since 2003, and until now sand filtration was not necessary, as the levels of suspended solids appear to be low enough to avoid clogging problems. Alternatives for the use of effluent were either groundwater or surface water.

Surface water as an alternative was studied and rejected because:

- In comparison to effluent, surface water had a lower and less constant quality, in particular concerning suspended solids and nutrients
- In drier periods, the possibility exists that no permit for surface water abstraction can be obtained, because of the relatively low flow.

Groundwater was rejected as an option because the levies for groundwater are higher than the cost for effluent use, and the pumping costs for groundwater would even increase this cost. Under the circumstances described above, the choice for effluent use seemed the most economical.

Project B: Industrial cooling

This project concerns the use of 70,000 m^3/yr of effluent of the nearby 80,000 p.e. WWTP as cooling water. Until recently, groundwater was used, but the cost for groundwater abstraction increases as a result of increasing levies and because the groundwater at lower depths contains too much iron, necessitating deeper wells. Surface water in this case is more expensive, because of the longer distance to the extraction point, and it is of lesser quality. The cost for the reuse water is based on the levies for surface water abstraction, but increased with a risk factor, investment and operation costs.

Tank Cleaning

The use of effluent for tank-cleaning is another "logical" application. This effluent is sometimes transported by containers to the tank-cleaning facility. In one case, the transport is replaced by a supply through fixed pipes. In the past, tap water was used for this low-quality application, making the choice for effluent as an alternative obvious. Risks for e.g.

contamination through aerosols are deemed less important, considering that those tank cleaning companies mostly transport septic material. This is a growing market which will be consolidated in the near future.

Domestic Waste Incinerators

A popular and one of the earliest applications of effluent in Flanders was the use for direct cooling of the incinerator's ashes in waste incinerators. This is a straightforward application of secondary effluent without extra treatment. In one case, 340 000 m^3/yr effluent from a 600 000 p.e. WWTP is used for the wet gas scrubbing of the nearby incinerator. In the past canal water was used , but for quality reasons, in particular heavy metals, the discharge of the cooling water was prohibited. The non-evaporated cooling water is now discharged in the sewer back to the WWTP.

Truck Cleaning

A composting and waste management facility uses effluent after chemical disinfection for truck cleaning, because the effluent is more nearby than the alternative surface water.

Irrigation

In Bruges, as well as in some other WWTP's near the coast, effluent is regularly used to control the surface water level in the wet "polder" area, for reason of irrigation and to provide water for the livestock.

Indirect Potable Reuse

At the Belgian coast, the Intermunicipal Water Company of the Veurne region (IWVA) is responsible for the potable water production and supply in the area; the source for the potable water production was the sandy aquifer in the dunes near the coast. The largely varying water demand as a result of tourism during summer and saline intrusion was threatening the sustainability of the potable water production. In 2002 the Intermunicipal Water Company of the Veurne region (IWVA) started artificial recharge of an unconfined aquifer in its dune water catchment St-André. Wastewater effluent was used as the source for the production of infiltration water. This plant, with a production capacity of 2,500,000 m^3/year, combined membrane filtration techniques to achieve the stringent standards set for the quality of the infiltration water. The whole project was developed to create a sustainable groundwater management; the natural groundwater extraction was reduced from 3,700,000 m^3/year to 2,700,000 m^3/year. By 2010 another 500,000 m^3/year will be saved (E. Van Houtte and J. Verbauwhede, 2005). Saline intrusion was gradually prevented and the sustainability of the water production was increased. The treatment scheme is presented in Figure 7.

Initially the infiltration water was composed of 90 % RO filtrate and 10 % MF filtrate In May 2004 it was decided to no longer use UF filtrate as part of the infiltration water. The RO filtrate was re-mineralised using sodium hydroxide. Since then the infiltration contained less organics and the nutrient content was lower, which should benefit the infiltration. On one exception for diuron (0,016 µg/l), pesticides were not detected in the infiltration water. As the RO removed all bacteria and viruses, the UV installation could be stopped. Table 3 displays the quality of the reclaimed water produced.

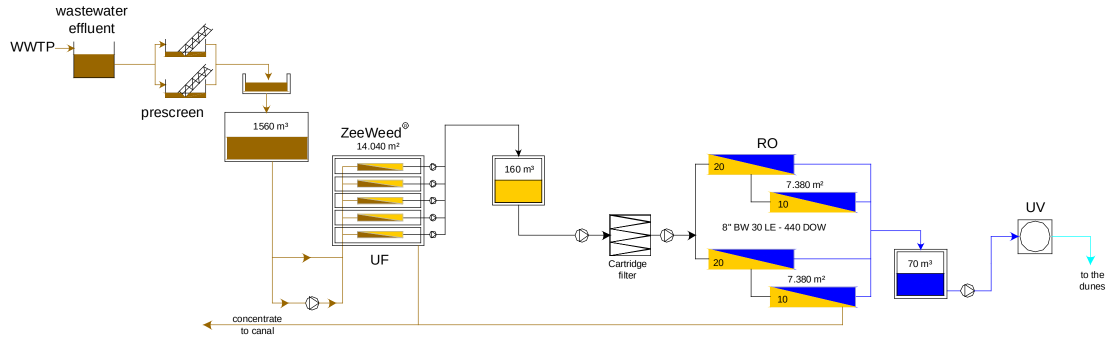

Figure 7. Treatmen scheme St-André aquifer recharge project (IWVA)

Table 3. Quality of infiltration water procuced at the "Torreele" plant. Mean value with minimum and maximum between brackets (E. Van Houtte and J. Verbauwhede, 2005)

Parameter	Infiltration water (July 2002 – May 2004)	Infiltration water (May 2004 – May 2005)	Infiltration water standards
pH	5,70 – 7,67	6,05 – 7,16	>6,5 and <9,2
Conductivity (µS/cm)	150 (35 – 262)	48 (22 – 73)	1000
Chloride (mg Cl/l)	22 (2 – 36)	2,5 (1 – 4)	250
Sulphate (mg SO4/l)	10 (6 – 17)	<1	250
Sodium (mg Na/l)	18 (5 – 30)	11 (5 – 16)	150
Total hardness (°F)	3,6 (1,8 – 5,8)	<1	40
Nitrate (mg NO3/l)	6,9 (1 – 16)	2,1 (<1 – 3,6)	15
Ammonia (mg NH4/l)	0,31 (<0,05 – 0,84)	0,19 (<0,05 – 0,61)	1,5
Total phosphorous (mg P/l)	0,1 (<0,1 – 0,3)	<0,1	0,4
Total Organic Carbon	0,9 (0,5 – 2)	<0,2	-

Nature enhancement/recreational

The use of "natural systems" for tertiary treatment is increasingly gaining interest in Flanders. The possibility of these systems for, on the one hand, adding some additional treatment to secondary effluent, and on the other hand, improving the ecological value of the natural surroundings, are largely valued and under investigation. The incorporation of wetlands in the treatment scheme is seen as a possibility to help in complying with the Water Framework Directive, basically to help in achieving a good ecological status in the receiving watercourse. With well designed 'free water surface' systems, amongst others, diurnal oxygen patterns can be induced in the effluent before discharging to surface waters, and fish spawning areas can be provided.

This concept is studied at length in the 'Waterharmonica' project. (REF Increasing the natural values of treated wastewater,the Waterharmonica: the missing link to transfer treated waste water into a usable surface water (Ruud Kampf et al.). An example in Spain can be found at the Empuriabrava WWTP.

In Flanders, the effluent from the 70,000 p.e. WWTP of Liedekerke is fed into a 1.66 km long, 2.5 m wide free water surface wetland followed by a lagoon. The water level in this lagoon can be manually adjusted in order to decrease the retention capacity. As such an average additional retention volume of 40,000 m³ is created. Originally this wetland was constructed to serve as a buffer area for flooding. The design is following the principles of ecological engineering (see Figure 8).

During the last 4 years birds were monitored on an irregular basis. A significant number of endangered species were observed. This is merely due to the fact that this wetland covers an important area in comparison to the little natural areas of the nature reserves in the surroundings/neighbourhood. In order to meet the desires of the local birdwatchers an observation point was installed on site.

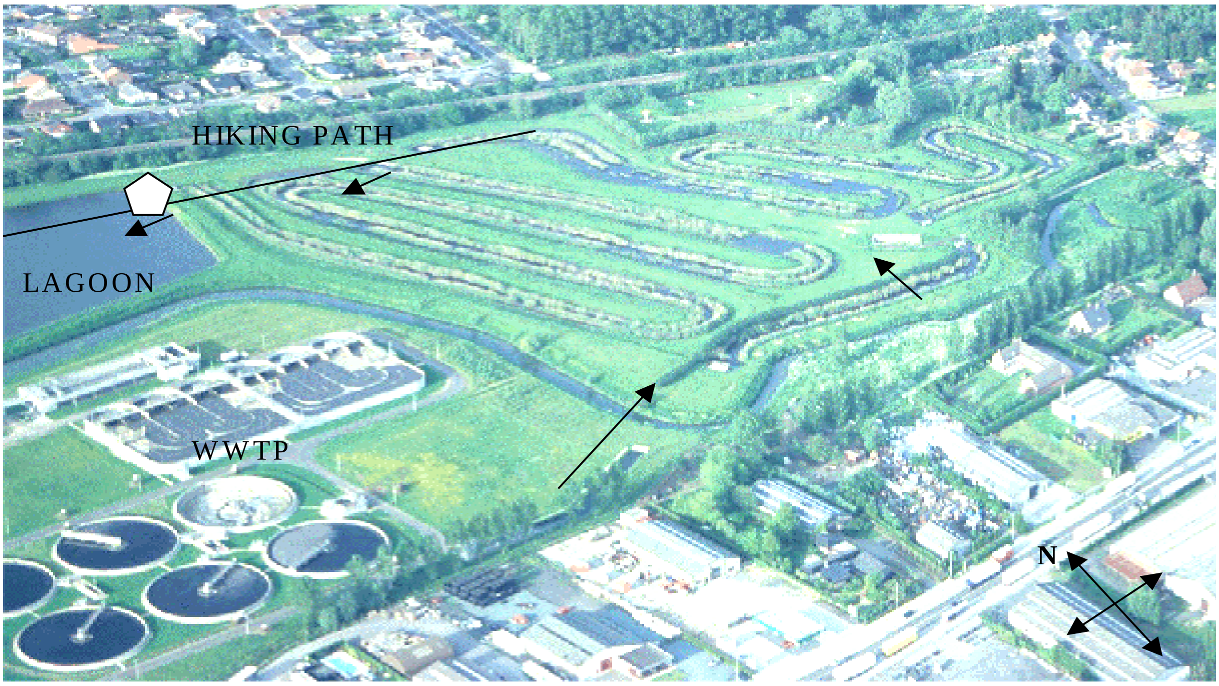

Figure 8. Aerial view of the free water system at Liedekerke.

THE FUTURE

As 80 % of the water use in Belgium is used for cooling, in 2005, a study was conducted to evaluate the potential of effluent use for cooling water applications. (A. Bertini 2005).

Forty-one case studies from around the world and a survey on cooling water applications in Flanders provided valuable information for the preparation of guidelines and showed a great interest from the end-users for this study. The results from the comparative analysis between surface water and WWTP effluent indicate that the level of chemical water quality of the secondary treated effluent is comparable to that of surface water.

On the other hand, the secondary treated effluent needs to be disinfected to meet the microbiological water standards for cooling water, while surface water does not need it. This study showed that the reuse of effluent as cooling water has a big potential, but some work still remains to be done, in particular, guidelines have to be developed and risks have to be quantified and controlled.

The major impediment for further reuse of reclaimed water as coolant in Flanders is certainly the policy on water tariffs. Under the present pricing policy, effluent is still a factor 1,5 to 2 times more expensive than surface water. Table 4 shows the results of a SWOT analysis of the use of effluent as industrial coolant.

Table 4. SWOT Analysis for the use of effluent as industrial coolant

Strenghts	Weakness
Minimum water quantity can be guaranteed *Low BOD5* *Low SS* *Successful case studies*	*Higher price of WWTP effluent* *Low microbiological quality*
Opportunities	Threats
Water conservation policy *Increasing industrial needs* *Public perception and acceptance of industrial reuse* *Increasing drought period*	*Lack in legislation* *Surface water quality is getting better*

CONCLUSION

Although the climate in Flanders is much different from the Mediterranean climate, and water is used mainly for industrial (cooling) purposes, as opposed to agricultural use in the Mediterranean, water reuse gradually increases also in Flanders. The main application is and will be in coolant make-up, but some bottlenecks have still to be tackled, such as water pricing policy and the development of guidelines.

Through the years, reuse practice has been demonstrated and confidence is gained. Reuse schemes vary from very basic treatment technology, over natural systems, to high-tech applications. Together with the political will to increase the sustainability of the local water management, this will undoubtedly increase the number of water reuse projects in Flanders.
In particular the Water Framework Directive can offer possibilities to integrate water reuse in standard integrated water management approach. Natural systems deserve special attention as a “reuse technology”, for they combine additional treatment with valuation of the effluent through nature enhancement and recreation.

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