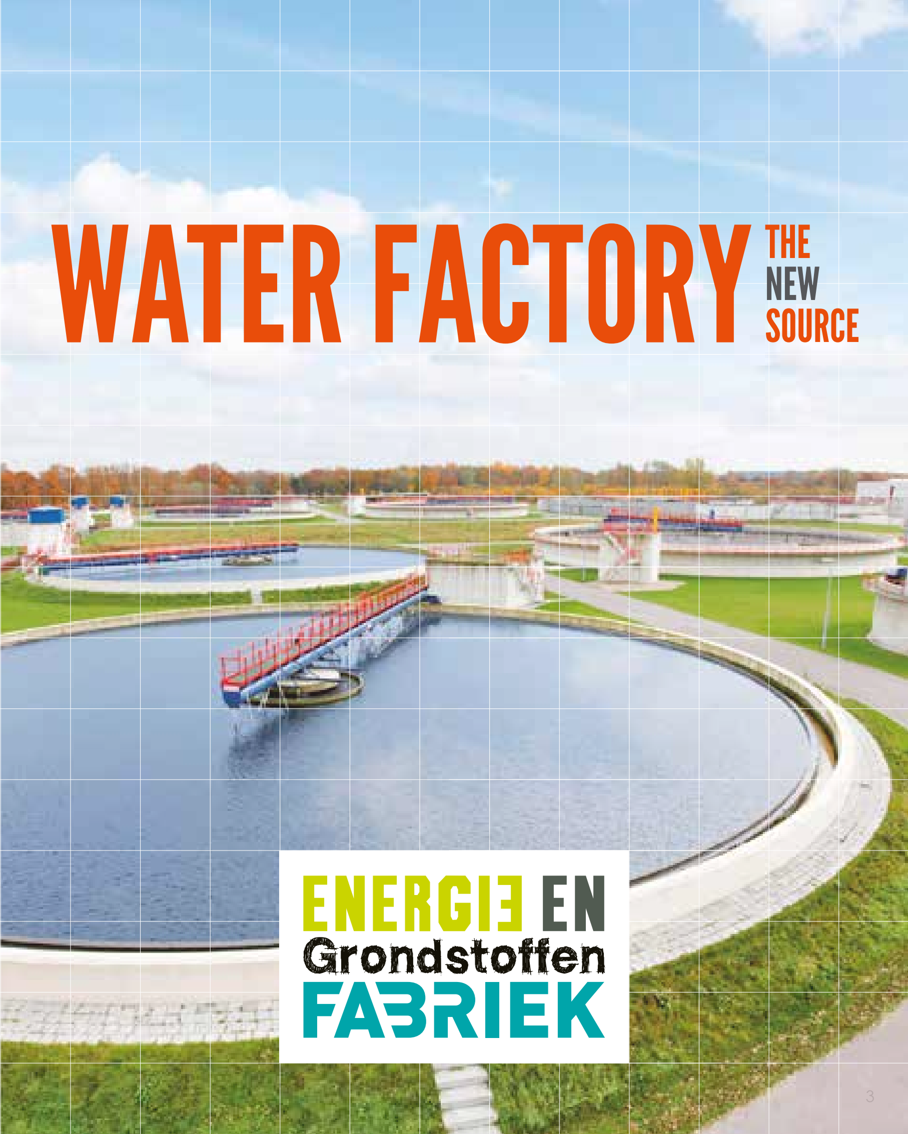
# WATER FACTORY THE NEW SOURCE



"There is no waste water, only water that is wasted"

**- H.R.H King Willem-Alexander, 2010**

**A product of the Energy and Resources Factory.**

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And with great thanks to various co-reading colleagues!

**Amersfoort, June 2019**

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# CONTENTS

# A NEW SOURCE OF INSPIRATION

**On average we use around 120 litres of water per person per day. Water is so obvious that we take it for granted. Until it becomes scarce.**

For example, due to a long period of drought such as in the summer of 2018. Inland vessels were then unable to sail in certain rivers because of the low water level. Agriculture suffered from increasing salinization. Numerous measures were needed to protect the quality and quantity of our water. The enormous significance of water was strikingly visible. Just like the expertise and creativity of many people who are needed to keep water at the right level for all purposes.

Fortunately, our country, to a large extent, possesses that expertise. And it remains indispensable. Drought raises new issues. New ideas and innovations are desperately needed to use our water as well as possible and not to waste a drop.

The Water Factory is a good example of this. It shows which opportunities there are for reusing treated wastewater in, for example, agriculture and industry. Theme park De Efteling has been using treated wastewater for more than 20 years and that is not a myth!

This publication offers concrete tools and ideas to end regarding wastewater as waste. Water is not nearly as self-evident as we think and it can be a new source in many ways. I therefore hope that this publication is an inspiration and will lead to new initiatives!

**CORA VAN NIEUWENHUIZEN**
**MINISTER FOR INFRASTRUCTURE AND WATER MANAGEMENT**

# 1. WHAT IS HAPPENING

**Sufficient fresh water can no longer be taken for granted.**
If you think of the Netherlands, you immediately think of a land of water. But the warm and dry summer of 2018 proved that water is not so obvious at all, and this can occur more often in the future. The consequences for nature and agriculture are considerable. Industry must also make more effort for a more sustainable use of water. Everybody is looking for a solution to use the water system efficiently and carefully. Alternative sources are  needed for groundwater and surface water, sources that we can always depend on.
Our answer to this is: the Water Factory.

**Water Factories as alternative source**
Together with partners, the regional water authorities can treat water from wastewater treatment plants (wwtps) to such an extent that it can be used for new marketing chains. These Water Factories are becoming increasingly interesting because the effluent from a wwtp is becoming  even more cleaner by the removal of, amongst others, residual medicine. In addition, new technologies make it possible to deliver water of any desired quality in a competitive manner. In this way the wwtps are an interesting alternative source for the supply of fresh water.

**Great opportunities for circular water.**
Sufficient reasons then to assess the opportunities for Water Factories. And what did we find?

In most cases it is possible to deliver water of a desired quality for competitive prices within a radius of 10 km from a wwtp.

This allows new marketing chains to develop between regional water authorities, agriculture, industry and drinking water companies.

So let yourself be inspired  by the insights in this booklet and help to use the most important resource on earth in a sustainable way!

# 2. WATER FACTORIES: WHAT IS NEEDED

Water Factories are wastewater treatment plants (wwtps) where its effluent is upgraded to a higher quality to be able to deliver it to specific customers. However, this is only taking place on a very limited scale (see the inspiring examples in the appendix). Until now there has been insufficient urgency to search for alternatives (availability, price, regulations), but there is also still much unfamiliarity with regard to the availability of effluent. If, however, this aspect is also explored, the possible risks associated with water quality will also come into view.

It is therefore time to determine what is needed to make wwtp effluent an interesting alternative for customers. On the following pages the possibilities are explored on the basis of:

- the required **water quality**: what water quality do customers require?
- the available **technology**: is that quality achievable with current technology?
- the **scale**: is sufficient volume available?
- **transport**: up to what distance can water be supplied within acceptable costs?
- the **costs**: is effluent still financially attractive with all these preconditions?

In a later chapter, four scenarios have been elaborated for both agriculture and industry. They can also be used to address the opportunities and points of attention in specific cases.

## WATER

Water ($H^2O$; aqua or aq .; sometimes called dihydrogen oxide or oxidant) is the chemical compound of two hydrogen atoms and one oxygen atom.
Water occurs in nature in three different main phases: as a liquid, as a solid and as a gas. At room temperature, water is a liquid with no specific colour and odour. Water covers 71% of the Earth's surface. Less than 1% of all water present is liquid fresh water.

## EFFLUENT

Treated sewage from a wastewater treatment plant that is usually used to supplement surface water.

# MARKET OPPORTUNITIES

**Water is perhaps the most important resource for the functioning of our society. The market opportunities for effluent are therefore countless.**

**Water system:** our (surface) water system consists of rivers, streams and ditches. The wwtps discharge their effluent into this water system and are therefore an important source of water supply during dry periods. Consider also using it for nature, swimming water or the prevention of salinization. The same water system, including the groundwater system, can also be used as a water buffer. Such storage is crucial for the reuse of water because applications are often strongly dependent on location and time. Smart control of water or even infiltration creates a strategic water supply for bridging periods of drought or even as raw material for drinking water production.

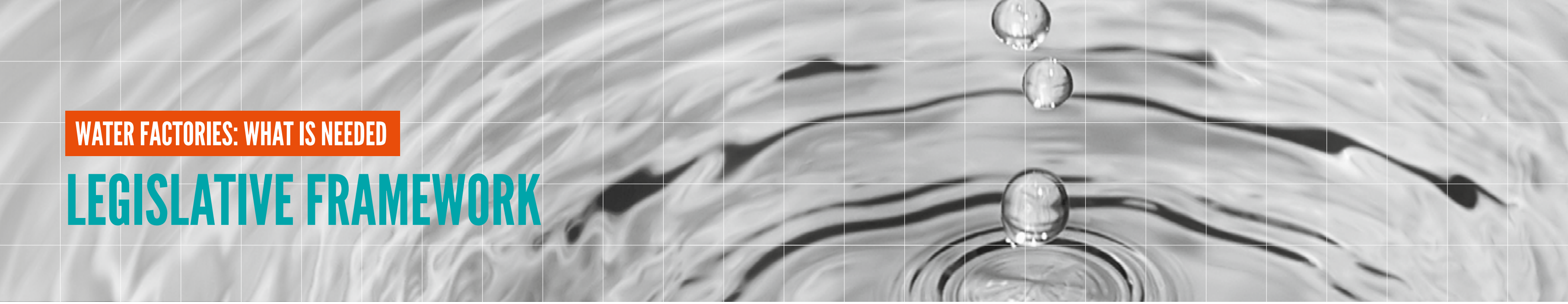
**Agriculture:** a major consumer of fresh water for our food supply. With specific opportunities for effluent in:

- intensively cultivated moisture-demanding crops around a wwtp;
- level-controlled irrigation: adjustable supply and discharge of water via existing drainage pipes;
- greenhouse horticulture: a consumer who places high demands on water quality (irrigation water).

## AGRICULTURE: A MAJOR CONSUMER OF WATER

**Industry:** this group of potential customers is very diverse in composition and has a wide spectrum of required water qualities, from rinsing water to ultra-pure water. Customisation is the key word here. A special sector is the food industry, which obviously places high demands on water quality (microbiologically reliable).

**Households and companies that use drinking water:** reprocessed effluent can offer an alternative for applications that do not require drinking water quality. This is only possible if this is not detrimental to legal quality requirements or public trust.



WATER FACTORIES: WHAT IS NEEDED

# LEGISLATIVE FRAMEWORK

**Which regulations apply depends on the application of the reprocessed effluent. The most important legislation and standards to take into account are explained here.**

**From a legal point of view, effluent is waste:** but fortunately it is quite possible to use it as a raw material. The Waste Framework Directive and the Environmental Management Act state that waste is no longer waste when it has undergone treatment for recovery and meets certain conditions (see appendix for details).

**Surface water:** from 2027 the water quality must comply with the European Water Framework Directive (WFD). Discharges into surface water must not cause water quality to deteriorate.

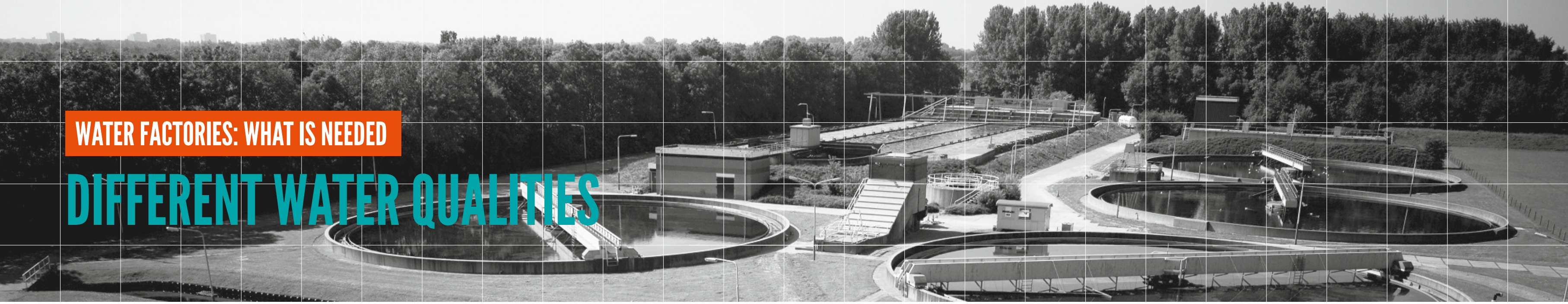
**Groundwater:** when using (reprocessed) effluent for infiltration of groundwater aquifers, the infiltration decree applies to protect soil.
(https://wetten.overheid.nl/BWBR0005957/2009-12-22)

**North Sea & Wadden Sea:** if the effluent ends up in the sea through discharge or reuse, then it must comply with the Marine Strategy Framework Directive (MSFD).

**Agriculture:** there is a European (draft) standard for effluent reuse in food production. Irrigation water for greenhouse cultivation does not have separate regulations, but does require a very high water quality.
(http://ec.europa.eu/environment/water/reuse.htm)

**Industry:** the Drinking Water Decree is the most commonly used standard for the food industry, but other qualities are also common.
(https://wetten.overheid.nl/BWBR0030111/2018-07-01)

**Drinking water:** only Dutch drinking water companies are allowed to produce drinking water. For that very high water quality, the Drinking Water Decree applies as a legal framework. The parameters that are important in that are shown in the appendices.
(https://wetten.overheid.nl/BWBR0030111/2018-07-01)



WATER FACTORIES: WHAT IS NEEDED

# DIFFERENT WATER QUALITIES

**The required water quality that the customer needs determines, of course, the reuse of the effluent. The regulations and laws for this have already been described in the previous section. Then basically, the question remains:**

**How far is the current effluent quality from the required water quality?**

The following table shows some important parameters for effluent reuse in main groups. A more extensive table, with all known substances that are found in effluent is in the appendix. This table also shows the specific values for the various underlying substances.

And guess what? For many parameters, the average effluent quality is very close to the required water qualities for reuse. With current laws and regulations, disease organisms such as viruses and bacteria (also known as pathogens) are now the biggest challenge. And there are also the micropollutants: chemical compounds that are often present in low concentrations, such as medicine residues or pesticides.

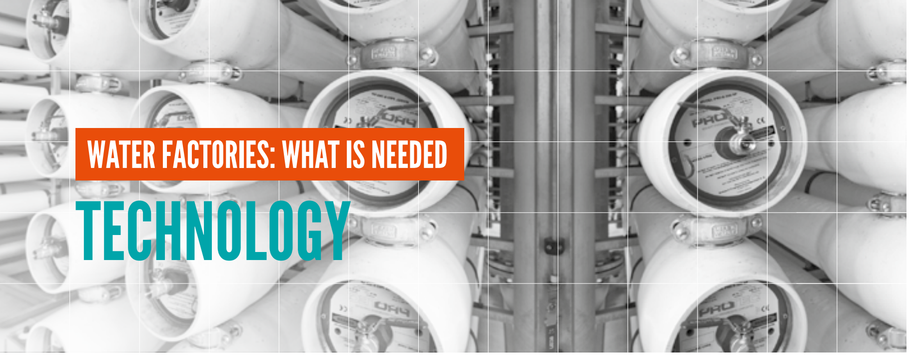
Comparison of effluent quality with known water quality requirements

| Parameters[1] | EU- Class A (Agriculture) | Drinking Water Decree | Irrigation Water[2] | Ultra Pure* |
|---|---|---|---|---|
| Organic Micro Pollutants[5] | | Extensive treatment necessary | Extensive treatment necessary | |
| Nutrients | | Little treatment necessary | Acceptable | |
| Heavy Metals | | Acceptable | Acceptable | |
| Sodium (Na) | | Acceptable | Extensive treatment necessary | |
| Chloride (Cl) | | Acceptable | Extensive treatment necessary | |
| Conductivity | | Acceptable | Extensive treatment necessary | Extensive treatment necessary |
| Pathogens | Extensive treatment necessary | Extensive treatment necessary | Extensive treatment necessary | |
| Undissolved matter (OB) | Acceptable | | | |
| $BZV_5$ | Acceptable | | | |

* Conductivity is the determinate parameter

Key

| | | | | | |
|---|---|---|---|---|---|
| (green) | Acceptable | (orange) | Little treatment necessary | (red) | Extensive treatment necessary |



## WATER FACTORIES: WHAT IS NEEDED

# TECHNOLOGY

### Drinking water technology?

The quality of the effluent may be close to potential applications but of course, it "simply" still has to be reprocessed.

To achieve this, significantly different technology is needed than is used in current wastewater treatment plants. It is then hardly a surprise that you arrive at technologies that drinking water companies have been using for some time. A great opportunity to work together and share knowledge!

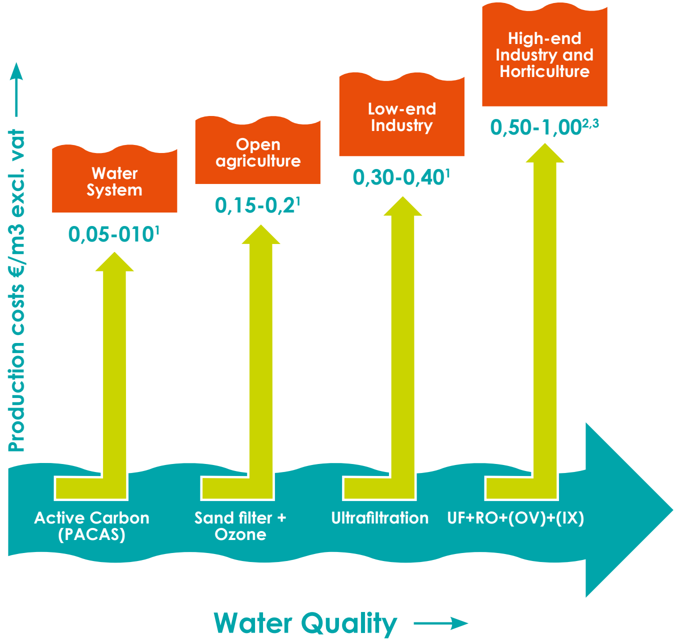
### High Tech

The following figure shows the required techniques, or combinations of techniques, that can achieve the aforementioned water qualities. Consider, for example, membrane filtration (ultrafiltration (UF)) or reversed osmosis (RO)), but also oxidative techniques such as UV or ozone. The latter techniques ensure the chemical breakdown of specific compounds. To fully tailor the water, specific ions can still be exchanged in an ion exchanger (IX). All proven technology! How wonderful is that?

# TECHNOLOGY & COSTS

### And is it still affordable?

Well, compared to the alternative water sources, actually it is.
The required quality can simply be achieved and the cost price is very similar to rates for alternative water sources. Four cases will be elaborated in more detail in the next chapter. The costs are indicative on the basis of various references, but are ultimately tailor-made for each case.

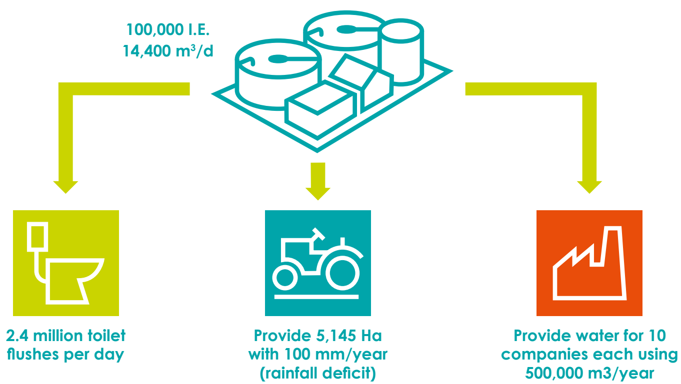


# WATER FACTORIES: WHAT IS NEEDED

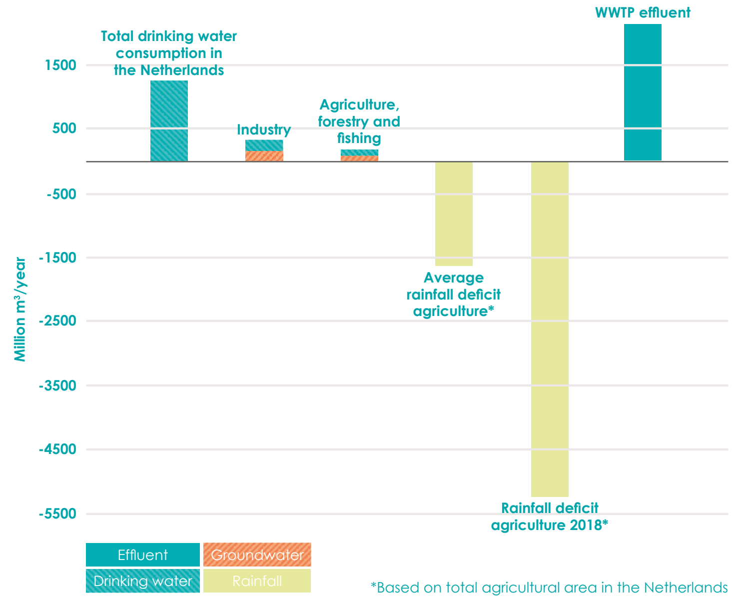
# SIZE OF SCALE AND QUANTITY

**Do the effluent volumes of wwtps make a significant contribution? Sure they do! But it remains custom work. Therefore, on the following pages some key figures to get an idea of the quantities involved.**

From these figures it becomes clear that the total effluent volume of the Dutch wwtps can contribute significantly. This volume is, logically, largely determined by the use of drinking water in the Netherlands. Moreover, this volume is even almost eight times larger than the total volume of groundwater and drinking water consumption by Dutch industry.
In short, certainly not a drop in the ocean.




Water consumption in the Netherlands, water shortage in agriculture v available effluent




*Based on total agricultural area in the Netherlands

- **Total effluent wwtps:** 1905 million m³ per year (CBS, 2016)
- **Total drinking water consumption in the Netherlands:** 1260 million m³ per year (CBS, 2016)
- **Agriculture:** with a precipitation deficit of 100 mm/year = 1,000 m³/ha/year required
- **Industry:** very different consumption
- **Drinking water:** average consumption of 120 litres/day/person.

WATER FACTORIES: WHAT IS NEEDED

# LOGISTICS AND TRANSPORT

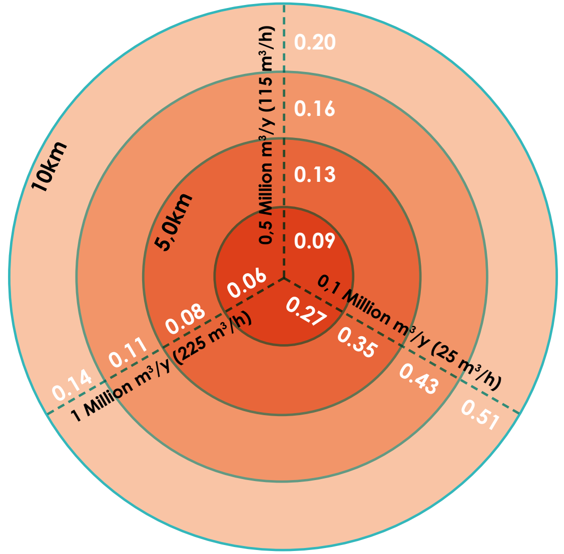
**To get the water to its destination, it has to be transported. A tank truck quickly turns out to be too expensive for this (at least €3/m³), but by using a separate pipeline the costs are lower.**

The figure opposite shows the transport costs estimated for three different annual volumes at four different distances (based on practical cases and module D1100, Sewerage Guideline). A 3D graph for several variants is shown in the appendix.

### But is it still affordable?

Depending on the alternative sources, which region in the Netherlands and the desired water quality, effluent can be a very competitive alternative. See also the detailed scenarios in the chapter below.

## EXAMPLE OF TRANSPORT COSTS (€/m³)




**Assumptions:**

**Pipeline:**

- Excl. VAT
- Optimal flow: 0.7 m/s
- PVC pipeline
- Assumption of 3 guided drillings (e.g. for dyke, canal, railroad, etc.)

**Pump:**

- Number of days active: 365
- Hours per day: 12
- Depreciation: 20 years

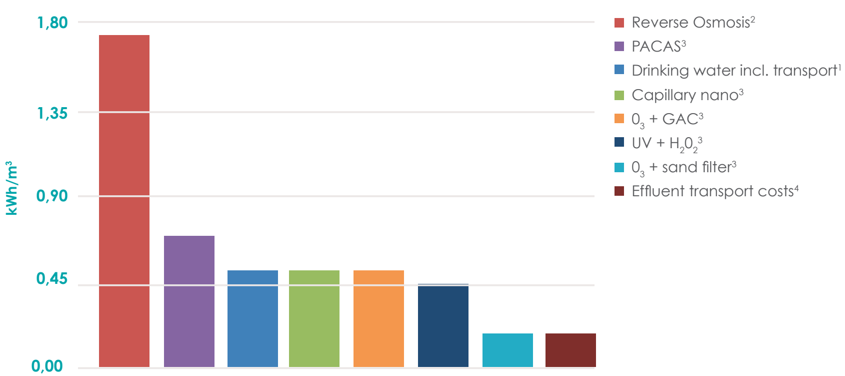
WATER FACTORIES: WHAT IS NEEDED

# ENERGY

## A similar energy consumption to drinking water production

All these new technologies naturally also require extra energy. We should therefore always use renewable energy for these reuse purposes! In the table below we compare the energy consumption of the technologies. The energy consumption for effluent reprocessing is comparable to that for the production and transport of drinking water (produced from groundwater).

Gross energy requirement (GER)[5*]




*Incl. production, raw materials and application



# 3 WHAT IS FEASIBLE: FOUR CASES ELABORATED

The feasibility of supplying reprocessed effluent depends on many parameters, according to the previous analysis. As a result, we cannot make generic statements about this. In order to get a general impression of feasibility, we have elaborated 4 scenarios to supply for:

1. **Irrigation in open agriculture**
2. **Irrigation in glasshouse horticulture**
3. **Industry using drinking-water quality**
4. **Industry using ultra-pure water quality**

**Basic principles for the elaboration of the cases are:**

- volume of 500,000 $m^3$/year;
- the aforementioned costs / $m^3$ include capitalisation and operational costs;
- all costs are excl. transport costs (see chapter "Logistics and Transport").

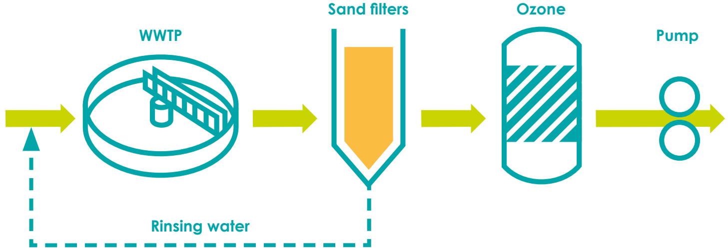
WHAT IS FEASIBLE: FOUR CASES ELABORATED

# IRRIGATION OPEN AGRICULTURE CASE

**For irrigation of agricultural land, water quality must at least comply with the EU directive drawn up for this. This will require additional treatment. The required water quality depends on the type of crop.**

## The treatment process

By means of a (nitrifying) sand filter, undissolved Components (SS), organic matter and ammonium ($NH_4$) are removed. An alternative is the use of a textile filter. Post-treatment with ozone ($O_3$) serves as a disinfection step and also breaks down organic micros.




Depending on the effluent from the wwtp, this combination meets Class A water for reuse in agriculture. It is possible to replace the sand filter with an active carbon filter to achieve a higher removal of organic micros.

## Costs

The costs for the treatment process presented here are between € 0.15 - 0.20 €/$m^3$. Based on the value of the crop, the water may cost between roughly 0.20-0.40 euros/$m^3$. Of course, the price depends on the type of crop, but there seems to be sufficient margin to still be able to pay for any transport.

## Points of attention

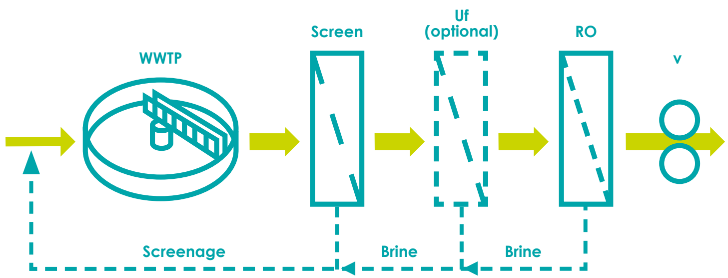
- Seasonal dependence plays a major role. The demand for water is high in the summer and low in the winter.
- Transport is possible via natural waterways.

# IRRIGATION GREENHOUSE HORTICULTURE CASE

**For irrigation water in horticulture, no organic micro-contaminants and microbiological activity may be present in the water. Furthermore, the sodium content must be extremely low to meet the class 1 standard for irrigation water. In this way the water can be recirculated for longer in the greenhouse.**

## The treatment process

A screening installation ensures the removal of a large part of the undissolved components (> 3 μm). The ultra-filtration membrane (UF) has a disinfecting function and also provides protection for the subsequent reversed osmosis (RO) membrane.




The RO membrane lowers the sodium content and removes the remaining organic micropollutants from the effluent. The conductivity of the water can then ultimately be lower than 30 mS/m.

## Costs

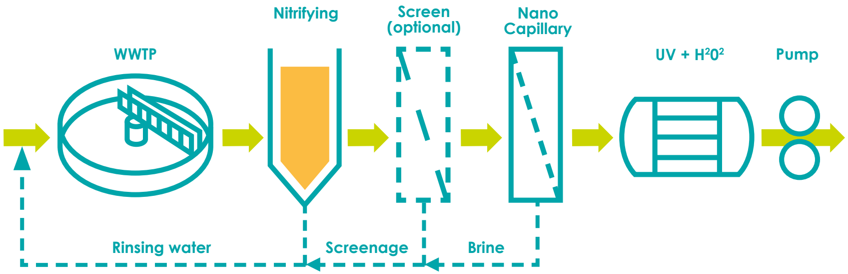
Such a chain of techniques costs around € 0.50 - € 0.60/$m^3$ of treated water. In practice, the costs for irrigation water (groundwater desalination in the Westland area) are between € 0.6 - € 1/$m^3$. With this in mind, there seems to be sufficient financial margin to pay for transport.

# INDUSTRIAL REUSE CASE

**For this case we use the parameters of the Drinking Water Decree; this is a level of quality that is suitable for use as process water in many industrial applications.**

## The treatment process

The (nitrifying) sand filter (ZF) reduces the $NH_4$ content so that it complies with the Drinking Water Decree. Optionally, a screening plant can be chosen as extra protection for the downstream capillary nanofiltration (NF). After NF, the water is particle-free and almost all dissolved organic matter has been removed with the exception of some of the organic micros. In addition, the NF also has a disinfecting function. The particle-free water is subsequently treated very effectively with ultra-violet light (UV) + hydrogen peroxide ($H_2O_2$).






This ensures removal of the remaining organic micros. There is also the combination of UV + $H_2O_2$ as the second disinfection step to guarantee pathogen-free water.

## Costs

This configuration costs between € 0.50 and € 0.60/$m^3$. This is competitive with the lowest drinking water rates in the Netherlands (0.45 - € 1.5/$m^3$ produced from groundwater), but then it still needs to be transported. With larger volumes (> 250,000 $m^3$/year), a transport distance of 5 to 10 km seems very feasible.

## Points of attention

- The feasibility is highly dependent on the costs of drinking water or alternative water sources.
- Capillary Nanofiltration makes it possible to purify water without removing all salts. This prevents the problem of too ‘weak’ water.

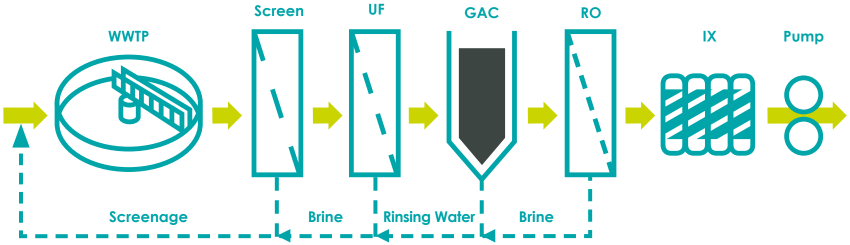
WHAT IS FEASIBLE: FOUR CASES ELABORATED

# ULTRA-PURE WATER FOR INDUSTRY CASE

**Ultra-pure water is required for certain industrial processes. In fact, this water only consists of water molecules. The most extensive form of treatment is required to achieve this quality.**

## The purification process

The first step is polishing the water through screens.
This removes a large part of the undissolved components.
The water then passes through ultrafiltration (UF) for further removal of undissolved and colloidal substances to relieve the reversed osmosis (RO) process. After the RO process, the water passes through a mixed-bed Ion exchanger (IX) to remove the last remaining salts from the water.




## Costs

Depending on the volume, the costs for such an installation will be between € 0.70 and € 1.00/$m^3$. This is still below the current cost price in the industry (€ 1.00 - € 1.25/$m^3$), but then the water still needs to be transported. With larger volumes (> 250,000 $m^3$/year), a transport distance of 10 km is very realistic.

## Points of attention

The incoming quality in such an installation has little impact on the final quality of the product. This makes wwtp effluent a very attractive option compared to alternative water sources. At relatively large volumes, the return flows (brine and wash water) can significantly increase the salinity of the remaining effluent.

# 4 WATER OPPORTUNITIES IN THE NETHERLANDS

Wastewater treatment plants and potential customers on business areas can be found everywhere in NL! This map gives a first impression of the delivery options for the Netherlands: all wastewater treatment plants in the Netherlands and the business areas that are within a 5 km radius.

Legend

- • WWTP
- Business areas within 5 km from a wwtp
- Business areas further than 5 km from a wwtp

Source: Nationaal Georegister

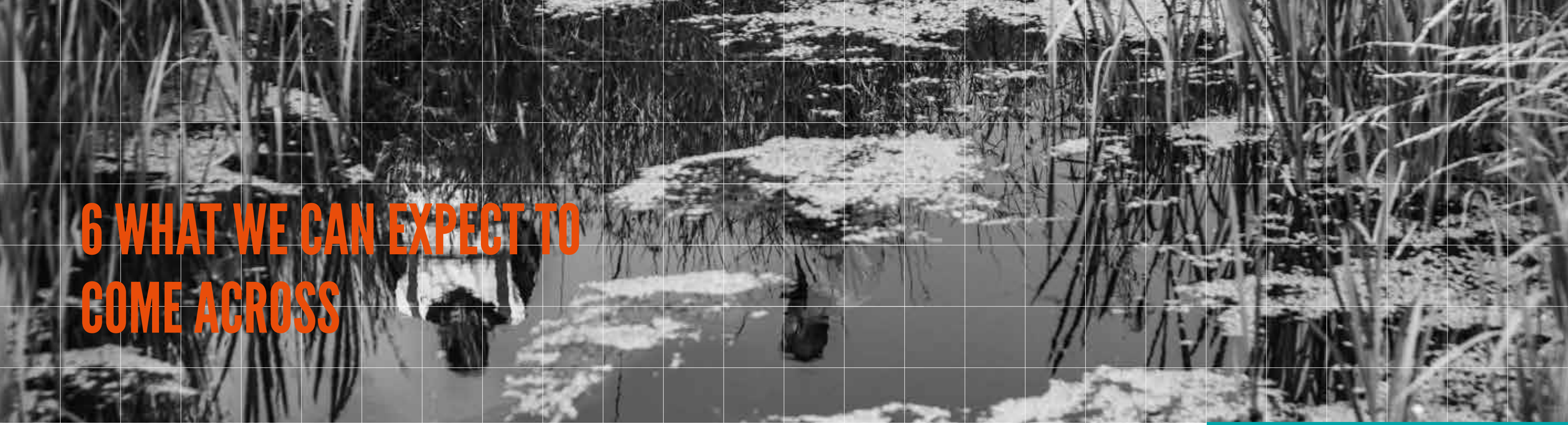
# 5 WHAT IS POSSIBLE

The opportunities for using treated wastewater (effluent) as an alternative water source for our freshwater supply are numerous, especially now that this effluent is already getting cleaner. The urgency is increasing for alternatives for both industry and agriculture, but also as a supplement to the groundwater system for nature and drinking water production. This has been taking place for some time in Southern Europe, but there is now also greater support for the reuse of effluent in the Netherlands.

**The following insights show that effluent is an attractive alternative water source:**

1. The required water qualities for industry, agriculture or for replenishing the groundwater system are technically very feasible;
2. The available effluent volumes are more than sufficient to supply a large part of industry and to be able to fulfil a large part of agricultural deficits;
3. The costs that must be incurred for industrial water quality are comparable to the lowest drinking water rates (produced from groundwater) in the Netherlands;
4. The costs for producing agricultural water are also competitive: comparable to the costs for irrigation water in greenhouses, or to cover costs in times of drought;
5. Transport of the treated water in large volumes is competitively possible up to distances of 10 km.

## EFFLUENT (TREATED WASTEWATER) IS AN ATTRACTIVE ALTERNATIVE WATER SOURCE



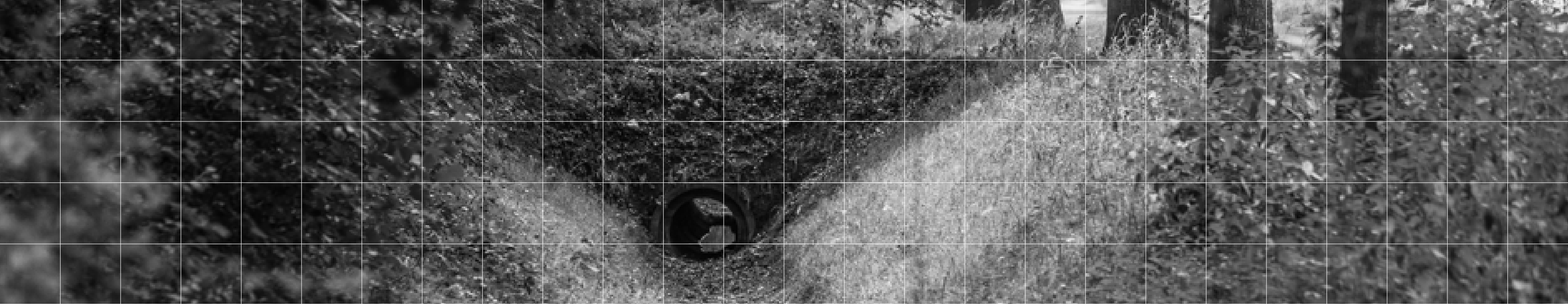
# 6 WHAT WE CAN EXPECT TO COME ACROSS

**Many aspects are now clear when it comes to the reuse of effluent from wwtps. Of course we will also come up against points of attention during realisation. The following must certainly be taken into account:**

- In these reuse projects the parties involved must discuss their own role in it. This will include quality control, redundancy, security of supply, etc. These costs are not yet included.
- The potential in industry may be greater than expected. There are more than 1001 types of "process water" ranging from cooling water to ultra-pure water. Together with the end users and the NVWA, the need for drinking water quality must always be considered.
- The monitoring of effluent could be improved. The effluentis not monitored for many reuse parameters. Pathogens in particular are often not included.
- Business cases for reuse are soon attractive if specific innovative technologies are used. Think of capillary nanofiltration or enzymatic filters.
- In some regions, several parties are already drawing on the effluent source. How do we deal with that distribution issue? A national strategy for this can help.
- **It starts with daring to do it! And we are happy to help you take the first steps! www.waterfabriek.nl**

**SPECIFIC INNOVATIVE TECHNOLOGIES COULD BRING REUSE CASES CLOSER**

# WHAT ELSE IS THERE



# REFERENCES


**Water qualities**

1. Available parameters of effluent, but not a complete list with regard to the set standards. The drinking water decree, for example, has a much longer list of parameters.
2. KWR (2017) Knowledge document on the reuse of residual water for agricultural water supply
3. Watson database average 2012-2018
4. CBS 2016
5. e.g. drug residues and pesticides; The Watson database shows that, of the approximately 700 substances measured since 2010, the 90 percentile of 21 substances exceeds the standard
6. Conductivity of the Harnaschpolder wwtp from 2011-2013

**Technology**

1. STOWA (2017) Exploring technological possibilities for the removal of medicines from wastewater
2. E. Van Houtte and J. Verbauwhede (2008) Operational experience with indirect potential at the Flemish Coast. Desalination. 218 (1–3): p. 198-207. (0.24-0.53)
3. Linares, R.V., Li, Z., Yangali-Quintanilla, V., Ghaffour, N., Amy, G., Leiknes, T., & Vrouwenvelder, J. S. (2016). Life cycle cost of a hybrid forward osmosis – low pressure reverse osmosis system for seawater desalination and wastewater recovery. Water research, 88, 225-234.

**Energy**

1. Ministry of Infrastructure and the Environment (2016) Performance comparison of drinking water companies.
2. Stillwell, A. S. & Webber, M. E. (2016). Predicting the specific energy consumption or reverse osmosis desalination. Water, 8 (12), 601. (brackish water)
3. STOWA (2017) Exploring technological possibilities for drug residue removal.
4. Simulated energy consumption for transport over 5 km at a pump capacity of $80m^3/h$ and a height difference of 3.5m.
5. Based on green power consumption.

# INSPIRATIONAL EXAMPLES

**DOW Terneuzen**
Together with Evides Industriewater, effluent from the Terneuzen wwtp is reprocessed into feed water for steam production at DOW Benelux BV.

**Gurgling Water**
Since 1997, Adventure park De Efteling has been using treated effluent (sand filtration and a helophyte filter) as an alternative to groundwater (saving 400,000 $m_3$/year). The water is used in various attractions which use water.

**Pure-Water Factory**
Since 2010, effluent from wwtp Emmen has been reprocessed into ultra-pure water (membrane filtration and electrode deionization) by the regional water authority Vechtstroom and WMD Water for the Nederlandse Aardolie Maatschappij.

**Delft Blue Water**
Research into the use of wwtp effluent for the freshwater supply to greenhouse horticulture. Collaboration between regional water authority Delfland, Evides Industriewater and Delfluent Services BV.

**Irrigation Haaksbergen**
Since 2013, agricultural plots around the wwtp Haaksbergen have been irrigated with its effluent. KWR and KnowH2O are investigating the effect of direct effluent reuse on agriculture.

**Water Factory Wilp**
The regional water authority Vallei en Veluwe is working with several partners on the wwtp of the future. The use of physical/chemical techniques must give every drop of wastewater a certain value

**The Freshwater Factory**
At the wwtp De Groote Lucht, far-reaching removal of nutrients, micro-pollutants and pathogens is achieved through ozonation and sand filtration for local bathing water.

**Healthy Water**
A pilot plant by PWN and regional water authority Hollands Noorderkwartier at the wwtp Wervershoof to upgrade effluent to high-quality industrial water.

# DRINKING WATER DECREE

## MICROBIOLOGICAL PARAMETERS

For microbiological parameters, the requirement is that there are no pathogens present in the water. In practice, this means a requirement of 0 cfu/100 ml. Another requirement is a geometric annual average of a maximum of 100 cfu/ml at 22 ° C for all microbiology present.

## CHEMICAL PARAMETERS

This parameter includes a very broad spectrum of problem substances, including heavy metals, pesticides, chlorine compounds and nitrogen compounds. The maximum concentration is determined on the basis of the toxicity of the substances. For example, a maximum limit of 0.1 µg/l is used for pesticides, while a maximum of 10 µg/l is the norm for a heavy metal such as arsenic.

## ORGANOLEPTIC / AESTHETIC PARAMETERS

With drinking water, the requirements for taste, odour and appearance of the water are high. However, these values will be of lesser importance for most reuse applications. For some specific applications, however, a number of parameters are important, such as sodium in the case of irrigation water (max. 150 mg/l).

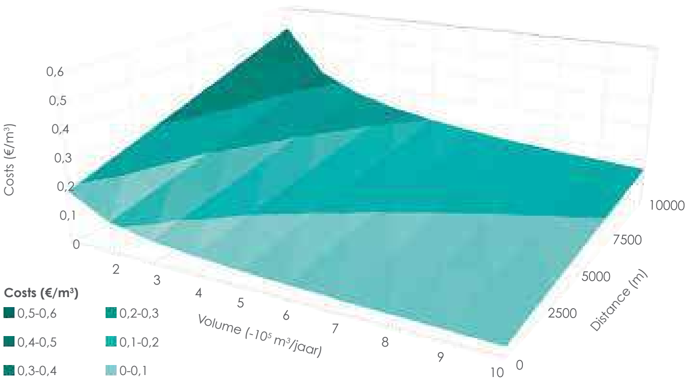
## SIGNALLING PARAMETERS

A signalling value of 1 µg/l is used for all anthropogenic substances. These values are primarily intended to monitor the quality of the source. At a value of 1 µg/l there is no risk to public health, but further investigation is required.

WHAT ELSE IS THERE

# DETAILED TRANSPORTATION COSTS

The pumped volume has relatively more influence on the cost price than the distance covered. A concrete example is worked out in the following figure.




**Assumptions:**

**Pipeline:**
- excl. VAT
- Optimal flow: 0.7 m/s
- PVC pipeline
- 3 controlled drillings (e.g. for dyke, canal, railroad, etc.)

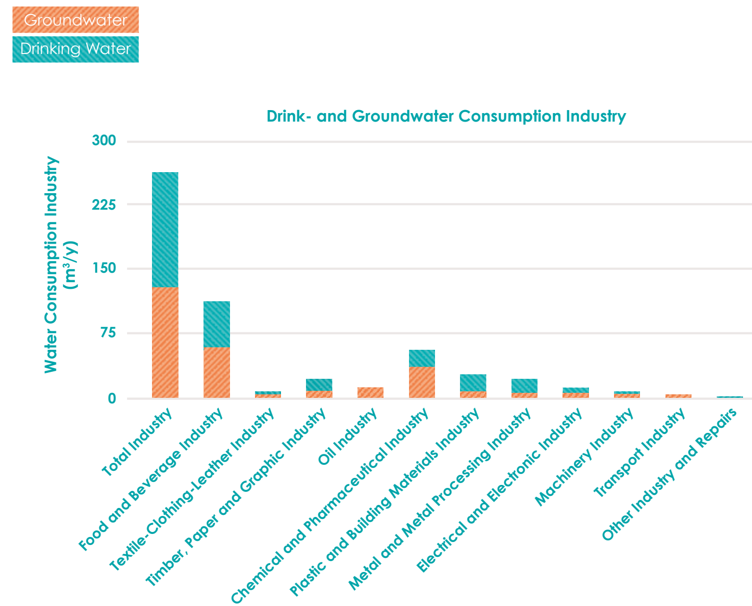
**Pump:**
- Number of days active: 365
- Hours per day: 12
- Depreciation: 20 years

**If a controlled drilling is needed because of an for obstruction.**
It will cost around € 80,000 per drilling.



WHAT ELSE IS THERE

# INDUSTRIAL WATER CONSUMPTION




Bron: CBS, 2016

WHAT ELSE IS THERE

# WATER FRAMEWORK DIRECTIVE

**Water Framework Directive (WFD)**
The WFD objectives are important for effluent reuse because they set the standard for surface water quality, effluent requirements are derived from it. One purpose of this is to monitor emerging substances that may be a problem for drinking water supply from surface water.

To be able to test this, so-called signalling values for drinking water sources have been established. A signalling value of 0.1 µg/l applies to all anthropogenic substances that are a threat to drinking water supply.

WHAT ELSE IS THERE

# EU QUALITY STANDARDS FOR AGRICULTURE

| Water Quality Class | Crop Category | Permitted Methods of Irrigation | E-Coli (CFU/100ml)[1] | Biological Oxygen Demand (mg/l)[2] | Suspended Matter (NTU) | Turbidity (NTU) | Additional requirements |
|---|---|---|---|---|---|---|---|
| A | All crops that are eaten raw where the edible part is in direct contact with treated effluent | All irrigation methods | ≤10 or undetectable (1 x week)[3] | ≥10 (1 x week) | ≥10 (1 x week) | ≤5 | Legionella spp1 <1000 CFU/l if there is a chance of aerosols (1 x week) |
| B | All crops that are eaten raw where the edible part is not in direct contact with treated effluent. Crops used in food production. Crops that are not used in food production or crops used for cattle feed | All irrigation methods | ≤100 (1 x week)[3] | ≤25 | ≤35 | n.a. | Intestinal nematodes (Parasitic worm) 2 ≥1 eggs/l for irrigation of pastures or crops for cattle feed (2 x month depending on the amount of eggs found) |
| C | | Only drip-feed irrigation | <1000 (2 x month) | [Values according to Urban wastewater treatment directive 91/271/EEC] | [Values according to Urban wastewater treatment directive 91/271/EEC] | n.a. | |
| D | Crops that are cultivated for industrial use, energy and seed production | All irrigation methods | ≥10000 (2 x month) | | | n.a. | |

[1] 90% of the measured values must comply and none of the measured values may exceed a maximum of 1 log unit above the stated requirement. [2] Total Suspended Solids (TSS) and Biological Oxygen Demand (BOD): 90% of the measured values must comply and none of the measured values may exceed a maximum of twice the requirement. [3] Required interval for measurement moments.

WHAT ELSE IS THERE

# SPECIFIC CONDITIONS OF WASTE LEGISLATION

Effluent is basically classified as a waste material. But fortunately it is quite possible to supply it. Article 6 of the Waste Framework Directive and Article 1.1 (6) of the Environmental Management Act state that waste is no longer waste if it has undergone treatment for recovery and meets the following conditions:

1. the substance or article is usually used for specific purposes;
2. there is a market for or demand for the substance or article;
3. the substance or article meets the technical requirements for the specific purposes and to the laws and standards applicable to products; and also
4. the use of the substance or article has on the whole no adverse effects on the environment or human health.

WHAT ELSE IS THERE

# DETAILED TABLE OF WATER QUALITIES

| Para-meters[1] | WWTP Effluent[4] (2012-2018) | EU Class A Agriculture | Drinking Water decree | Irrigation water[3] | Ultra-Pure 0.0054-<0.005 | Unit |
|---|---|---|---|---|---|---|
| Undissolved matter | 7 [5] | 10 | - | - | - | NTU |
| $BZV_5$ | 4,6 | 10 | - | - | - | mg/l |
| E. Coli | 2,7•10[5] [6] | 10 | 0 | - | - | cfu/100ml |
| Legionella spp | <100 [2] | 1000 | 100 | - | - | cfu/l |
| Anthropogenic substances | - | - | 1 [7] | - | - | µg/l |
| Conductivity | 100 [8] | - | 125 | 30 | 0,0054 | mS/m |
| $NH_4$ | 3,9 | - | 0,2 | 0,4 | - | mg/l |
| $NO_2$ | 0,35 | - | 0,1 | - | - | mg/l |
| $NO_3$ | 2,8 | - | 50 | 217 | - | mg/l |
| $PO_4$ | 0,8 | - | - | 27 | - | mg/l |
| Iron (Fe) | 290,6 | - | 200 | 250 | - | µg/l |
| Copper (Cu) | 0,006 | - | 2,0 | 0,2 | - | mg/l |
| Chrome (Cr) | 0,03 | - | 50 | 1000 | - | µg/l |
| Zinc (Zn) | 0,05 | - | 3,0 | 0,196 | - | mg/l |
| Lead (Pb) | 0,85 | - | 10 | 50 | - | µg/l |
| Manganese (Mn) | 90,3 | - | 50 | 250 | - | µg/l |
| Cadmium (Cd) | 0,03 | - | 5,0 | 10 | - | µg/l |
| Nickel (Ni) | 3,9 | - | 20 | 200 | - | µg/l |
| Mercury (Hg) | 0,006 | - | 1,0 | - | - | µg/l |
| Arsenic (As) | 1,2 | - | 10 | 50 | - | µg/l |
| Sodium (Na) | 129,6 | - | 150 | 2,3 | - | mg/l |
| Chloride (Cl) | 148,1 | - | 150 | 17,7 | - | mg/l |

***1.*** Available parameters of effluent, but not a complete list with regard to the set standards. The drinking water decree, for example, has a much longer list of parameters. ***2.*** Legionella Aa & Maas sample <100 cfu/l in effluent for all wastewater treatment plants. ***3.*** KWR, knowledge document on the reuse of residual water for agricultural water supply. ***4.*** Watson database average 2012-2018. ***5.*** CBS 2016 ***6.*** Stowa (2018) the role of wastewater. ***7.*** The Watson database shows that, of the 700 substances measured since 2010, the 90 percentile of 21 substances exceeds the standard. ***8.*** Conductivity of the Harnaschpolder wwtp from 2011-2013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