

New pretreatment Andijk

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INTRODUCTION AND PROBLEM DESCRIPTION

1.1 Introduction PWN

PWN is the water supply company North-Holland, with a head office in Velsersbroek.

With 1.500.000 customers with 700.000 connections PWN supplies 110 billion liter of drinking water to private- and commercial users in the province of North Holland.

Surface water is used to make the drinking water. The surface water from the lake IJsselmeer is treated in Heemskerk, Andijk and the dunes.



Figure 1.1: Location Andijk

1.2 Situation Andijk

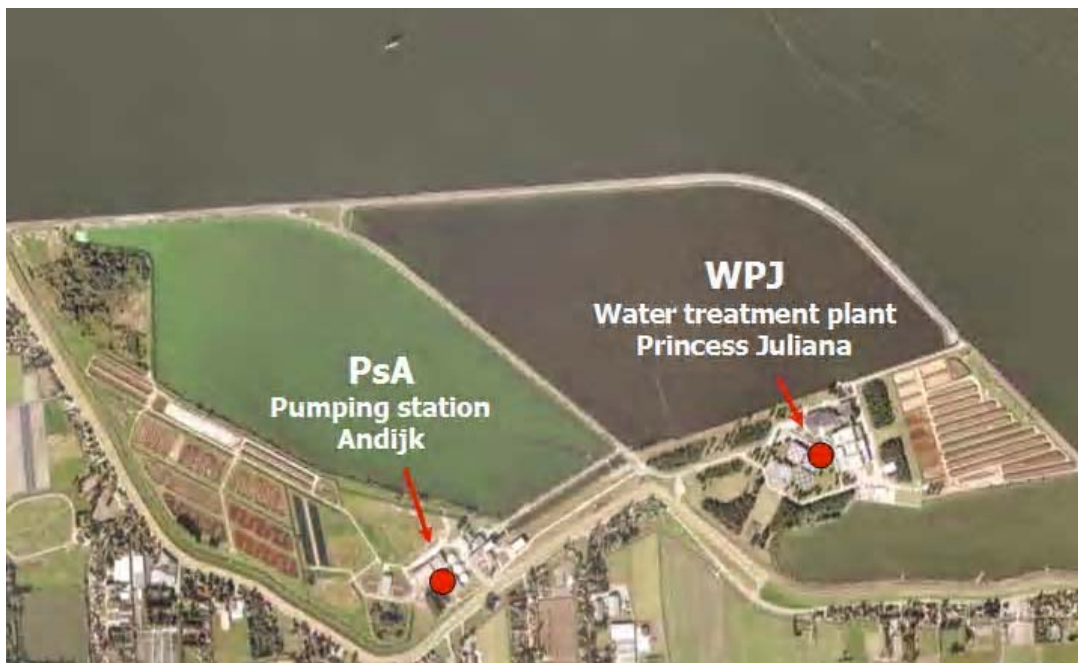


Figure 1.2: Location PsA

In Andijk there are two treatment plants: Pumping station Andijk PsA and water treatment plant Princess Juliana (WPJ) In Andijk the pretreatment is outdated.

The pretreatment dates from 1960 and consists of:
microscreens → coagulation → sludge blanket settling → RSF.

In 2004 the post treatment is updated to a UV-H₂O₂ treatment. Right now PsA Andijk is the only treatment plant in the world with a UV treatment at this scale.

1.3 Problem description and objective project

The pre-treatment of Pumping station Andijk consists of coagulation, sludge blanket settling and

rapid sand filtration. The pre-treatment is out-dated and must be replaced. It was already built in the sixties and designed for the standards of the sixties. Nowadays the water quality should be on a higher level.

Since October 2004 a UV/H₂O₂ post-treatment is in use. The UV/H₂O₂ post-treatment in Andijk was the first full scale installation in the world. The UV/H₂O₂ installation removes organic micro pollutants in the water, but since there is a lot of DOC and nitrate present in the water the UVT is low which results in a high energy use.

The UV/H₂O₂ installation consists of 3 streets with each a capacity of 2000 m³/h so the total capacity is 6000 m³/h. But the sludge blanket settling can only run on a capacity of 2500 m³/h, else the sludge blanket will get instable which results in a poor effluent quality.

So the objective is:

Develop a practical alternative for the new pre-treatment of Pumping station Andijk, taking into account: the optimum in costs and efficiency of pre and post treatment.

1.4 Design Capacity

The UV/H₂O₂ installation consists of 3 streets with a total capacity of 6000 m³/h

The average demand is 2250 m³/h with a peak factor of 1.8 this results in a maximum demand of 4000 m³/h.

PWN choose to design the UV streets based on the future demand.

Always 1 street is not running, so it means in case of failure or maintenance PWN can switch to this street. This will ensure the high quality drinking water at any time.

The design of the pretreatment has to be based on the design of the UV/H₂O₂ installation, taking into account that the flow is fluctuating in time.

So the design should be capable of treating 6000 m³/h but also should be able to treat the minimum flow.

During small maintenance Andijk should be able to supply enough drinking water. So an operator should be able to repair a part of the treatment without switching of the total plant.

1.5 Introduction UV/H₂O₂

Since the pretreatment should be based on the post treatment it important to know something more about the UV/H₂O₂ installation and why a high DOC and nitrate concentration result in a low UVT.

The UV H₂O₂ process aims to remove the organic micro pollutants from the water. H₂O₂ is dosed in front of the UV reactor. Inside the reactor the hydroxyl radicals are formed from the H₂O₂. The hydroxyl radicals react with the DNA of organic micro pollutants. The micro pollutants will be made inactive.

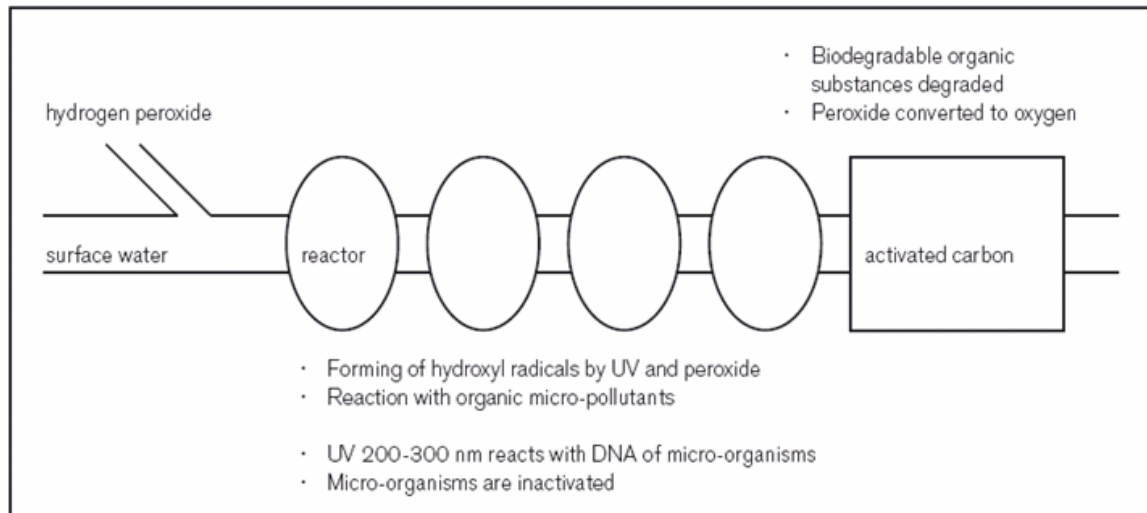


Figure 1.3: Process scheme UV/H₂O₂ installation [PWN Brochure UV/H₂O₂]

In the UV reactor the UV adsorption and the transmission are of key importance. If the adsorption is high the transmission will be low. This means it is possible not all the micro pollutants are made inactive. To ensure all the micro pollutants are made inactive more UV has to be dosed, but dosing more UV will result in a higher energy usage.

1.6 Influence DOC and Nitrate on UVT

The UV adsorption of the nitrate is high in the range of 200 to 230 nm. This will affect the photolysis from H₂O₂ to OH* radicals in a negative way. So less OH* radicals will be formed. Nitrate (NO₃⁻) will be converted into Nitrite (NO₂⁻). Nitrite will react with the OH* radicals. So less OH* radicals are available for the treatment.

The UV adsorption of the DOC is high in the range of 255 to 265 nm. This will affect the photolysis from H₂O₂ to OH* radicals in a negative way. So less OH* radicals will be formed. DOC will react with the OH* radicals. So less OH* radicals are available for the treatment.

To save energy in the UV reactor, nitrate and DOC have to be removed in the pretreatment.

DOC has a bigger influence on the UVT than nitrate.

When designing a pretreatment it will be important to remove as much DOC and nitrate as possible, but it may not cost too much energy else the savings on energy in the UV reactor are spent on the pretreatment.

2 Design of the new process scheme

2.1 Design criteria

For the new pretreatment different alternatives can be developed. The selection of the best alternative is made for different design criteria. Based on the information provided by PWN the alternatives are evaluated on the following aspects.

2.1.1 Main criteria

Obviously the first criterion is to meet the same removal efficiency in the new pretreatment as in the existing one. The description of the present influent quality and the present effluent quality of the pre treatment step is shown in paragraph 2.1.4. With this data there is a kind of black box model: the input is known and the output is known. Only the process, the black box, has to be designed. Besides this basic requirement, below the other *enhanced* criteria are formulated.

Process/treatment criteria

DOC removal

As described in paragraph 1.6 the amount Dissolved Organic Carbon (DOC) has a large influence on the UV transmittance (UVT). When fewer DOC is present in the water, the energy costs of UV/H2O2 post treatment step are lower and the efficiency is higher.

Nitrate removal

It is the same situation for Nitrate. A higher concentration of Nitrate has a negative effect on the UV post treatment step. Therefore this is an important parameter. But the influence of Nitrate on the UVT is lower compared to DOC. Therefore this criterion has a lower importance than the first one.

Use of chemicals

Pure, water and nature: these are the key-words for PWN. Therefore minimal use of chemicals is preferable. This is from a ecological / environmental point of view and of course because of the operational costs of chemicals.

Robustness (multi barrier approach)

Safety and robustness are parameters about which no negotiation is possible. The reliability of drinking water in the Netherlands is really important. Therefore a multi barrier for the removal of pathogenic micro organisms and a robust system is necessary. Recent incidents demonstrate that even in 2007 drinking water treatments systems are not impeccable (figure 2.1)

Infrastructure (of the pipes)

For the maintenance of the pipes and the operation of the system a clear pipe-layout is important.

Financial and immaterial criteria

Investment costs and Operational costs

There is of course a balance between high investments costs and high operational costs. A high investment in a sustainable technique is defensible when it is proved that it will save operational costs.

Surface



Figure 2.1: News about E.coli in drinking water (www.nu.nl 15/07/2007)

The more surface as alternative needs, the more investment is costs. This criterion is not of that importance, because at the location Andijk a lot free space is available.

Innovative

In the corporate brochure of PWN the following is stated:

PWN is devoted to ongoing innovation, in the purification techniques we employ and in the way we study, analyze and manage the nature reserves. Innovation is one of the best instruments for continuing to achieve excellent results. (pg. 7 – Corporate Brochure PWN)

And further:

PWN is at the forefront of developing innovative treatment techniques. Time and again, we show that innovation is our greatest strength. (pg. 7 – Corporate Brochure PWN)

Hence, innovation is an important aspect to take into consideration. When PWN wants to stay a frontrunner in drinking water treatment, new promising techniques are preferable.

2.1.2 Desired characteristics

Besides above mentioned criteria, there are some desired characteristics for the new pretreatment. These are aspects in the category '*it would be nice, but are not necessary*'.

- Lower temperature
The temperature in the Lake IJssel is relatively high. The drinking water has to be delivered below 25 °C. But in summer times it is sometimes hard to stay below this temperature. Thus a temperature reduction would be preferred.
- Chlorine
The Dutch Water law prescribes a maximum of 150 mg/l Chlorine. The incoming water for Lake IJssel comes partly from the Rhine, where concentration of 200 mg/l is allowed. This can cause difficulties in the future. Therefore it would be nice when in the new pretreatment the chlorine concentration is lowered.
- Less Sodium Hydroxide
In the reservoir Sodium Hydroxide is dosed for softening reasons. Minimal use of chemicals is always preferable. Hence, when it is possible to skip this chemical-addition it would be nice.
- Less sludge
Obviously the treatment produces sludge. The treatment of the sludge engenders costs and waste. The less sludge is produced, the better it is.

2.1.3 TOC/NOM/DOC

Definition

The removal of Dissolved Organic Carbon (DOC) is one of the main design criteria. Therefore it is important to have a clear view on the definition of DOC and with it the Total Organic Carbon (TOC) and Natural Organic Matter (NOM).

DOC is the concentration what should be lowered, but it is difficult to measure. Therefore no online data from the process is available. TOC is easier to measure and therefore online data is available.

The difference between TOC and DOC is a filter of 45 µm. Thus the difference between those two consists of substances larger than 45 µm.

Natural organic matter (NOM) contain also other parameters like color and turbidity and is therefore from slightly other category than TOC and DOC.

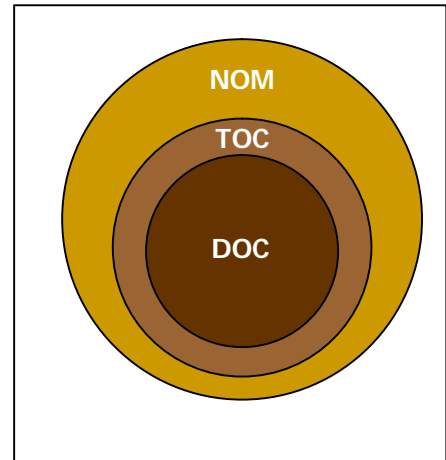


Figure 2.2: Difference NOM, TOC and DOC

Concentration TOC and DOC in the water at Andijk

In figure 2.3 the measured concentration DOC and TOC of the lake influent, provided by PWN, are shown. It is remarkable that it seems that the DOC concentration is even higher than the TOC concentration. By definition this is not possible. Most likely some measurement faults are made. But from these graphs the conclusion can be drawn that the TOC consist almost completely of DOC; large particles are not that much present.

Thus, although DOC is not measured directly, the TOC values are a good indication for the DOC.¹

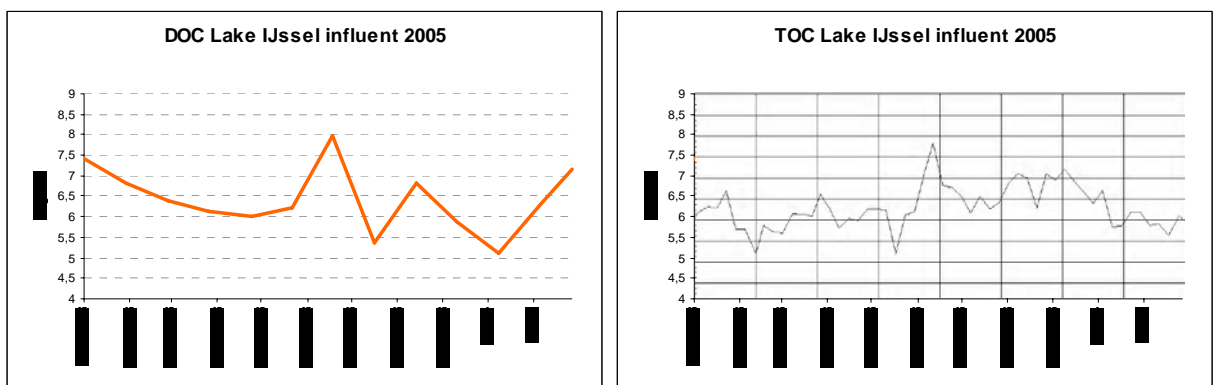


Figure 2.3: DOC and TOC concentration Lake IJssel influent

¹ a.o: Bourke, M; Use of a continuous ion exchange process (MIEX) to remove TOC, pg 1.

2.1.4 Present Water Quality

To design a new pre-treatment it is essential to know what the removal efficiency should be for different characteristics. Obviously the new pretreatment should meet the quality standards prescribed by the Dutch Water-law.

The problem is approached with a kind of 'black box' approach. What is the present influent quality from the Lake IJssel as input for the pre-treatment step, and what is the present effluent quality of the pretreatment? The new pretreatment should at least reach this quality, and preferably a higher quality as described in paragraph 2.1.1 and 2.1.2.

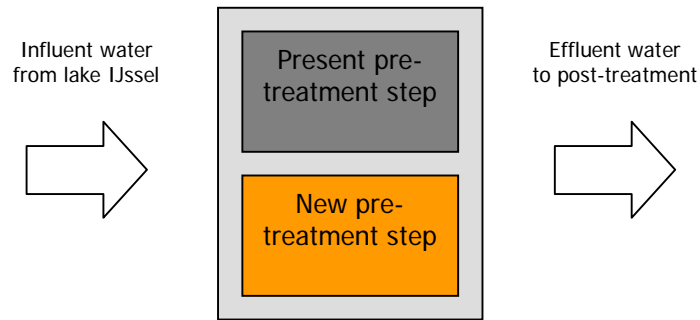


Figure 2.4 the 'black-box' approach

In table 2... for some known parameters for the whole treatment plant are shown. These are not yet the desired parameters for the pretreatment step.

During the project it seems to be difficult to receive all data of several parameters of the pre-treatment step. Because the main design criteria are the removal of DOC and Nitrate, this is the data in which the desired quality is described.

	Influent (2006) (mg/l)	Effluent (mg/l)
Oxygen	6.5 - 14	unknown
Acidity (pH)	7.3 - 8.6	8
Chloride	95 - 126	145
Calcium	27 - 48	41
Magnesium	10 - 12.5	12
Ammonium	0.03 - 0.24	<0.02

Table 2.1 Removal efficiency whole treatment
Ps Andijk [PWN-website, 2007]

The average DOC concentration in the Lake IJssel is about 6,5 mg/l. This is shown in graph 2. ... The data over the year 2005 does not differ much from other years, and can therefore be seen as a reliable indicator. The Nitrate concentration of the lake IJssel is unknown.

On the next page also two graphs are depicted with the Nitrate and TOC concentrations of the effluent of the pre-treatment step. The average Nitrate concentration after pre-treatment over 2006 is about 4 mg/l. The average TOC concentration, which consists of 95% of DOC, is about 3,5 mg/l.

Thus the present removal efficiency of DOC in the pre-treatment is about 46 %.

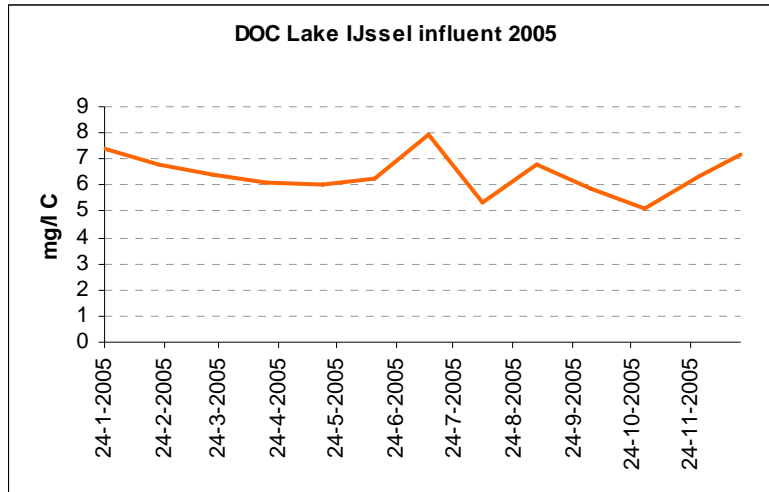


Figure 2.5 DOC concentration influent pre-treatment step [PWN, 2005]

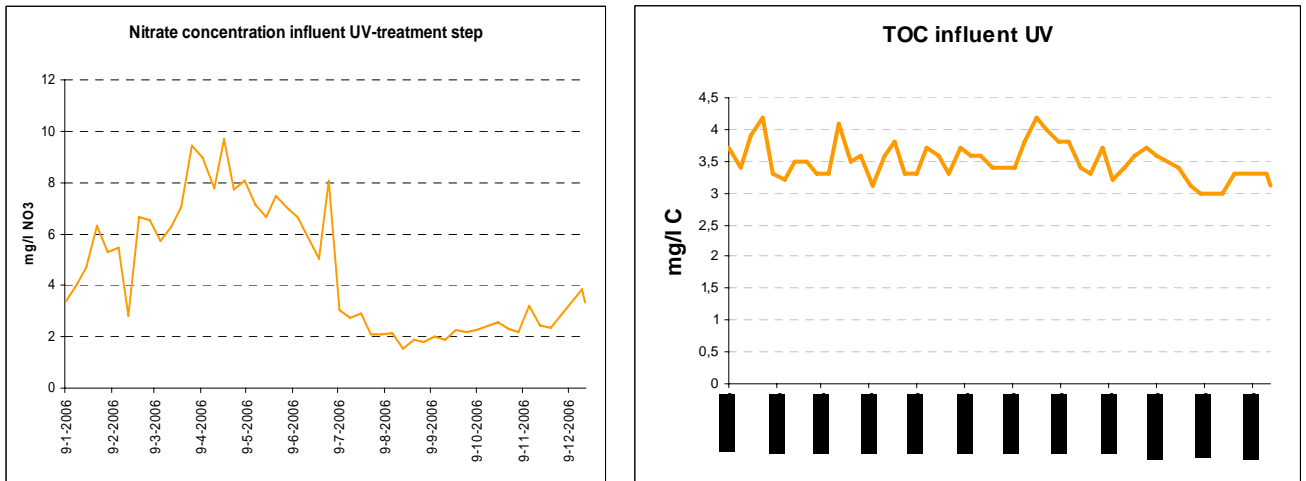


Figure 2.6 Nitrate and TOC concentration of the effluent of the pre-treatment step [PWN, 2006]

2.2 Alternatives

Based on the different criteria several alternatives are developed. In this section all these alternatives are presented, with the benefits and drawbacks of each alternative on the earlier mentioned design criteria. In the paragraph 2.3 the best alternative is selected.

2.2.1 0+ alternative: improve existing treatment

The present treatment plant does not meet the capacity requirements. But with some improvements of the existing process, it can be expanded to meet the actual criteria:

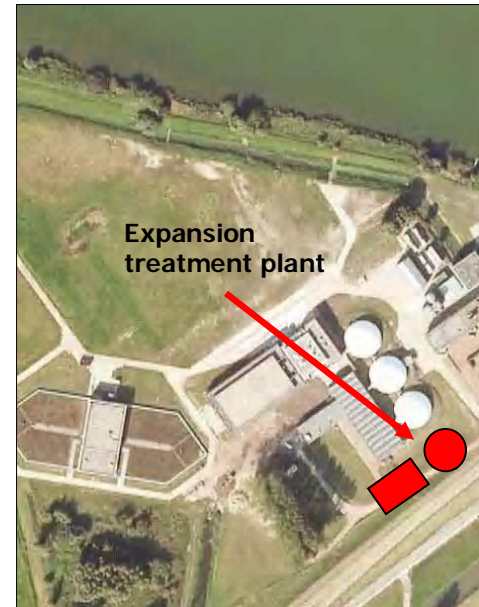
Add extra capacity flocculent/sedimentation
 Add extra capacity rapid sand filter
 Extra capacity should be minimal 1500 m³/h

Possibility to add PAC (extra removal DOC)²

New process scheme

reservoir – micro sieves – floc/sed – (PAC) - RSF

critereon	value	comments
DOC removal	+/-	<i>improvement because of PAC</i>
Nitrate removal	0	
Costs	++	<i>low investment costs</i>
Innovative	--	
Surface	+	
Robustness	-	
Use of chemicals	+/-	
Infrastructure	-	



2.2.2 Alternative A: same process, new installation

Because of the worse condition of the present installation, in this alternative a complete new installation is build, meeting today's high standards and applying new knowledge in the known treatment steps of Rapid Sand Filtration and flocculation/sedimentation.

Complete new installation min 4000 m³/h , RSF
 improved technologies:
 enhanced coagulation
 tilted plate settling
 Possibility to add PAC ¹

New process scheme

reservoir – micro sieves – floc/sed – PAC - RSF



² For all alternatives it is possible to add Powdered Activated Carbon (PAC) in the process. This optimization step will not be discussed into detail in this report. It is recommended to find out if the addition of PAC in the final selected alternative can optimize the performance of the system.

critierion	value	comments
DOC removal	+	<i>improvement because of PAC</i>
Nitrate removal	0	
Costs	+/-	
Innovative	+/-	
Surface	-	
Robustness	++	
Use of chemicals	+/-	
Infrastructure	+	

2.2.3 Alternative B Break-point Chlorination

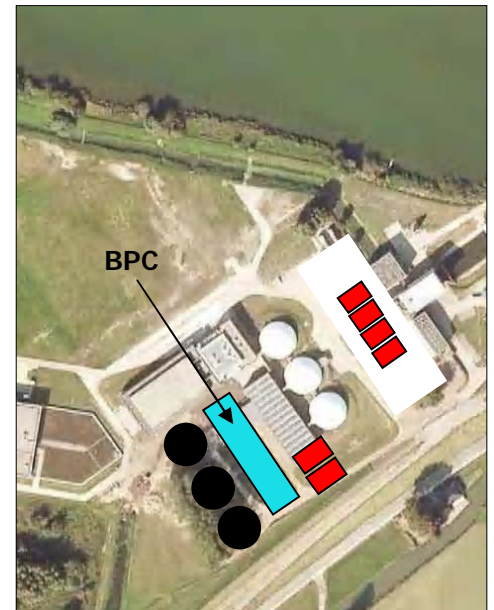
This alternative is only a theoretical alternative. With the application of Break-point Chlorination there is a high removal efficiency of Nitrate. Also an extra Activated Carbon filter is applied, to remove partly the Chlorine from the water. This extra ACF also removes some more DOC. For the removal of the particles still the RSF has to be applied.

Obviously this is not innovative at all. More strongly, this is a step back in time. Because thirty years ago this was the common treatment but nowadays the application of Chlorine is not preferred at al. Thus, this is not a realistic alternative.

New process scheme

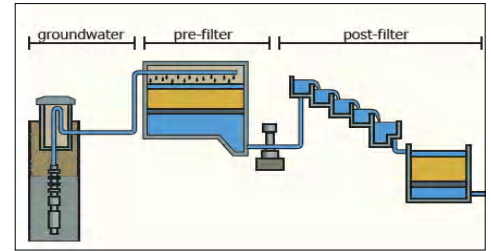
reservoir – micro sieves – floc/sed – RSF – Chlorination – Activated Carbon filter

critierion	value	comments
DOC removal	+	<i>by RSF and ACF</i>
Nitrate removal	++	<i>by BPC</i>
Costs	-	
Innovative	- -	
Surface	+	
Robustness	+	
Use of chemicals	- -	<i>use of Chlorine is not Dutch favorite</i>
Infrastructure	+/-	<i>more complex pipe-system</i>



2.2.4 Alternative C Bank filtration

The same water quality can be reached with Bank filtration. On the bank of the reservoir or on the Lake IJssel bank, bank filtration pumps can be installed. Because the water is subtracted through the ground layers the water gets more groundwater characteristics.



The DOC removal will be quite good, and there is a temperature advantage. Because of the bank filtration treatment detention in the ground, the water temperature will be lower. Still a RSF has to be applied. **Figure 2.7 Bank filtration treatment scheme [vanDijk, 2005]**

New process scheme

Bank extraction - aeration – dry filtration – cascade - RSF

critereon	value	comments
DOC removal	++	
Nitrate removal	0	
Costs	-	
Innovative	+/-	
Surface	+/-	
Robustness	+	
Use of chemicals	+	
Infrastructure	+	



2.2.5 Sub alternative D ION exchange

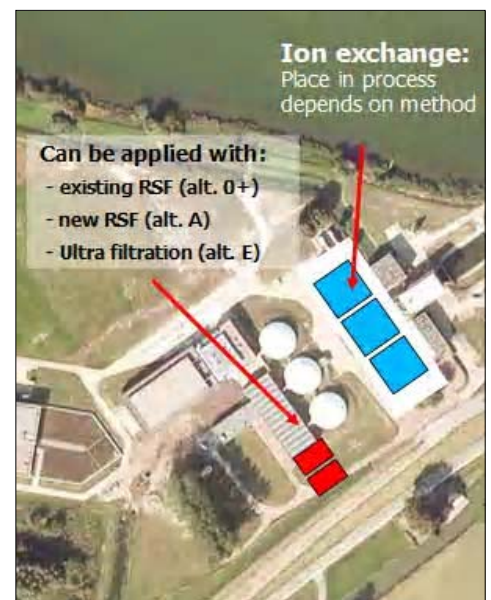
In the development of different alternatives one of the strategies was to focus on just one criterion: removal of DOC. ION exchange is innovative treatment process which can be optimized for the removal of DOC. High removal efficiency are feasible. Several suppliers worldwide provide in different methods of ION exchange; a.o. the fluidized bed method and Magnetic ion-exchange (MIEX).

Ion-exchange is only a sub-alternative because still the particles have to be removed. This can be done by a RSF or a ultra filtration step. The place in the process scheme depends on the chosen ion-exchange method. Ion exchange can also be applied for nitrate.

New process scheme

reservoir – micro sieves – IEX – floc/sed - RSF

critereon	value	comments
DOC removal	++	
Nitrate removal	0	<i>Optional: other resin applied</i>
Costs	-	
Innovative	++	
Surface	+	
Robustness	+	
Use of chemicals	-	
Infrastructure	+	



2.2.6 Sub Alternative E Ultrafiltration

Particle removal is an important function of the pretreatment. Another way to do this is the application of a ultra filtration step.

Looking to the rest of the treatment process a micro filtration step could be enough, because the UV/H2O2 and the ACF removes a lot.

But since the investment and operation costs for micro and ultra filtration are more or less the same, a ultra filter is preferred. A better removal of particles and other substances results in a higher UV transmittance with lower energy costs.

Ultra filtration alone is not enough. Then the membrane would clog too fast and the operational costs would be too high. Therefore it should be combined with some treatment step for DOC removal, like ion-exchange. For higher removal efficiency coagulation can precede the ultra filtration.

New process scheme

reservoir – micro sieves – IEX – coagulation - ultra filtration

critereon	value	comments
DOC removal	++	
Nitrate removal	0	
Costs	-	
Innovative	++	
Surface	+	
Robustness	+/-	
Use of chemicals	+	
Infrastructure	+	

2.2.7 Other techniques

Besides above mentioned alternatives there are some other techniques which can be used for the enhanced removal of DOC and Nitrate. These options are not discussed as realistic alternatives for different reasons.

- MEMSTILL (enhanced distillation)
This technique of membrane distillation developed by a Dutch consortium of 8 companies is a promising technique. But it is mainly developed as a desalination technology. Therefore it is too expensive to apply only as pretreatment; hence this alternative is not taken into consideration.
- MBR (membrane bio reactors)
Membrane technique based on the conventional wastewater process, but the separation of micro organisms is performed by filtration with membranes. Best to apply in wastewater circumstances. Also to 'heavy' for application only as pre treatment.
- Use of vegetable oil to remove nitrate from flowing groundwater³
Just a remarkable publication focusing on the removal of nitrate. Not ready to apply on full scale.
- Wastewater treatment technique : aerobe and anaerobe zones with active sludge
Treatment in wastewater technology for nitrate-removal. Not applicable for drinking water: addition of active sludge is not an option.
- Reverse Osmosis
RO removes almost everything from the water. Too sophisticated and expensive technique as a pretreatment step.

2.3 Choice final process scheme

³ Publication: Use of vegetable oil to remove nitrate from flowing groundwater, Hunter W. J. ; Follet R. F. ; Cary J. W. ;

In table 2.2 an overview is given to compare the different alternatives.

Table 2.2: Comparison alternatives

Criterion	0 ⁺	A	B	C	D	E
DOC removal	+/-	+	+	+	++	++
Nitrate removal	0	0	++	0	0	0
Costs	++	+/-	-	-	--	--
Innovative	--	+/-	--	+/-	++	++
Surface	+	-	+	+/-	+	+
Robustness	-	++	+	+	+	+/-
Use of chemicals	+/-	+/-	--	+	-	+
Infrastructure	-	+	+/-	+	+	+

- 0⁺ = improve existing treatment
- A = same process, new installation
- B = break-point Chlorination
- C = bank filtration
- D = ion-Exchange
- E = ultra filtration

Based on these values, alternatives A, C, D and E are the four lasting serious possibilities. Alternative A is the cheapest alternative, D and E the more expensive ones. On the other hand are D and E the most innovative ones.

Further research made it clear that it is insecure if the application with bank filtration is possible in Andijk. The composition of the ground and the ground layers is unknown. A good ground layer composition is essential for this alternative. Because of this uncertainty and the fact that this alternative is not that innovative, alternative C is excluded. All the more because a high DOC removal efficiency with bank filtration is not always certain.

Based on the vision and mission of PWN to be a front runner in the drinking water treatment plus the fact that ion-exchange and ultra filtration will have really high removal efficiencies on the DOC-concentration alternative D and E are chosen for the new pretreatment.

When the DOC is well removed, the UV transmittance will be higher and the energy costs will decrease. The performance of the new pretreatment with its removal efficiencies is described in paragraph 3.6.

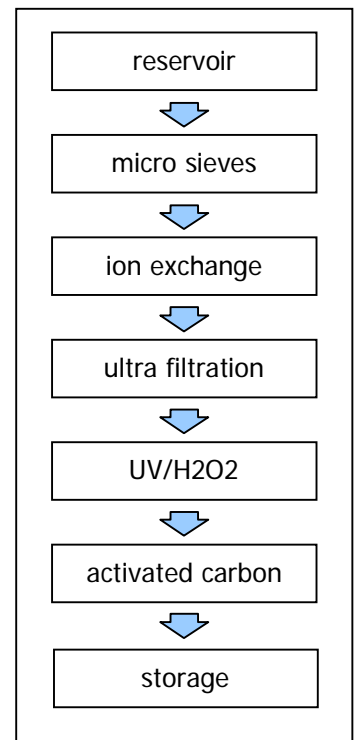


Figure 2.8 New treatment scheme Ps Andijk

2.3.1 Choice ion-exchange system

There are different methods for ion-exchange. The fluidized bed method and magnetic ion-exchange are the two most commonly applied systems.

The fluidized bed method is comparable to a normal rapid sand filter. Instead of a sand layer the water flows through an bed of resin, where the ion-exchange takes place. After some time the bed has to be regenerated. In this regeneration time the ion-exchange can not be used.

The magnetic ion exchange system (MIEX) is a continuous ion exchange process that has been developed in Australia that overcomes many of the problems associated with conventional ion exchange systems and makes this technology economically feasible for large water treatment plants.

The main advantages of the MIEX DOC Process over other ion exchange processes for the removal of DOC in drinking water treatment are:

- No pre-treatment is required which enables the MIEX DOC Process to be used at any stage of the treatment chain,
- Simple process design that offers a flexible operation at a lower capital, operating and maintenance costs,
- Process design that enables a simple and effective retrofit to existing conventional water treatment plants,
- More effective DOC removal based on the full utilization of the unique properties of the MIEX DOC Resin
- Stable and consistent DOC removal rate that can be adjusted on-line to manage raw water quality fluctuations.

[source: Bourke, M; Use of a continuous ion exchange process (MIEX) to remove TOC]

Further there are some other advantages:

- Because of the specific design of MIEX the head loss is lower compared to conventional ion exchange methods. The MIEX resins are smaller than the ones used in fluidized bed system. Obviously in the fluidized bed system smaller resins can not be applied, because of the backwash and carry over.
- The small resins have an advantage that the contact surface is larger compared to bigger ones, although the magnetic core of the MIEX resin reduces also a bit of the effective contact surface.
- The continuous process causes a low use of the resin. 90 - 95 % can be regenerated, through which the waste is minimized.

The good performance on DOC removal, the minimal use of the resins and the characteristic that MIEX does not need any pre-treatment are the three main reasons why MIEX is selected to apply in the new pre-treatment of Andijk.

2.3.2 Choice ultra filtration system

There are different techniques available for ultra filtration. High and low pressure techniques, immersed methods, outside-in and inside-out, etcetera.

A low pressure immersed ultra filtration has several advantages. The supplier Zenon gives the following benefits of these systems⁴:

- Reduced lifecycle costs and extended membrane life;
- Simplified design and operation;
- Smaller footprints with reduced land acquisition costs;
- Outside-in flow path provides a more robust system;
- Consistent performance through virtually any change in raw water quality.
- Highest solids tolerance of any hollow fiber membrane
- Works through virtually any raw water quality change or upset
- Does not require preclarification

Men should bear in mind that this not the most objective list of advantages, because of its source.

Based on the objective of this project, to build a cost and energy effective pre-treatment there are two main reasons why this low immersed technique is selected above a high pressure UF installation, which is applied in Heemskerk at PWN.

- Energy costs – a low pressure system has a lower energy use. A high energy system should not be a logical choice, because energy saving is one of the main goals to reach at the UV installation.
- This immersed system fits in the existing rapid sand filters. The plant has to be a little bit adapted to the new system and then the membrane can be installed in the present building. This saves a lot of investments and time. Plus that it is a beautiful combination of value-management and innovation.

Therefore the low pressure immersed ultra filtration is selected for the design of the new pre treatment.



Figure 2.9 High-pressure UF



Figure 2.9 Low-pressure immersed UF

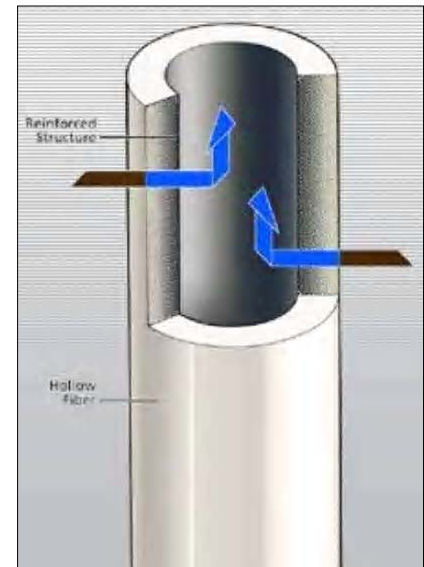


Figure 2.10 outside – in flow

⁴ Zenon website, June 2007:

http://www.zenon.com/products/MembraneTechnology/ZeeWeed500/features_and_benefits.shtml

3 Technical design of new pretreatment

3.1 Capacity and 3 independent streets

As mentioned earlier the pretreatment design will be based on the 3 UV reactor streets with a total capacity of 6000 m³/h. Operating a treatment plant should be made as easy as possible. This starts with making a simple and good layout for the total plant. This can be accomplished by making 3 treatment streets of 2000 m³/h for the pretreatment, each of them will connect with one of the UV reactors.

With 3 streets of each 2000 m³/h, it can cope with the future demand. At this moment only 4000 m³/h is required this means that always one street is out of order. This makes it possible to repair the street without having problems with the drinking water demand.

3.2 MIEX

3.2.1 Description and design MIEX

Magnetic ion exchange is a relatively new process with enables a high removal of DOC. The MIEX resin is designed specifically to be used in a continuous ion exchange process with mixed reactors at very low resin concentrations and short detention times. The magnetic properties of the resin results in quick forming of agglomerates that will settle in the separator tank.

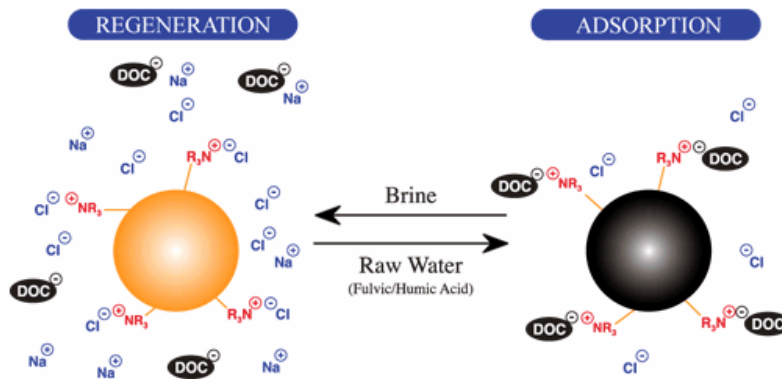


Figure 3.1: DOC removal with miex resin [www.miexresin.com]

The process is based on exchanging Cl^- ions for DOC. The resin loaded with chloride will react inside a contactor with the water. The DOC is exchanged for the chloride ions. In the separator tank the loaded resin will settle and flow to the regeneration tank or directly back to the contactor.

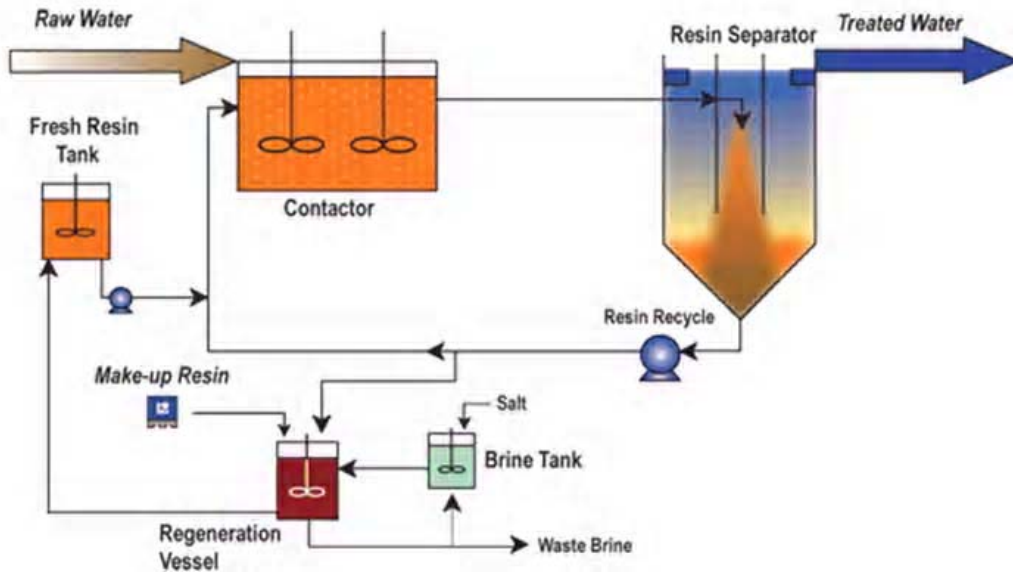


Figure 3.2: MIEX system [www.miexresin.com]

3.3 The design

The design consists of three streets with a capacity of 2000 m³/h each. One street actually consists of 2 contactors and 2 settlers. The vessels are circular vessels. The diameter of the resin contactor vessel is based on a retention time of 15 min.

6 resin contactor vessels
 Tank = 167 m³
 Height = 6 m
 Diameter = 6 m

The loading rate resin settlers 244 l/(min * m²)
 6 resin settlers
 Each tank = 68.3 m²
 Diameter = 9.3 m

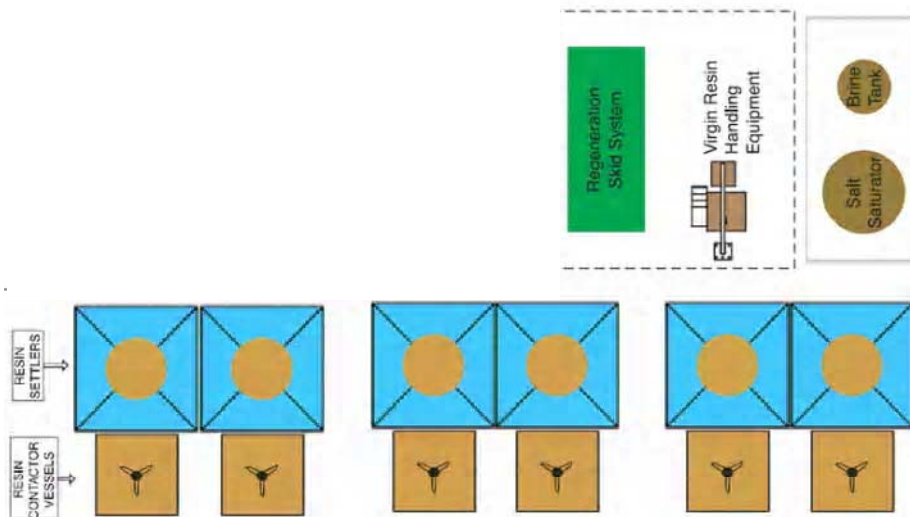


Figure 3.3: layout MIEX treatment

3.3.1 Use of chemicals

The use of chemicals based on the present flow of 4000 m³/h.

Table 3.1 Used chemicals

Resin	Regeneration salt (NaCl)
0.24 m ³ resin / day that is a loss of 0,02% resin	11.5 kg NaCl / day

3.3.2 Optimization MIEX

During mixing the blades of the mixer inside the contactor destroys some of the resin particles.

Since the resin particles are positively charged and the membrane is negatively charged, the resin particles will settle at the membrane surface. The resin particles on the membrane surface are very difficult to remove.

There are a few possible solutions, which have not been tested yet.

- A water jet that “shoots” the water tangentially into the contactor. Because of the high velocity the resin will mix with the water.
- Make an optimum design for the mixing blades.
- By using air jets, to “shoot” the air through the contactor and mix the resin with the water

3.3.3 Costs

For each 1000 m³ treated 48.9 kWh is used. With a yearly demand of 19466666 m³ the MIEX installation uses 961659 kWh each year. This costs **98.000 Euro** with a unit price of 0,1023 Euro/kWh

With a resin concentration of 14ml/l, the costs for the MIEX makeup and the regenerant makeup are **570.000 Euro**

[source: McGuire environmental consultants]

The investment costs of the MIEX installation are **5.4000.000 Euro**. This is an estimation based on comparable reference projects.

[source: Selective DBP precursor removal with an innovative ion exchange process]

3.4 Immersed Ultra filtration

3.4.1 Description immersed Ultrafiltration

Each module contains thousands of horizontally strung membrane fibers that have millions of microscopic pores in each strand. Water is filtered by applying a slight vacuum to the end of each fiber which draws the water through the tiny pores and into the fibers themselves. The pores form a physical barrier that allows clean water to pass through while blocking unwanted material such as suspended solids, bacteria, pathogens and certain viruses.

Modules are joined together to form a cassette, which is the smallest operable unit of the filtration system. Each cassette can have a variety of module configurations depending on the amount of water that the cassette is required to treat.



Figure 3.4 : One ZeeWeed 500 module [Zenon, 2007]

Multiple cassettes are joined to form what is known as a process train. The train is a production unit containing a number of cassettes immersed in a membrane tank. Multiple process trains form a ZeeWeed treatment plant.

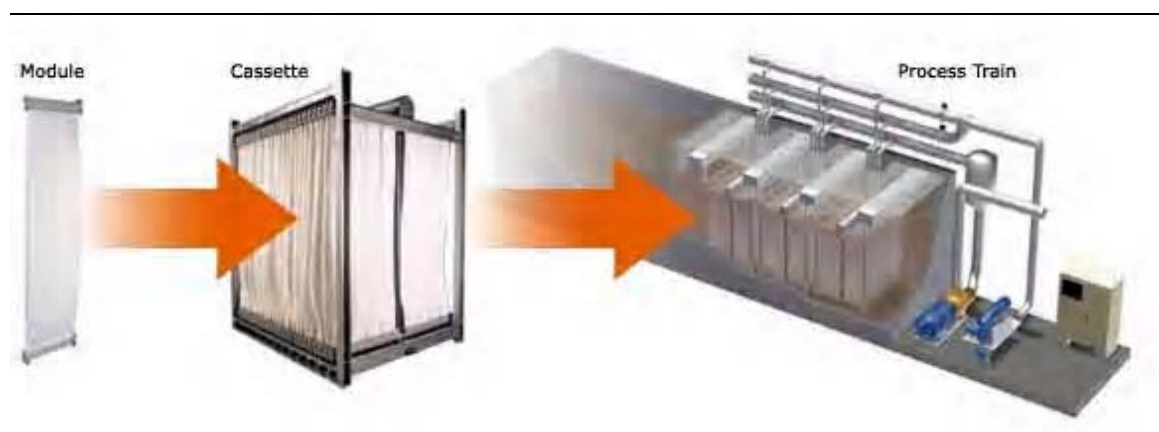


Figure 3.5 : a process train of immersed ultra filtration modules [Zenon, 2007]

Feed water flows into the membrane tanks and treated water is drawn through the membranes during Production by applying a vacuum to the inside of the membrane fibers. The water removed by permeation is replaced with feed water to maintain a constant level in the tank.

The particles that are rejected by the membrane pores remain in the process tank and are periodically removed by a process called a Backwash (BW). During a backwash, filtered water reversed through the membrane fiber to dislodge any particles that may be physically lodged in the membrane fiber. Simultaneously, aeration scours any solids that are attached on the surface of the fibers.

To prevent fouling of the ZeeWeed membranes operators are required to perform regular maintenance cleans (MC). Maintenance cleaning begins by draining the membrane tank and soaking the membranes in a cleaning solution for several minutes. The solution is then drained and chemical residues are flushed from the membranes before the system resumes normal operation.

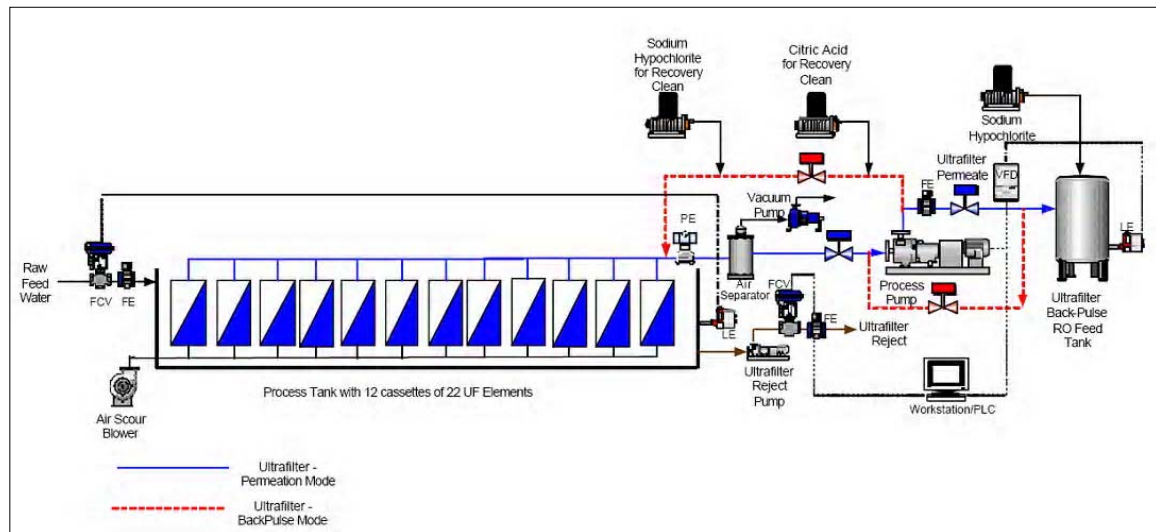


Figure 3.7 : Process scheme of backwash procedure [international water conference 2003]

If one of the modules breaks down, it is easy to remove this module and repair it. So you do not have to close down the whole street during the repair of only one module.

3.4.2 The design

The immersed UF modules with coagulation (to improve the removal efficiency) will be placed into the existing rapid sand filters.

There are 12 rapid sand filters at Andijk, with a surface of 33 m² and a depth of 2,25 m. The size of the cassette is 2,1 * 1,75 * 2,7 (l*b*h) There is space to put 4 cassettes with coagulation in front into a RSF. or the capacity of 2000 m³/h , for each street four filters are needed.

So all 12 RSF will be used for the UF. Four RSF form one street. Each street has a capacity of 2000 m³/h

A detailed overview of the whole construction is given in the structural drawings in paragraph 3.5.



Figure 3.8: one ultra filtration street

3.4.3 Costs

For each 1000 m³ treated 173 kWh is used. With a yearly demand of 19466666 m³ the UF installation uses 3367733 kWh each year. This costs **350.000 Euro** with a unit price of 0,1023 Euro/kWh

For the use of chemicals, the cost of chemicals and other operational data no data was available, for a project comparable to the designed installation above.

3.5 Design drawings

In this section all schemes and drawings of the final new pretreatment are presented. For the hydraulic line and the main process scheme / PID the MIEX and the Ultra filtration are presented in one drawing.

3.5.1 Hydraulic line

3.5.2 Main process scheme / PID

3.5.3 Structural drawings MIEX

3.5.4 Structural drawings Ultra filtration

3.5.5 Layout overview whole treatment plant



3.6 Performance of the new pre-treatment

Plant	DOC removal efficiency
Big Elk Meadows	60-80%
Mt. Pleasant	42%
Vallejo	60%

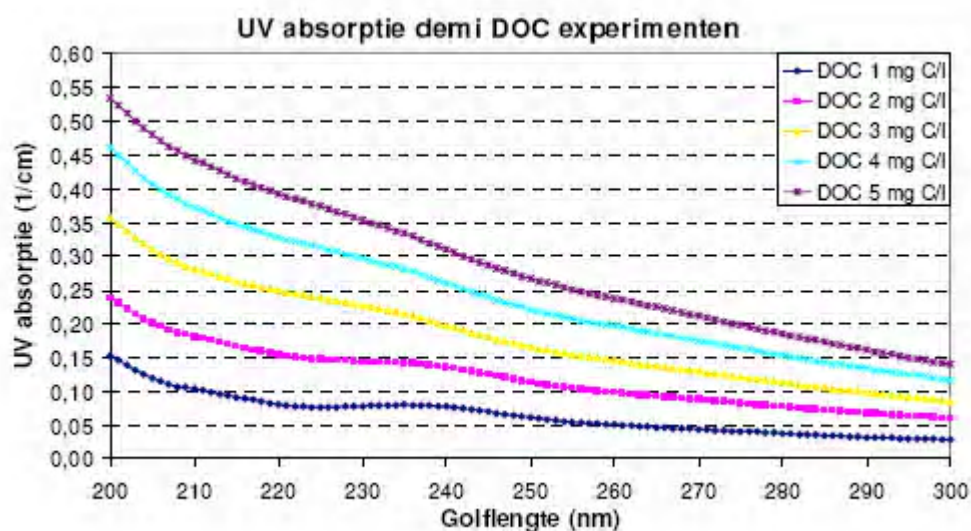
Based on the results from treatment plants which already use Miex it is estimated to reach a DOC removal of 60% in the Miex phase.

The Zeeweed 500 together with the coagulation phase will remove an estimated 73% DOC.

A total of 84% DOC will be removed in the new pretreatment.

The feed water contains on average 6,5 mg/l DOC during the existing pre-treatment 3 mg/l DOC is removed and than a UVT of 88% is reached.

Based on a removal of 84% DOC in the new pretreatment the feed water of the UV-reactor contains 1,1 mg/l DOC.



[1] UV H2O2 thesis David de Ridder

	DOC feed UV-reactor	UVA (1/cm)	UVT= $100 \cdot 10^{-UVA}$ (%)
Existing pre-treatment	3.5	0.18	66
New pre-treatment	1.1	0.07	85
Savings			19

1% 0,05 kWh/m³ water With a yearly demand of 19466666 m³ it saves 18493333 kWh. This saves 1.900.000 each year based on a unit price of 0,1023 Euro/kWh

4 Conclusions and recommendations

4.1 Conclusions

4.2 Recommendations

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