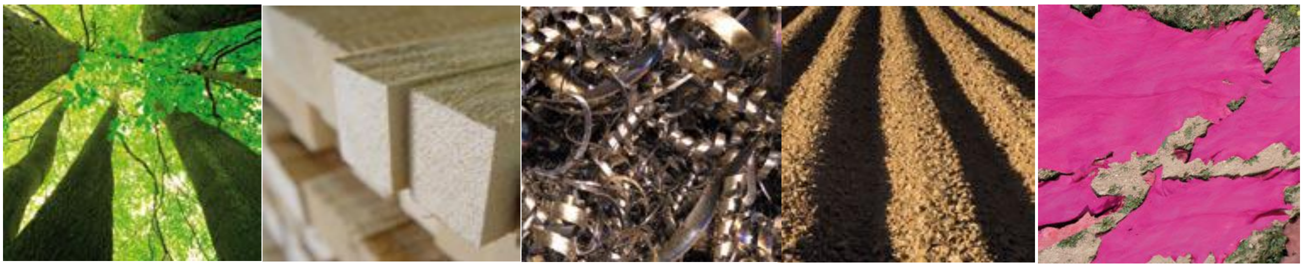

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Final Monitoring report

IWEC water reuse 3.0

Agreement number ECO/11/304469

Reporting Date
27/06/2015

Project coordinator: André Reigersman, RWB Water Services B.V.
Project website: www.iwec-water-reuse.eu

Co-funded by the Eco-innovation Initiative of the European Union

MONITORING REPORT

1. SUMMARY

The commissioning of the water reuse installation at production site Wierden was in February 2015. Aim of the installation is to get (bacteriological) reliable water out of backwash water, with a low energy consumption and chemical use. The first results shows that making of reliable water is possible with the installation (good reduction of micro-biology and metals). The energy consumption of the installation itself is comparable with the amount of energy necessary for the extraction of groundwater, but there is also a same amount of energy necessary to keep the backwash water mixed in the storage tank. Tests will be done to look if mixing will be necessary in the future.

2. INTRODUCTION

Since February 2015 the backwash water at production site Wierden is no longer treated by sedimentation (see figure 1) but treated with (ceramic) membrane filtration (figure 2). The monitored period in this report is from February till the end of June 2015.

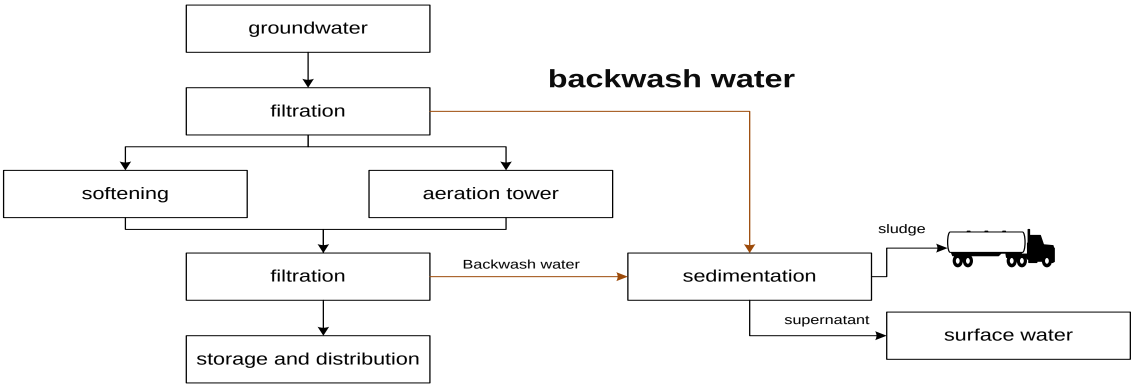


Figure 1; simplified PFD WTP Wierden, situation until February 2015

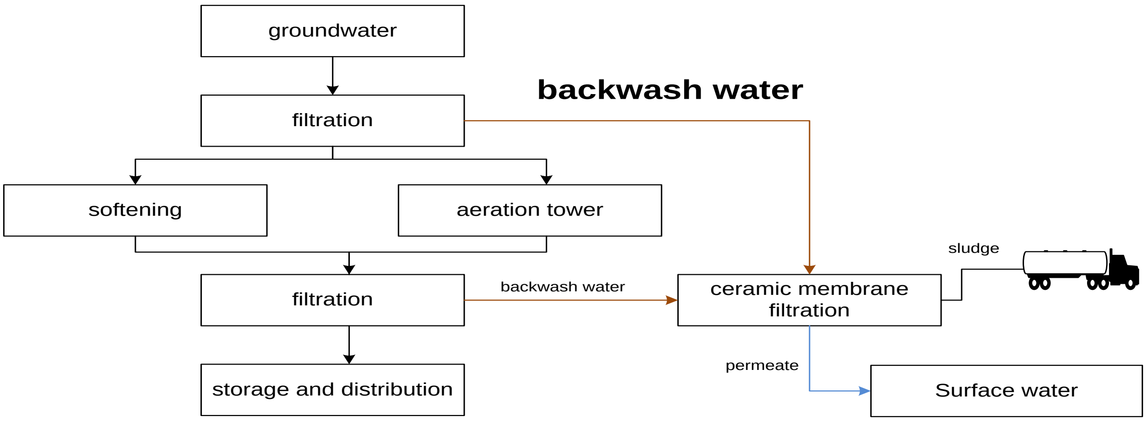


Figure 2; simplified PFD WTP Wierden, situation since February 2015

Until April 2015 the permeate of the ceramic membranes is not re-used, but discharged to the surface water. The main reason that the permeate was not reused is that some (hardware) modifications were not realized to make reuse possible. These modifications were done in May and since then the backwash water is reused. Since the commissioning of the installation about 91,355 m^3 of backwash water is treated with the installation The average recovery of the installation in this period is 99%.

3. MONITORING ENERGY

Although the backwash water is yet discharged to the surface water, the amount of energy needed for the re-use installation is similar to the situation with re-use. The energy consumption of the total installation can be divided in 2 main parts: the mixing in the storage tank to prevent settling of suspend solids and the membrane installation itself.

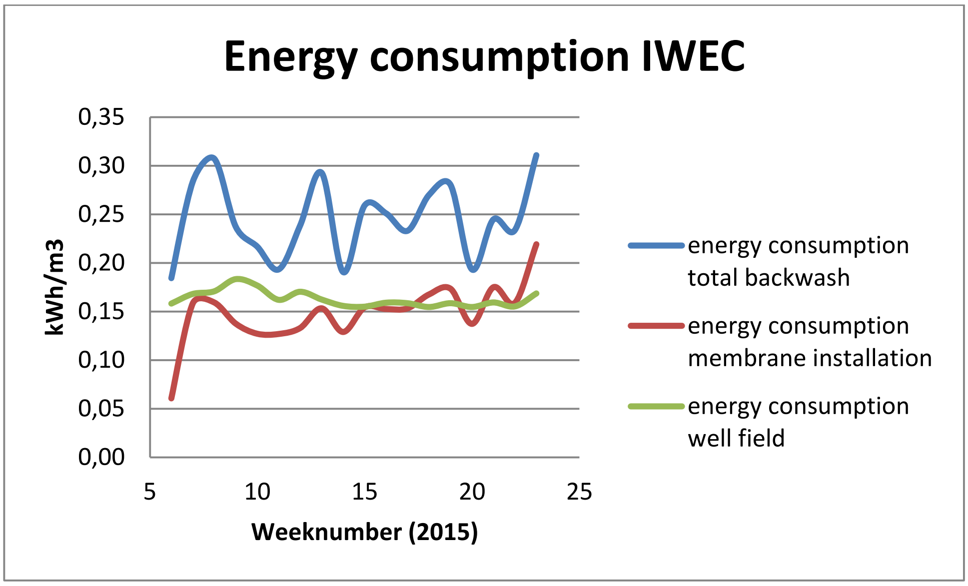


Figure 3; Energy use IWEC system

The reference for energy consumption, is the needed energy for extracting groundwater in the well fields. If backwash water is reused, less groundwater has to be extracted to have the same amount of water to distribute tot the costumers. The needed energy for extracting groundwater is approximately 0,16 kWh for this period. This amount of energy per m^3 is similar with the amount of energy for the membrane installation. Because the backwash water has to be mixed to prevent settling, extra energy is needed. This amount of energy is approximately 0,1 kWh/m^3. A test will be done in the nearby future to look for the possibilities to reduce or stop mixing.
In figure 3 a slight increase of energy consumption of the membrane installation is determined. The cause of this increase of energy consumption is fouling of the membranes. Fouling of the membranes results in a higher feed pressure combined with more backwashes and a higher energy consumption. This effect is especially monitored during the last weeks of the monitoring period, and motivates the urgency of a Cleaning in Place.

4. MONITORING QUALITY:

Regarding the quality there are a few main aspects of the installation:

1. Micro-biological barrier
2. Reduction of suspended solids (turbidity)
3. Reduction of metals (Iron, Arsenic, Nickel, Zinc, etc)
4. Acidity

For monitoring the installation, three sample points are used; influent, permeate (effluent of membrane installation) and permeate 2 (same water as permeate 1, but sampling point close to point where the permeate will be added at the drinking water process). In appendix A all the results can be seen. In the text below, some parameters are mentioned specifically.

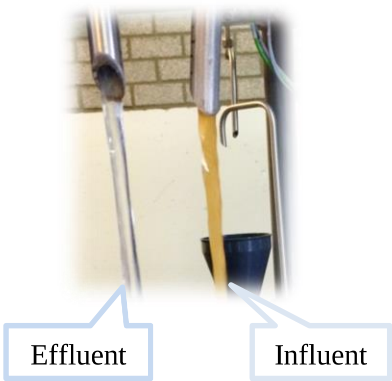


Figure 4; Visual difference between influent and effluent membrane installation (at sampling point).

Ad 1) Micro biological barrier

The general parameter for a bacteriological activity is the Colony Forming Unit (CFU at 22ºC). It's an estimation of the amount of living bacteria in a sample. In the monitored period, the amount of bacteria in the backwash water was relatively low and even lower than the Vitens upper limit. After the membrane installation the CFU 22ºC was also lower than this limit, and similar as in the backwash water. One of the things for further research is, do bacteria pass the membrane (because amount of bacteria is equal in influent as effluent) or, more likely, regarding the higher CFU in the effluent as in the influent in May/June and removal of Aeromonas, are there some bacteria at the permeate side of the membranes and can they survive with the little amount of nutrients available in the permeate.

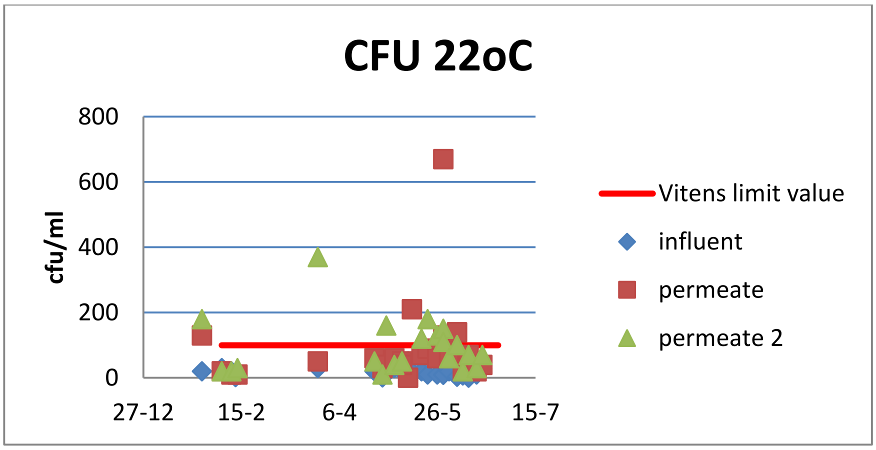


Figure 5; CFU influent and effluent

Regarding a more specific bacteria as Aeromonas, it's to see that the membranes do form a bacteriological barrier for this specific type of bacteria.

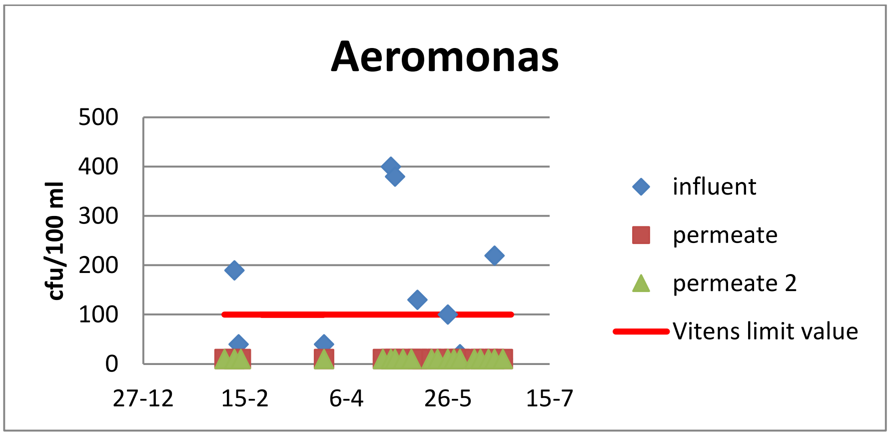


Figure 6; Aeromonas influent and effluent

Other specific bacteria as E-coli, Enterococcus and Clostridium were not detected in both influent as effluent. To test the integrity for micro biology a test with dosing E-coli bacteria in the influent is done. The research question was, is a reduction of > 4 log possible with this installation. A solution with a high concentration E-coli was dosed in the influent of the installation. The results can be seen in figure 7.

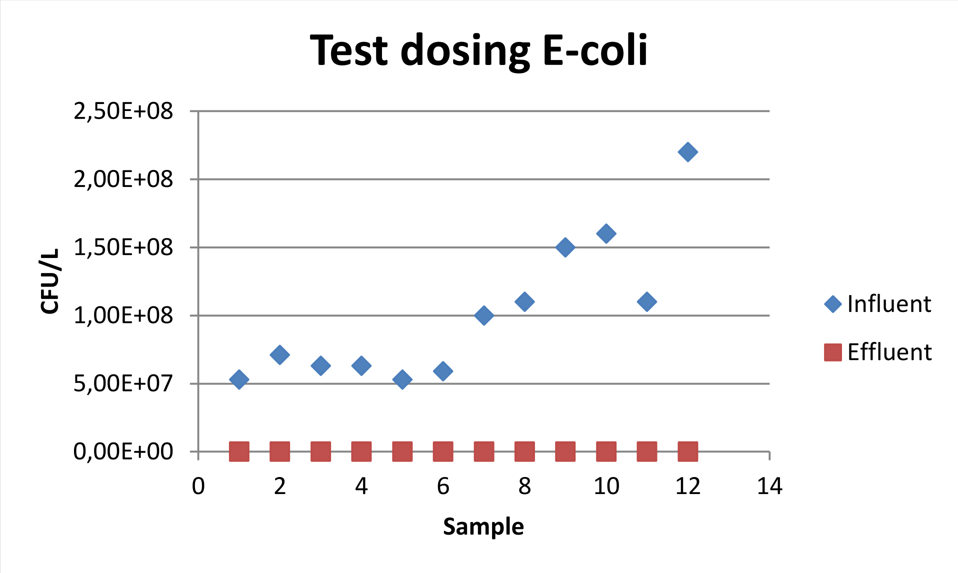


Figure 7; Test dosing E-Coli

Conclusion of this test is that a reduction> log4 is possible. The membranes are a good microbiological barrier for E-coli.

Ad 2) Reduction of suspended solids (turbidity)

The collected backwash water has a dry matter content of about 0,05%. The main component of the dry matter is iron oxide. This gives the water it's brown/orange color (can be seen in figure 4). Although the dry matter content is low, it gives a high turbidity. The membrane installation reduces the turbidity with a factor 10^4, see figure 8.

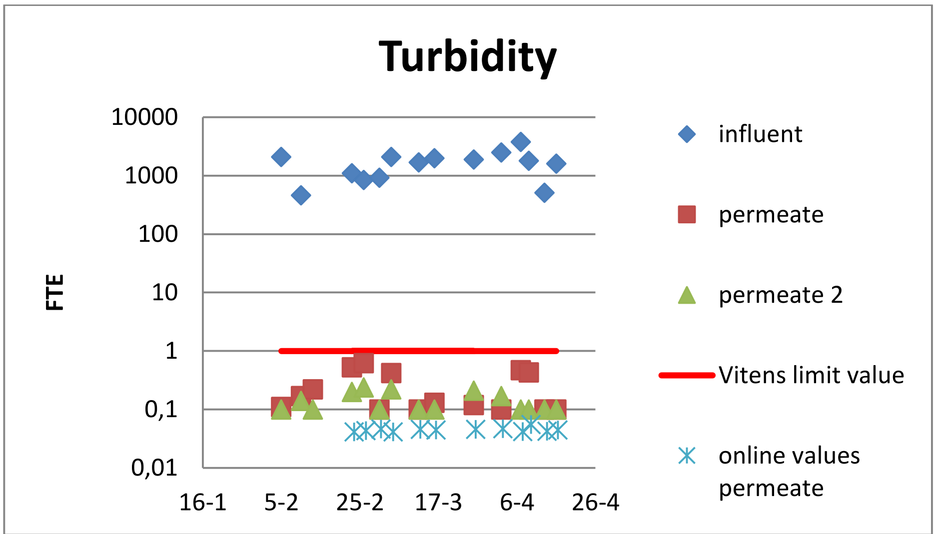


Figure 8; Turbidity influent and effluent

The online measuring in the permeate shows lower values than the laboratory values. This difference between laboratory and on-line values is a normal phenomenon which occurs at more Vitens sites.

Ad3) Reduction of metals

The groundwater at WTP Wierden contains many metals. The most common ones are iron and manganese. The pilot study[i] showed us that manganese was only partially removed. This is the main reason for an extra filterstep (already existing at WTP Wierden) after the membrane installation. In the full scale installation the manganese is removed partially as well, see figure 9.

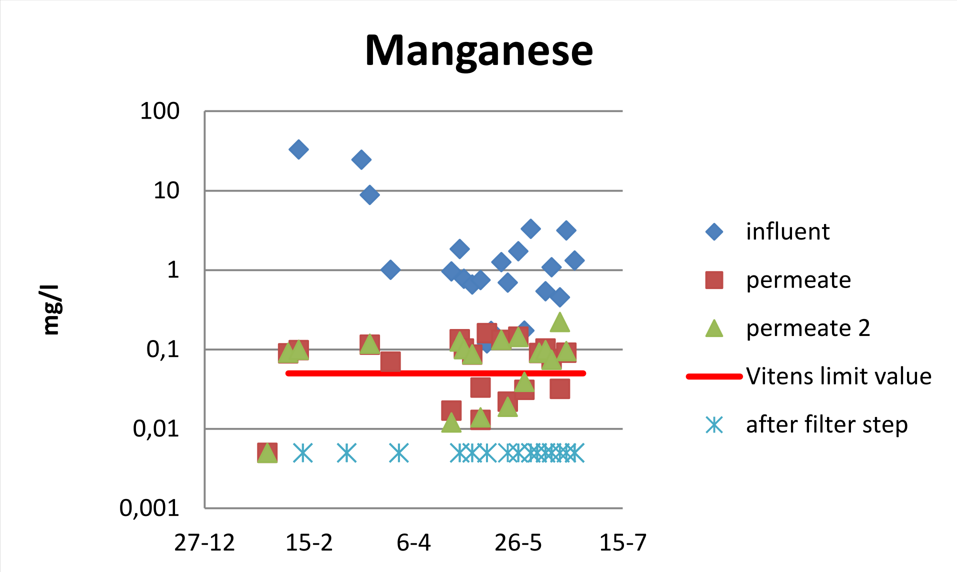


Figure 9; Manganese influent and effluent

After the (already existed) filter step, the amount of manganese was continuously <0.005 mg/l.

Other metals in backwash water (Aluminum, Arsenic, Iron, Nickel, Zinc) are stopped by the membranes to below the company limits, see for graphs Appendix A.

Ad 4) Acidity

Filters are backwashed with drinking water, so the acidity met our standard. By adding Iron chloride (= acid) for better settling of sludge, the pH will decrease little (see figure 10) and is below the Vitens lower limit. Because the permeate is mixed with water from the already existing filters 11 en 21 (mainly for the removal of Manganese), the pH will increase.

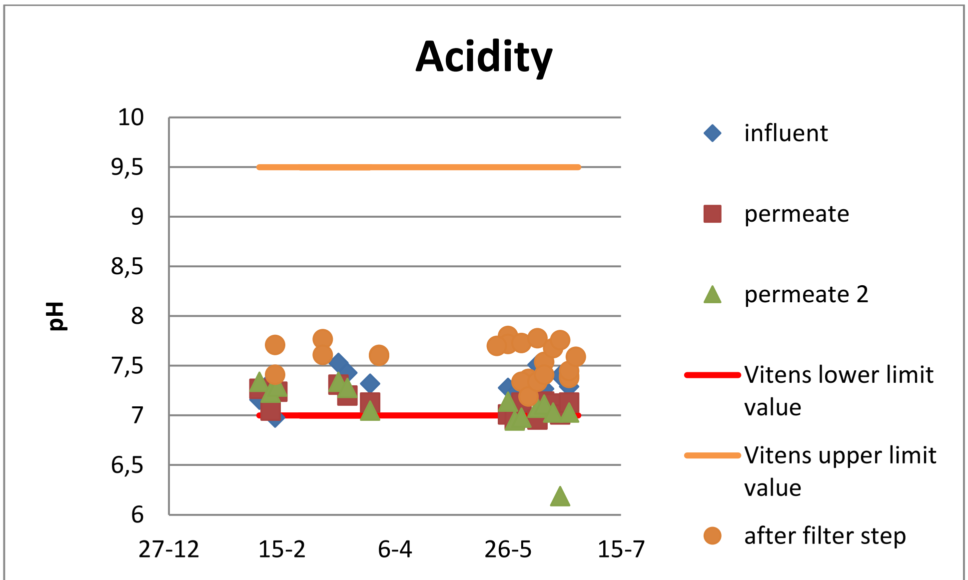


Figure 10; Acidity influent and effluent

5. OTHER PARAMETERS TO BE MONITORED

- Amount of produced sludge

  The dry matter content of the backwash water is very low and depending on which filters are rinsed (dry matter content of backwash water from first filter step is higher than from the second filter step and varies between 0,01% and 0,05 %). After the installation the dry matter content of the sludge is between 0,75 en 1,5 %.In May 2015 the sludge storage is emptied (about 200 ton sludge), the average dry matter content was 7,2%. The goal is to have a dry matter content after the sludge storage (settling) tank > 12%. So an optimization sludge settling (for example dosing extra$FeCl_3$) is necessary.

- Chemical use
  - There are three different chemicals for the installation, $FeCl_3$ (40%), HCl (10%) and H_2O_2 (35%). Since the commissioning till the end of April, the amount of chemicals used:
    - $FeCl_3$ 2900 liter
    - HCl 450 liter
    - H_2O_2 95 liter

  Dosing of $FeCl_3$ is not necessary for the working of the membrane installation, but is needed for the settling of the sludge. It' s dosed at the influent of the installation in normal use, or in situation that the installation is not in use, or the amount of backwash water is too high at the influent of settling tank 2. In this period the amount of $FeCl_3$ dosed was 750 liter and dosed at the settling tank also 750 liter. Optimization of FeCl3 will be done as soon as the sludge storage tank is emptied and the dry matter content is known.

- Operational costs
  - Will be shown in deliverable

- Environmental and sustainable benefits
  - The results of the Life Cycle Analysis are available deliverable D4.6.

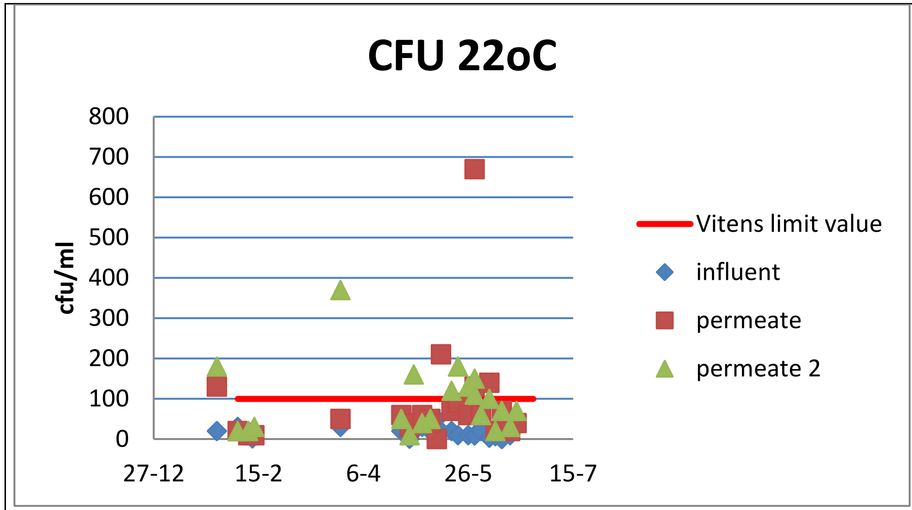
- User experiences
  - First experiences are good, seems to be a robust system with only a few start up problems.

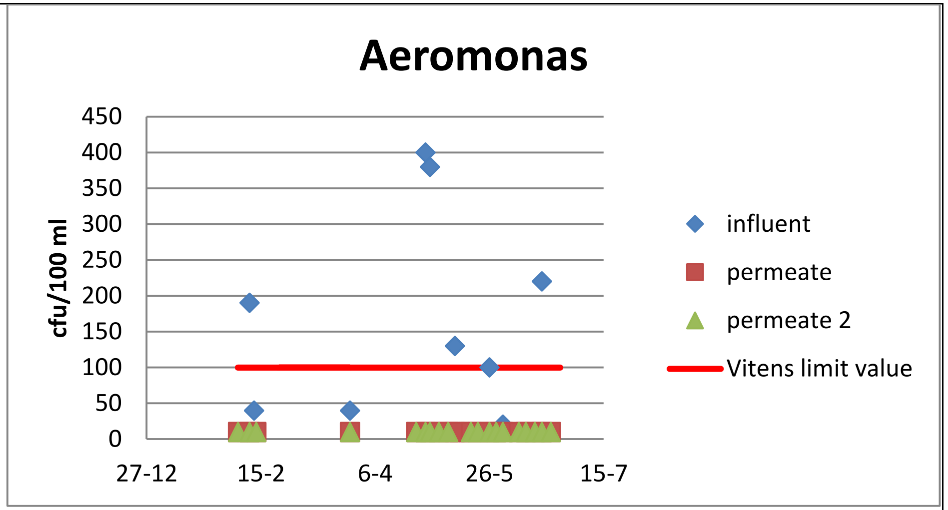
6. FINAL CONCLUSION.

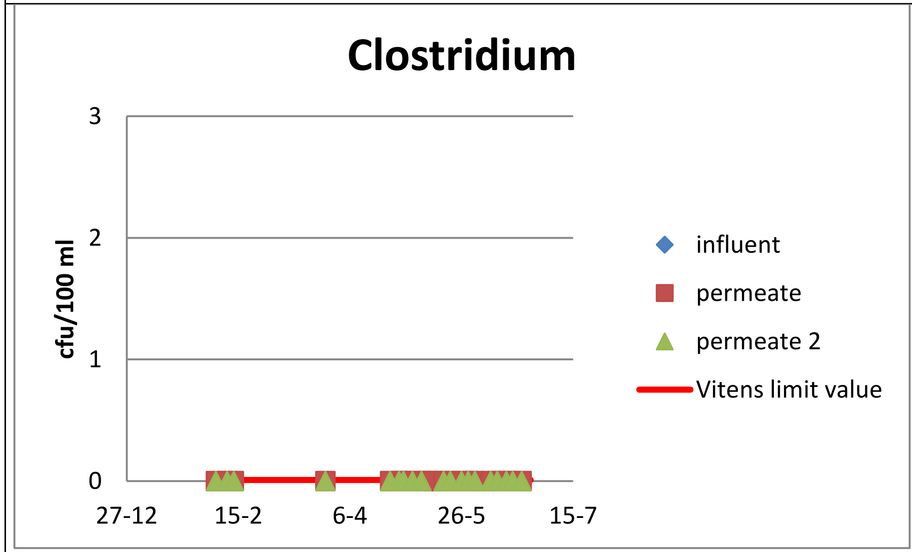
Most important for reusing backwash water is a stable and good quality of the permeate. During the monitoring period, the micro biological quality was quite good. Retention of E-coli is very good. Some higher values for Colony Forming Unit are, most likely, related to the presence of some bacteria at the permeate side of the membranes. A planned disinfection at the permeate side will probably confirm this hypothesis. Regarding other water quality parameters, the installations works good, the turbidity of the effluent is low, removal of iron and other metals are good or as expected (manganese).

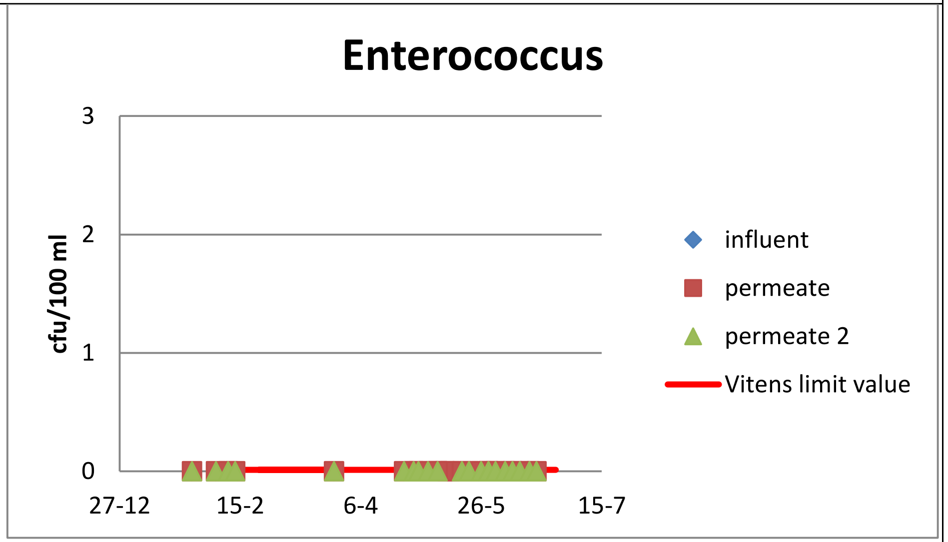
Another goal of the project was to demonstrate that the energy consumption of the installation is lower as the energy consumption of extracting water out of the wells. This goal is not achieved (yet). The energy consumption of the installation is good comparable with the amount of needed energy for extraction, but the energy necessary for mixing in the storage tank is rather high. Further research in reduction (or stopping) of mixing will be done.

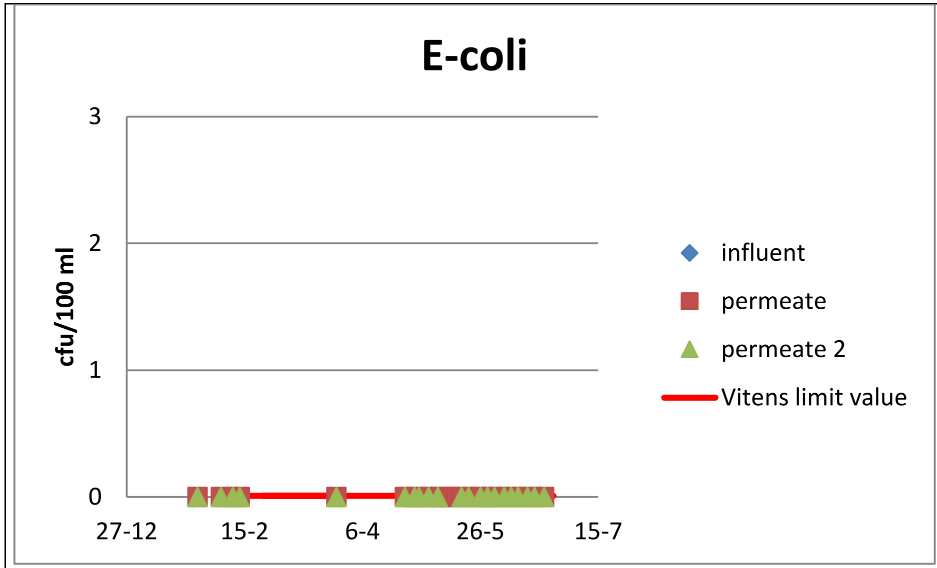
Extra effort is necessary to optimize the dry matter content of the sludge.

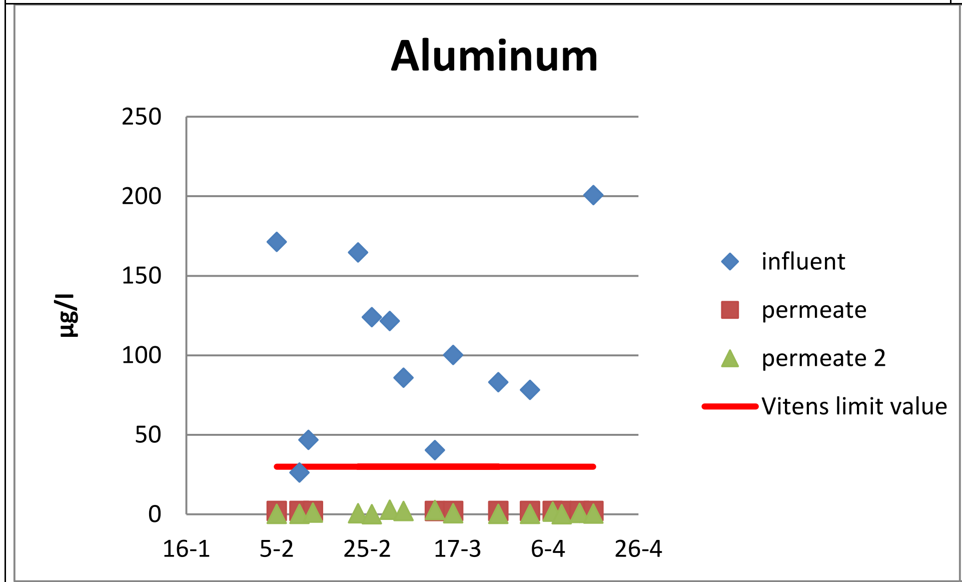

CFU 22oC
800
700
600
500
400
300
200
100
0
cfu/ml
27-12
15-2
6-4
26-5
15-7
Vitens limit value
influent
permeate
permeate 2

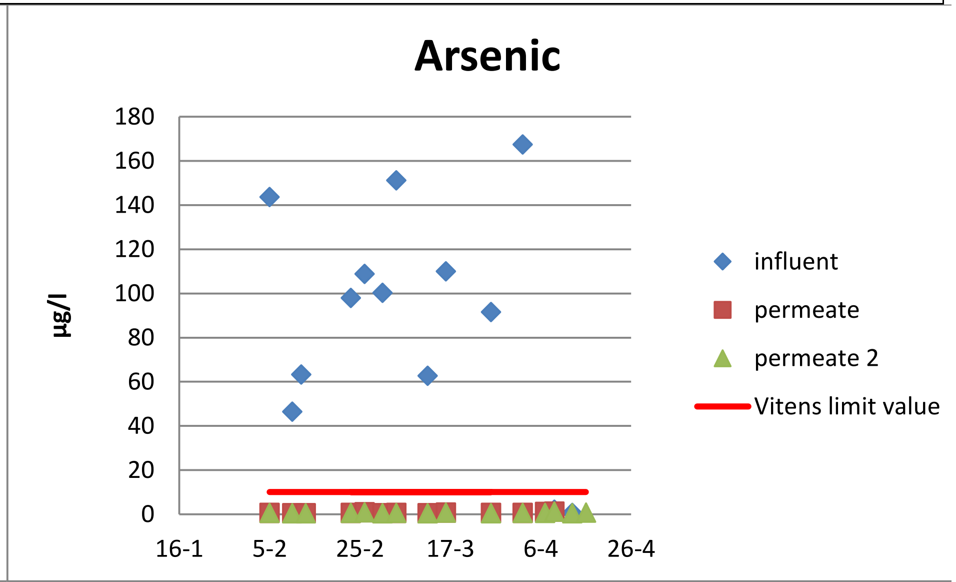

Aeromonas
450
400
350
300
250
200
150
100
50
0
cfu/100 ml
27-12
15-2
6-4
26-5
15-7
influent
permeate
permeate 2
Vitens limit value

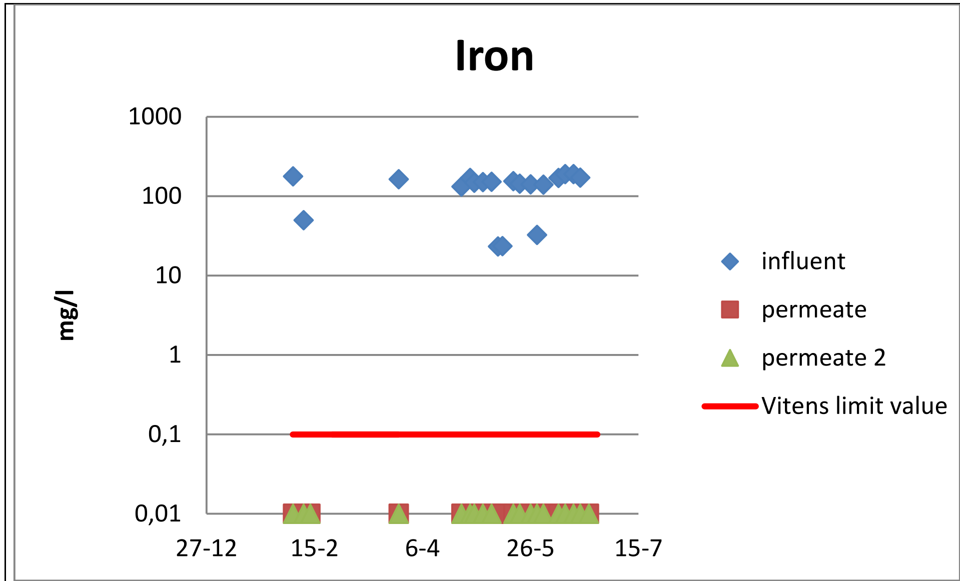

Clostridium
3
2
1
0
cfu/100 ml
27-12
15-2
6-4
26-5
15-7
influent
permeate
permeate 2
Vitens limit value

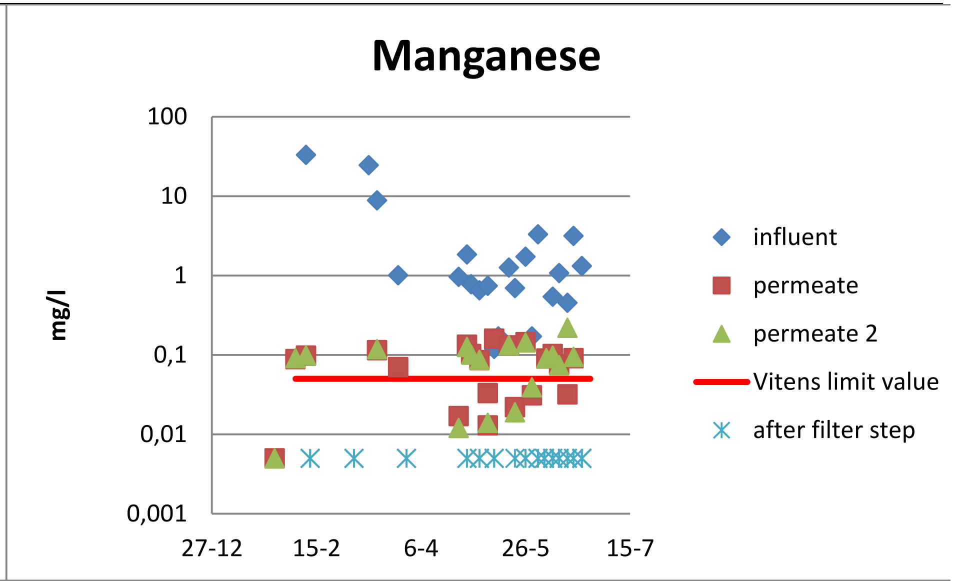

Enterococcus
3
2
1
0
cfu/100 ml
27-12
15-2
6-4
26-5
15-7
influent
permeate
permeate 2
Vitens limit value

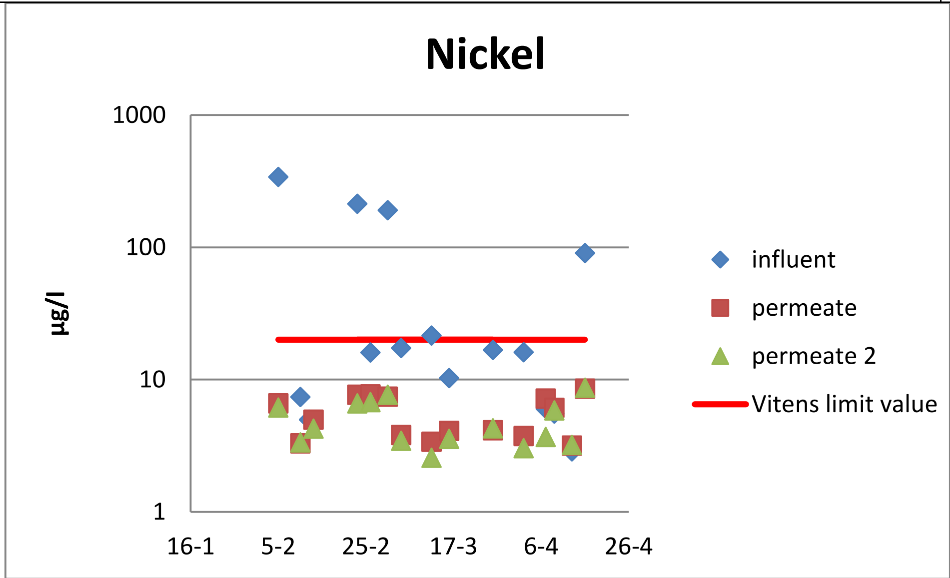

E-coli
cfu/100 ml
3
2
1
0
27-12
15-2
6-4
26-5
15-7
influent
permeate
permeate 2
Vitens limit value

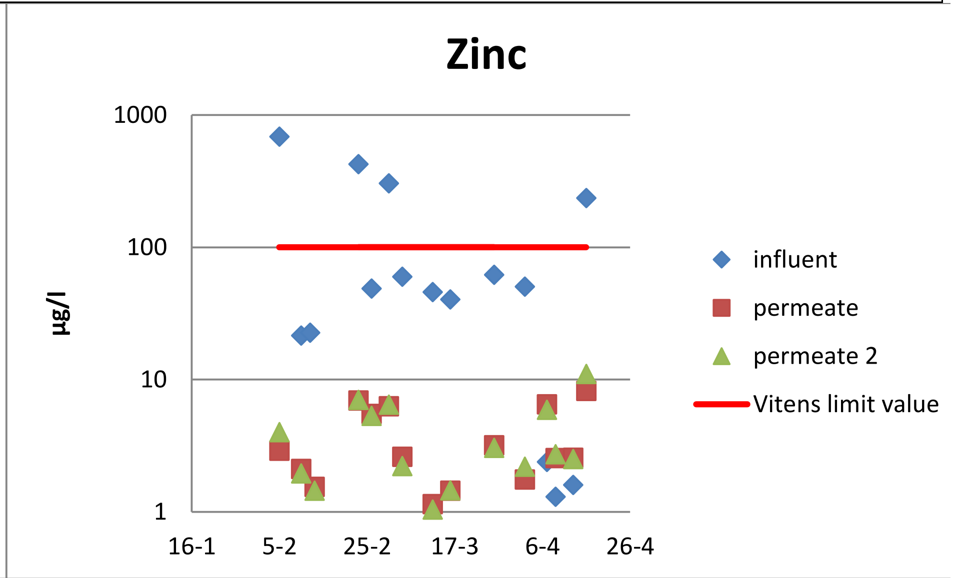

Aluminum
µg/l
250
200
150
100
50
0
16-1
5-2
25-2
17-3
6-4
26-4
influent
permeate
permeate 2
Vitens limit value

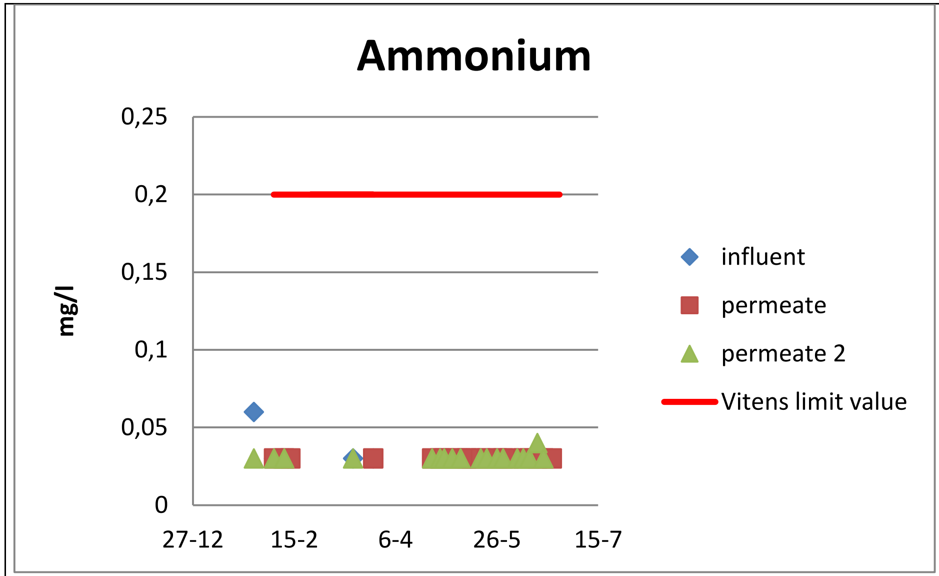

Arsenic
µg/l
180
160
140
120
100
80
60
40
20
0
16-1
5-2
25-2
17-3
6-4
26-4
influent
permeate
permeate 2
Vitens limit value

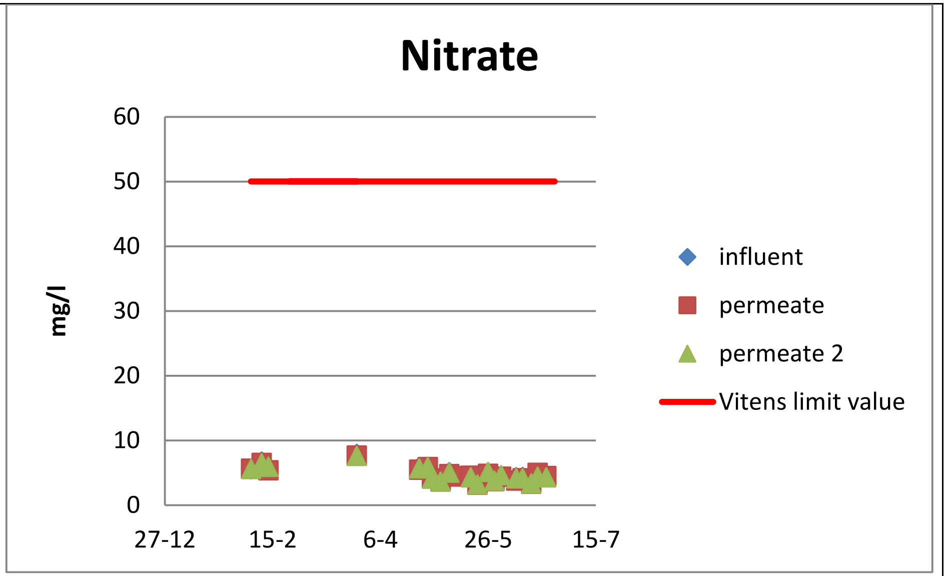

Iron
mg/l
1000
100
10
1
0,1
0,01
27-12
15-2
6-4
26-5
15-7
influent
permeate
permeate 2
Vitens limit value

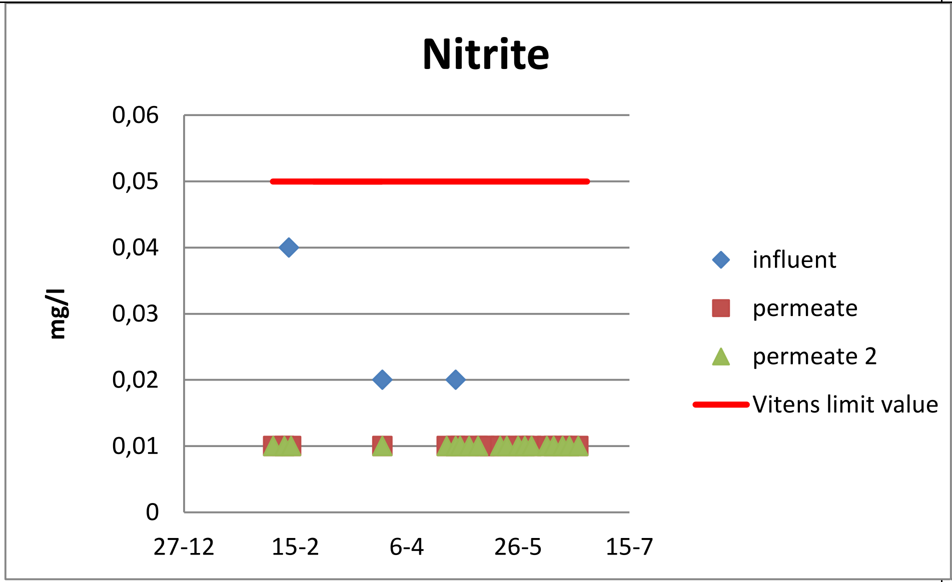

Manganese
mg/l
100
10
1
0,1
0,01
0,001
27-12
15-2
6-4
26-5
15-7
influent
permeate
permeate 2
Vitens limit value
after filter step

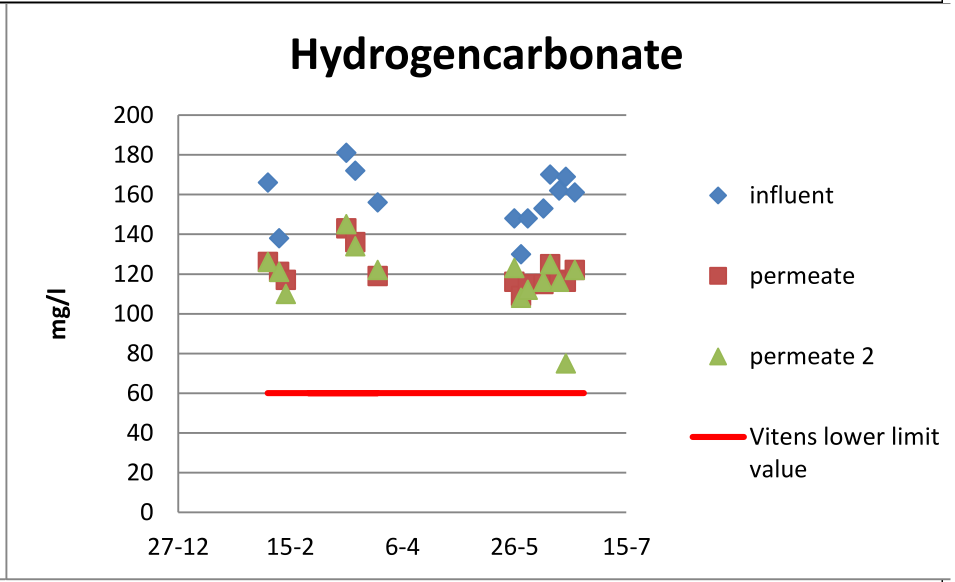

Nickel
µg/l
1000
100
10
1
16-1
5-2
25-2
17-3
6-4
26-4
influent
permeate
permeate 2
Vitens limit value

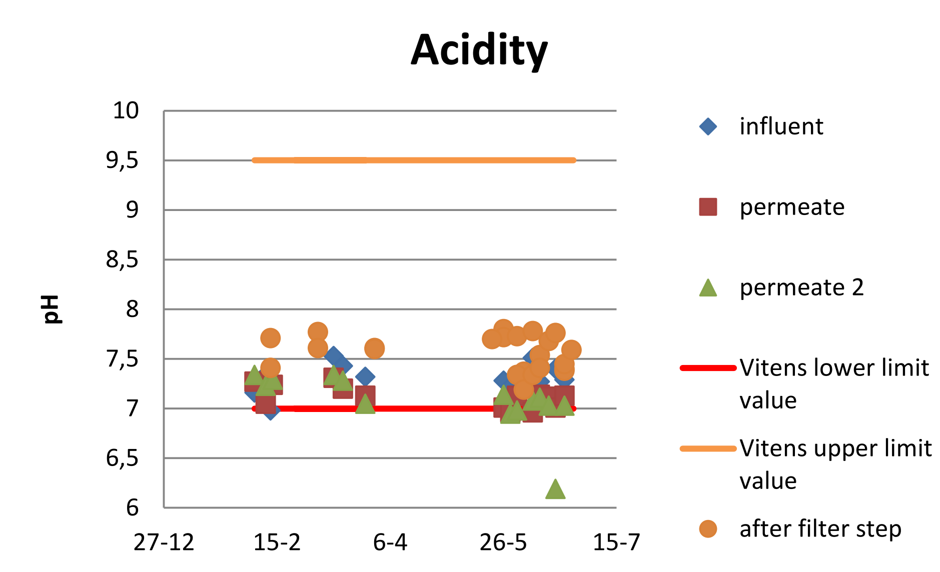

Zinc
µg/l
1000
100
10
1
16-1
5-2
25-2
17-3
6-4
26-4
influent
permeate
permeate 2
Vitens limit value

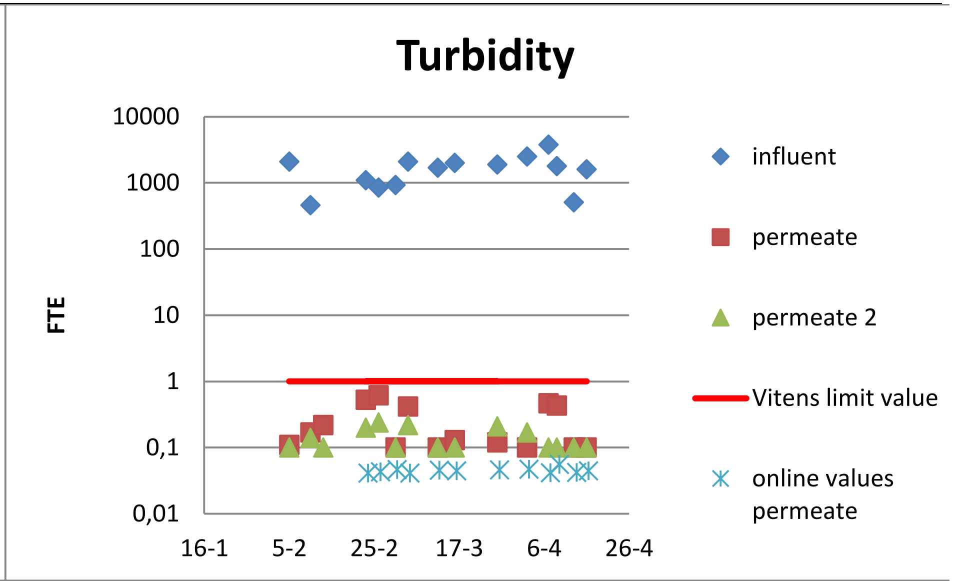

Ammonium
mg/l
0,25
0,2
0,15
0,1
0,05
0
27-12
15-2
6-4
26-5
15-7
influent
permeate
permeate 2
Vitens limit value


Nitrate
mg/l
60
50
40
30
20
10
0
27-12
15-2
6-4
26-5
15-7
influent
permeate
permeate 2
Vitens limit value


Nitrite
mg/l
0,06
0,05
0,04
0,03
0,02
0,01
0
27-12
15-2
6-4
26-5
15-7
influent
permeate
permeate 2
Vitens limit value


Hydrogencarbonate
mg/l
200
180
160
140
120
100
80
60
40
20
0
27-12
15-2
6-4
26-5
15-7
influent
permeate
permeate 2
Vitens lower limit value





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i [Paassen, van J. et al; Re-use of backwash water, Comparative study of 6 MF/ UF membranes; Vitens 2009]