

PAC retention by microsieve

Piloting at Viikinmäki WWTP
Part of the CWPharma project



EUROPEAN UNION

EUROPEAN
REGIONAL
DEVELOPMENT
FUND



Helsingin seudun ympäristöpalvelut -kuntayhtymä
Samkommunen Helsingforsregionens miljötjänster
Helsinki Region Environmental Services Authority

Helsinki Region Environmental Services Authority

P.O. Box 100

FI-00066 HSY

phone +358 9 156 11

fax +358 9 1561 2011

www.hsy.fi

Contact

Lindell Paula, +358 50 412 3162

paula.lindell@hsy.fi

Copyright

Kartat, graafit, ja muut kuvat: HSY

Kansikuva: HSY

Table of contents

1	Introduction	4
1.1	Background	4
1.2	Objectives of study	4
2	Material and methods	5
2.1	Piloting arrangements	5
2.1.1	Piloting equipment	5
2.1.2	Chemicals	6
2.1.3	Influent	7
2.2	Monitoring and analyses	8
2.2.1	Online monitoring	8
2.2.2	Laboratory analyses and sampling	8
2.2.3	Other analyses	8
2.3	Assessing the effect of PAC on microsieve	8
2.4	Trial planning	9
3	Results	10
3.1	Assessing the amount of PAC breakthrough	10
3.1.1	Effluent quality	10
3.1.2	Correlation between analyses	11
3.2	Effect of chemical dosing	12
3.2.1	PAC removal without coagulation or flocculation	12
3.2.2	Response to coagulant and polymer addition	12
3.3	Effect of PAC on filter panels	14
3.4	Filtration tests	15
4	Discussion	17
4.1	Amount of PAC breakthrough	17
4.1.1	Effect of PAC particle size	17
4.1.2	Effect of coagulant and polymer dosing	17
4.2	Practical experiences	17
4.2.1	PAC dosing	17
4.2.2	Assessment of PAC breakthrough	17
4.3	Further tests needed	18
5	Conclusions	19
6	References	20

1 Introduction

1.1 Background

CWPharma (Clear Waters from Pharmaceuticals) is a project funded by EU's Interreg Baltic Sea Region Programme. CWPharma will give tools and recommendations to policy makers, authorities and municipalities on the best ways to reduce emissions of pharmaceuticals in the Baltic Sea Region. In the work package (WP) 3 of CWPharma, advanced wastewater treatment to remove pharmaceuticals from wastewater is studied.

Primarily ozonation and activated carbon treatment can be considered as mature technologies for removing pharmaceuticals from municipal wastewater. Even though ozonation is effective in removing pharmaceuticals, it produces by-products with potential ecotoxicological effects. WP3 explores the alternatives for post-treatment after ozonation to reduce ecotoxicity. The most well-known method for removing ozonation by-products from wastewater is treatment by powdered activated carbon (PAC). The removal capacity of PAC is well-known in literature, but the separation of PAC from wastewater requires further study.

Helsinki Region Environmental Services Authority (HSY) has studied the separation of PAC from wastewater at Viikinmäki WWTP with three different technologies. The focus of the study has been in process operation and optimization, not in the removal of pharmaceuticals. The performance of PAC in removing pharmaceuticals and the effects of PAC dosage and residence time on micropollutant removal from wastewater have been previously studied at Viikinmäki WWTP in laboratory scale in 2015 (Castrén 2016).

Disc filtration of wastewater has been piloted at Viikinmäki WWTP since 2013. Disc filtration has been studied for treatment of by-pass waters and for tertiary treatment. In 2015, a brief pilot scale study on PAC retention was conducted with a Dynadisc disc filter. In this study, PAC retention by a Hydrotech microsieve was examined in pilot-scale.

1.2 Objectives of study

The main objective of the pilot was to examine the retention of PAC by a microsieve. The focus of the pilot was on PAC retention by coagulation, flocculation and disc filtration. Two different PAC products with different particle sizes were used and their operational applicability compared.

Research questions:

- How well can PAC be separated with a microsieve?
- What are the effects of PAC on the microsieve (e.g. increase in backwash ratio)?
- What doses of chemicals are required to achieve minimal PAC breakthrough?
- Does PAC particle size affect the results?
- How can the amount of PAC breakthrough be assessed?

2 Material and methods

2.1 Piloting arrangements

2.1.1 Piloting equipment

The existing Hydrotech disc filter was tested with PAC addition. Effluent wastewater from Viikinmäki WWTP was conveyed from the effluent tunnel straight to the pilot. The flow rate of the pilot was constant at approximately 7.5 m³/h. The qualities of the influent are described in Chapter 2.1.3.

The process configuration of the pilot is shown in Figure 1. The piloting equipment consists of coagulation, flocculation and disc filtration. Two coagulation basins (volume of each 0.178 m³) with rapid mixing are followed by one flocculation basin (volume 0.584 m³) with slow mixing. The disc filter (Hydrotech HSF1708_1-1F) has the total filtration area 2.8 m². The pore size used in the filters was 10 µm.

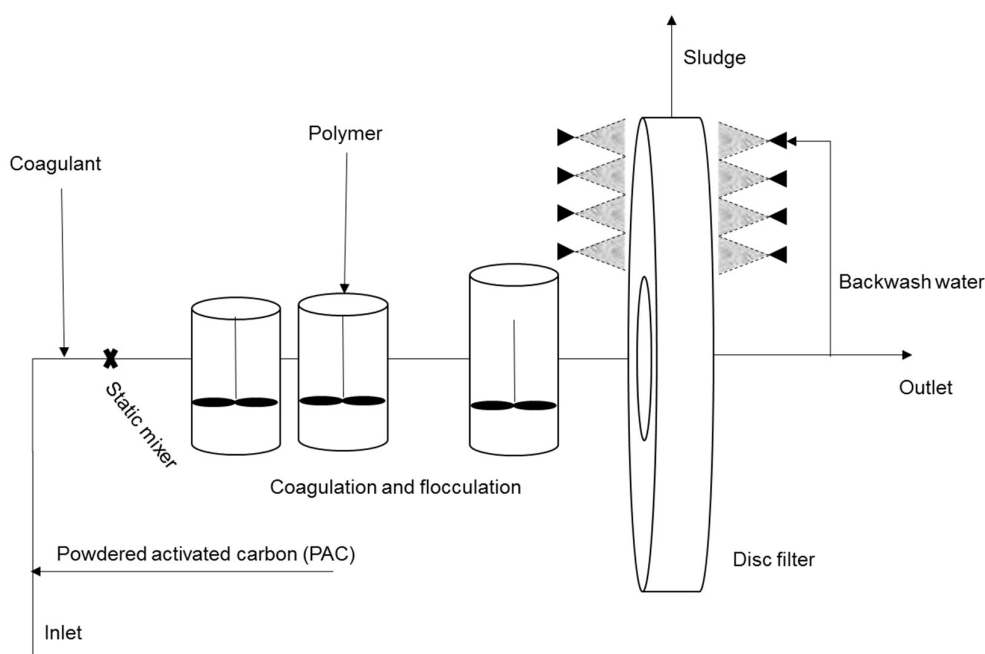


Figure 1. Process configuration of the PAC retention disc filter pilot.

The dosing points of chemicals are illustrated in Figure 1. Powdered activated carbon, suspended in water, was added to the inlet pipe before other chemicals. No contact time was given for PAC to adsorb pharmaceuticals, because a large enough basin (3.75 m³ for 30 minutes contact time) with a mixer was not available. Moreover, PAC maturation does not affect the flocculation and retention of PAC.

Chemical dosing was proportional to the influent flow. PAC was dosed directly before coagulant to the inlet pipe, using a peristaltic pump. The coagulant was dosed using a membrane pump. After the coagulant dosing point, a static mixer ensured the sufficient mixing of the coagulant before the two coagulation tanks. Polymer was added to the second coagulation tank using a membrane pump. Polymer was prepared using a Tomal PolyRex 1.0 Polymer Make-Up unit.

Figures 2 and 3 show the coagulation and flocculation tanks, the disc filter and the backwash discharge pipe.



Figure 2. Coagulation and flocculation tanks and disc filter.



Figure 3. Backwash discharge pipe.

2.1.2 Chemicals

The choices of coagulant and polymer was based on previous experience with the influent and the piloting equipment. The chemicals used in the pilot and their dosing are listed below.

Powdered activated carbon

- dose 10 mg/L, 20 mg/L and 30 mg/L
- stock solution concentration 30 g/L
- fixed dosing rate
- dosing directly in front of coagulant dosing point, before static mixer

Coagulant

- polyaluminium chloride, Kemira PAX XL-100
- dose 1.0-2.5 mg Al/L
- dosing in relation to influent flow rate
- dosing to inlet pipe before static mixer

Flocculant

- anionic polymer, Kemira SUPERFLOC A-100
- dose 1.0-2.0 mg/L
- dosing in relation to influent flow rate
- dosing to second coagulation tank

Two different PAC products with different particle sizes were applied to compare their operational applicability. Norit SAE Super is a very fine PAC product, which is widely used in water treatment. AquaSorb® MP25 PAC-C is a coarser product. The properties of the two PAC types are listed in Table 1. The two PAC types were selected to find out whether the coarse PAC-C could be better retained by the microsieve with the 10 µm pore size, using less coagulant and polymer.

Table 1. Properties of PAC products applied

	AquaSorb® MP25 PAC-C	Norit SAE Super
Supplier	Jacobi	Cabot
Raw material base	Mineral coal	Mineral coal
d50	35-50 µm	15 µm
Total surface area (BET)	1150 m ² /g	1150 m ² /g

The particle size of PAC affects the removal of pharmaceuticals. Finer PAC is able to adsorb pharmaceuticals more efficiently, and therefore smaller dosing or shorter contact time can be sufficient, depending on what is the goal for pharmaceuticals removal. For PAC retention, the particle size distribution is significant. For Norit SAE Super, the particle size distribution is shown in Figure 4. The graph shows that over 30 % of the particles in Norit SAE Super are smaller than 10 µm, which is the smallest pore size available for Hydrotech disc filters. Although the average particle size of AquaSorb® PAC-C is larger than that of Norit SAE Super, it is likely that there is also a significant portion of particles smaller than 10 µm in PAC-C.

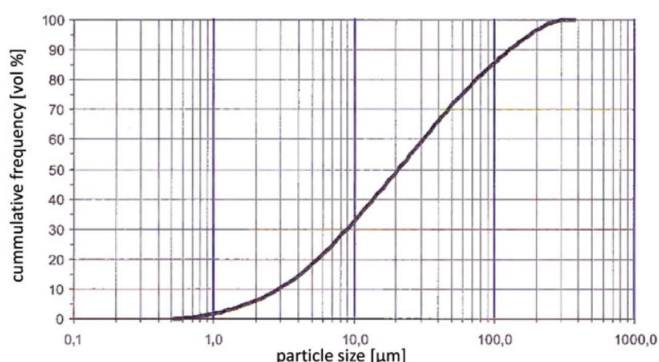


Figure 4. Particle size distribution in Norit SAE Super powdered activated carbon.

2.1.3 Influent

Water used as the influent for the disc filter came directly from the effluent tunnel of Viikinmäki WWTP. Piloting with PAC took place from 11 July to 9 August 2018. The quality of the influent is listed below in Table 2, for biological oxygen demand (BOD), chemical oxygen demand (COD_{Cr}) and suspended solids (SS).

Table 2. Viikinmäki WWTP average effluent quality during during July and August 2018

	BOD (mg/L)	COD (mg/L)	SS (mg/L)
Average	4.28	40	2.9
Maximum	5.82	61	4.2
Minimum	3.08	30	1.6

2.2 Monitoring and analyses

2.2.1 Online monitoring

The pilot process had online flow measurement as well as turbidity meters for influent and effluent. The meters were based on nephelometric scattered light technique (Ultraturb system, HachLange) with the measurement range from 0.00001 to 1000 NTU. Online turbidity monitoring was used in process operation to determine steady state process conditions. Samples were taken only after effluent turbidity stabilised.

2.2.2 Laboratory analyses and sampling

1 L samples were taken from the influent and effluent after changes in chemical dosing. The sampling points were in the inlet pipe before chemicals, and in the outlet pipe after disc filtration (see Figure 1). The samples were sent to an external laboratory (MetropoliLab Oy) to be analysed for turbidity, suspended solids (SS) and COD_{Cr}. The methods used by MetropoliLab Oy are listed in Table 3.

Table 3. Laboratory analyses performed by MetropoliLab Oy

Parameter	Method	Uncertainty	Unit
Turbidity	SFS-EN ISO 7027	15%	FNU
Suspended solids	SFS-EN 872:2005	10%	mg/L
COD _{Cr}	ISO 15705:2002	15%	mg/L

2.2.3 Other analyses

Besides online monitoring and laboratory analyses, the amount of PAC breakthrough was assessed by filtrating samples through glass fibre filters as the studies by Langer (2013) and Isgaard & Thörnqvist (2016). A fixed volume of sample was filtrated through 0.5 µm glass fibre filter (MN GF-2) to visually compare the amount of PAC in the effluent.

The concentrations of pharmaceuticals in the pilot influent and effluent were analysed at Aarhus University, which is a project partner in CWPharma. Although the removal of pharmaceuticals was not optimised in this study, samples were sent to Aarhus University to get comparable results between different CWPharma pilots. No other analyses were made to determine the removal of pharmaceuticals.

2.3 Assessing the effect of PAC on microsieve

To determine the clogging of filter panels, the backwash ratio of the disc filter was monitored. The backwash ratio represents the amount of time the washing sequence of the disc filter is activated. In the Hydrotech disc filter, backwash starts automatically when the water level inside the central cylinder rises due to solids accumulating on the filter panels. Filtration continues during backwash. The backwash ratio was calculated from the time the automatic washing sequence was on, compared to the total filtration time, using the following formula:

$$BW\% = \frac{t_{wash}}{t_{tot}} \cdot 100\%,$$

where $BW\%$ is backwash ratio (%)
 t_{wash} is washing time (s)
 t_{tot} is total filtration time (s).

2.4 Trial planning

PAC trial runs with the disc filter lasted approximately four weeks, from 16 July to 9 August 2018. Trial runs were conducted only during office hours, on weekdays. Operation was started with a clean disc filter (filter panels washed with acid). First, samples were taken of normal running of the disc filter without any chemicals, and with coagulant and polymer. The remaining time was divided in two between the two PAC types. Varying doses of coagulant and polymer were tested with different PAC concentrations (10 mg/L, 20 mg/L and 30 mg/L) with both PAC types. The carbon type was switched in the middle, without cleaning the filter panels with acid.

Only short trial runs were conducted in this study, with plans to continue with long runs later in the next phase of piloting. After changing each chemical dosage, it took approximately one hour for the effluent turbidity to stabilise. Samples were taken only after the online turbidity meter indicated stable effluent turbidity.

3 Results

3.1 Assessing the amount of PAC breakthrough

3.1.1 Effluent quality

Figures 5-7 present the changes in influent and effluent quality during the course of piloting, measured by turbidity, suspended solids and chemical oxygen demand. Each point represents a different combination of chemical doses. The dosing of each carbon type is marked with grey.

Figure 5 shows that the influent turbidity was stable at approximately 1.6 FNU. Without any carbon or other chemicals added, the effluent turbidity was lower than the influent turbidity at approximately 1.2 FNU (reduction around 30%), and with coagulant and polymer addition, the turbidity increased to about 1.9 FNU. Carbon addition increased the effluent turbidity to at least 3 FNU, regardless of chemical dosing. The effect of chemical dosing is further discussed in Chapter 3.2.

In Figure 5, a clear difference can be seen in the effluent turbidity of the two PAC types applied. Effluent turbidity with AquaSorb® PAC-C is lower than with Norit SAE Super. The larger particle size of Aquasorb seems to result in less PAC breakthrough, compared with the finer Norit carbon. Significantly higher effluent turbidity occurred with Norit carbon. Optimisation of coagulant and polymer dosage were able to decrease effluent turbidity with each PAC dosage, but PAC escaped through the microsieve with each chemical dose. The increase in turbidity when comparing influent and effluent was at the smallest 50-100% (AquaSorb® PAC-C dose 10 mg/L), and at the highest over 1600% (Norit SAE Super dose 30 mg/L).

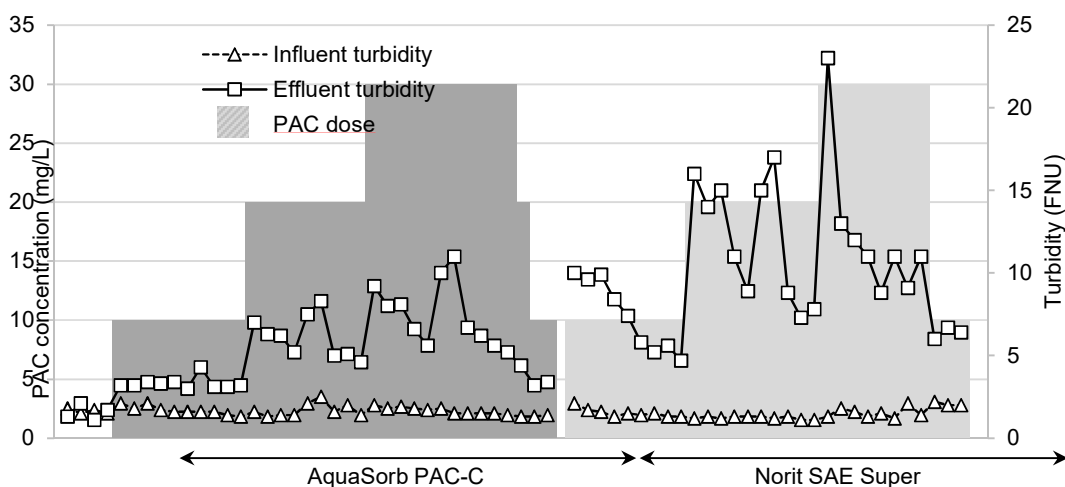


Figure 5. Changes in turbidity during the PAC trial runs with microsieve.

Figure 6 shows the corresponding results for suspended solids. The analysis of suspended solids has the detection limit of 2 mg/L. Some influent results fall below the detection limit, and their values in Figure 6 are represented as zero. With increasing PAC concentrations, effluent SS increases, although this correlation is less evident than with effluent turbidity. Contrary to the turbidity results, some reduction in suspended solids did occur. Up to 30% reduction in SS was achieved with AquaSorb® PAC-C dosed at 10 mg/L. In other cases, effluent SS was up to 650% higher than influent SS. PAC breakthrough measured by SS was thus smaller than PAC breakthrough measured by turbidity.

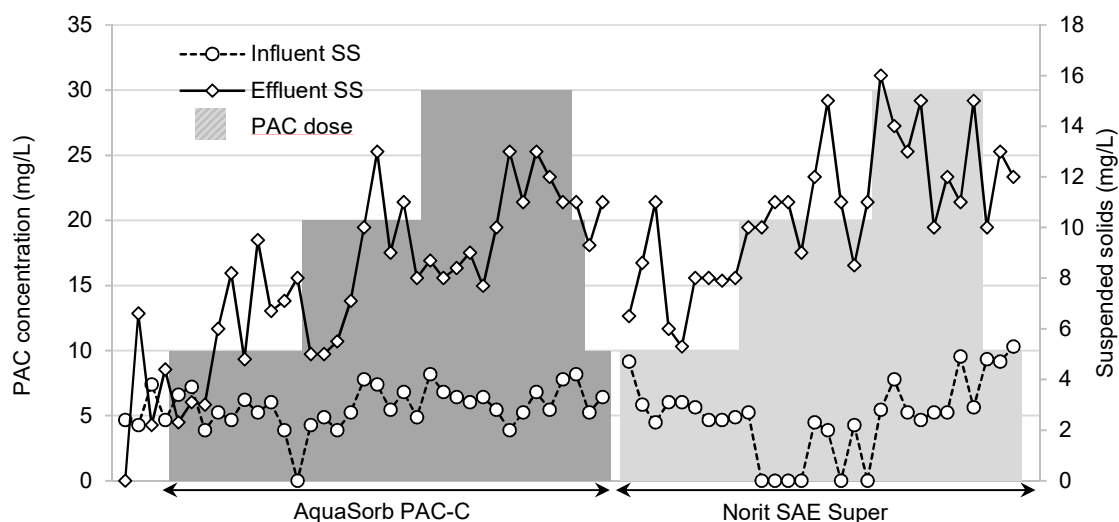


Figure 6. Suspended solids during the PAC trial runs with microsieve. Influent SS results below detection limit are shown as zero.

The average chemical oxygen demand of Viikinmäki effluent was 40 mg COD_{Cr}/L during the piloting period (see Table 2). Figure 7 shows that COD_{Cr} reflects mainly the influent quality, and it is therefore unsuitable in detecting PAC breakthrough.

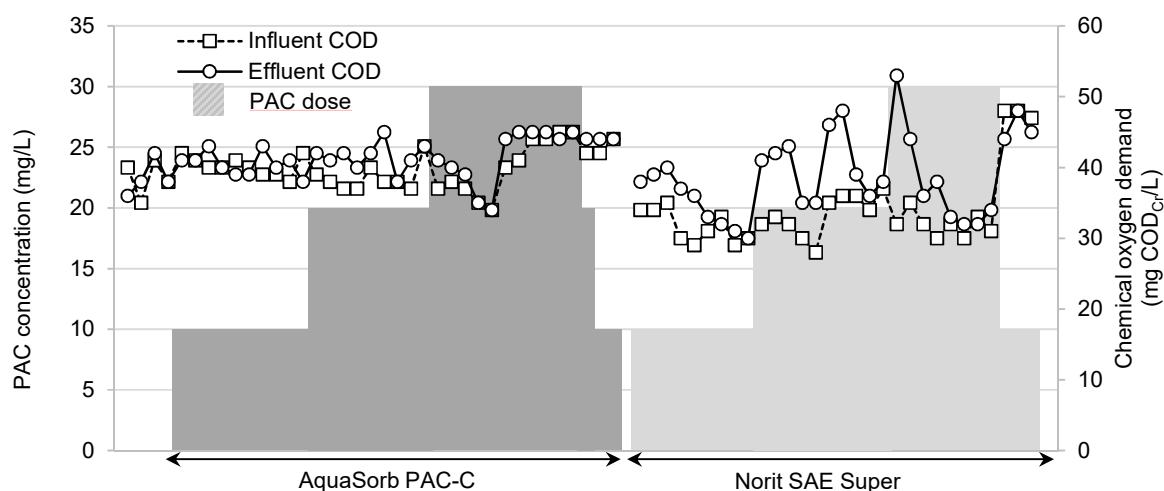


Figure 7. Changes in COD during the PAC trial runs with microsieve.

3.1.2 Correlation between analyses

The correlation between turbidity and suspended solids in the effluent is shown in Figure 8. The figure shows that suspended solids correlate with turbidity, although a difference can be seen between the carbon types. With the finer Norit SAE Super, turbidity seems to better reveal the excess breakthrough of carbon. With the coarser AquaSorb® PAC-C, a narrower range of turbidity can indicate that less PAC breakthrough happened, or that turbidity does not work as well detecting PAC-C compared to SAE Super.

Figure 9 clearly demonstrates that COD_{Cr} reflects poorly the amount of PAC in the effluent. The COD_{Cr} results vary little from the 40 mg COD_{Cr}/L average in pilot influent.

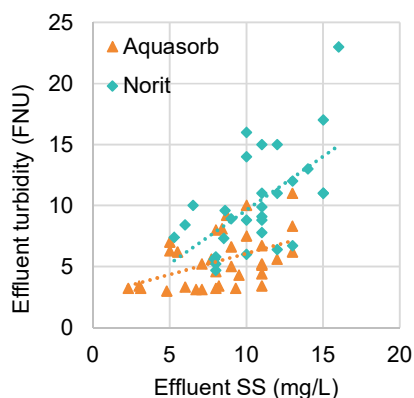


Figure 8. Correlation between effluent turbidity and suspended solids.

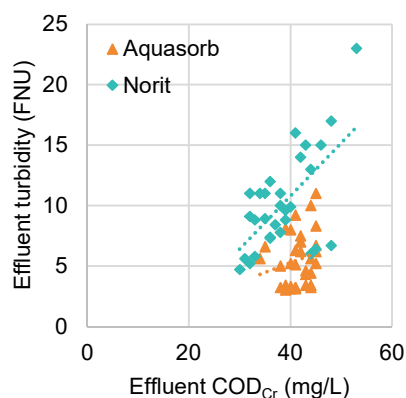


Figure 9. Correlation between effluent turbidity and COD_{Cr}.

3.2 Effect of chemical dosing

3.2.1 PAC removal without coagulation or flocculation

The sieving properties of the disc filter were tested when PAC was dosed without coagulant or polymer addition. Figures 10 and 11 show the effluent quality with only PAC added, comparing the two different PAC types. Both the effluent turbidity and the effluent suspended solids show that PAC breakthrough increased linearly with increasing PAC dose. These results are among the highest of all effluent turbidity and SS shown in Figures 5 and 6, indicating that only a portion of PAC can be removed with just the sieving properties of the Hydrotech disc filter. The results indicate that more AquaSorb PAC-C could be captured by the microsieve than Norit SAE Super.

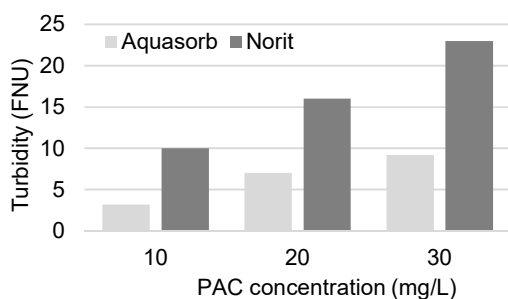


Figure 10. Effluent turbidity when only PAC was added, without coagulation or flocculation.

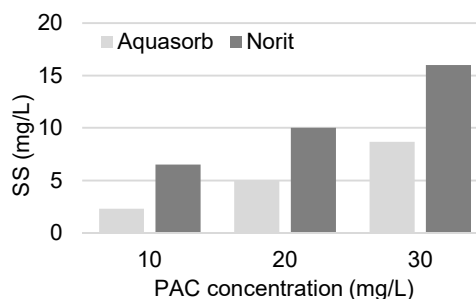


Figure 11. Effluent SS when only PAC was added, without coagulation or flocculation.

3.2.2 Response to coagulant and polymer addition

The effects of coagulation and flocculation on the effluent quality were determined by applying various doses of coagulant and polymer. First, only polymer or only coagulant was added. Figures 12 and 13 show the effluent turbidity and effluent SS with the corresponding chemical doses. There are no results for Norit SAE Super dose 30 mg/L, because the filters immediately got clogged when only polymer was added. Chemical dosing had to be paused until the following day to allow the process time for recovery. To prevent further time lag, tests with only coagulant were left out.

Figures 12 and 13 show that although adding only polymer or only coagulant did improve effluent quality compared to when no polymer or coagulant were added (Figures 10 and 11), there was still significant PAC breakthrough. Not much difference can be seen between only using polymer, or only using coagulant. Furthermore, increasing the dosing of either chemical did not improve effluent quality.

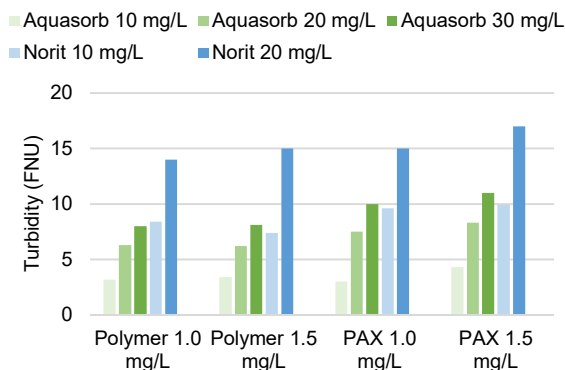


Figure 12. Effluent turbidity with different PAC doses when adding only polymer or only coagulant.

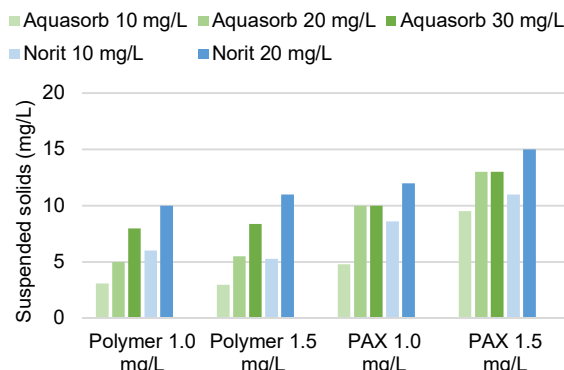


Figure 13. Effluent SS with different PAC doses when adding only polymer or coagulant.

Both coagulation and flocculation were applied to find out optimal doses of chemicals. The effect of varying coagulant and polymer doses to effluent turbidity is shown in Figure 14. The lowest effluent turbidity was achieved with the coagulant dosed at 2.0 mg Al/L, and the polymer at 1.0-1.5 mg/L. Increasing the polymer dose from this resulted in increased effluent turbidity. However, even with the optimal chemical doses, the effluent turbidity varied between 3.3 FNU and 10 FNU, depending on PAC dosing and type. This means that a large portion of PAC escaped through the microsieve.

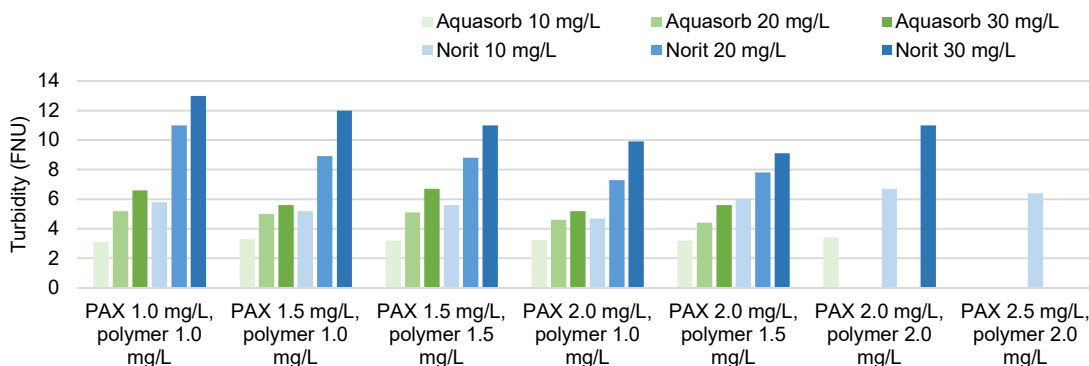


Figure 14. Effect of varying doses of coagulant and polymer on the effluent turbidity.

The corresponding results for effluent suspended solids are shown in Figure 15. The best results for effluent suspended solids were achieved with the coagulant dosed at 2.0 mg Al/L, and the polymer at 1.0 mg/L. There is however less of a difference between the results. Even with the optimal chemical doses, the effluent SS was 7.7-11 mg/L due to PAC breakthrough.

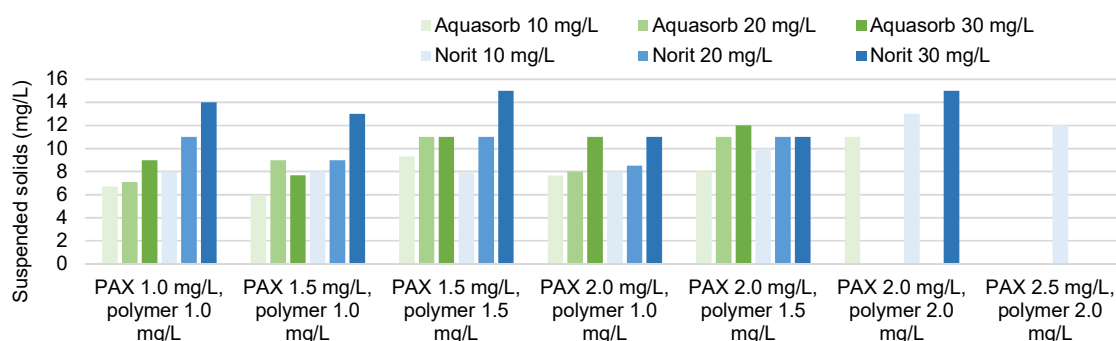


Figure 15. Effect of varying doses of coagulant and polymer on the effluent suspended solids.

3.3 Effect of PAC on filter panels

The accumulation of solids on the microsieve can be estimated from the backwash ratio of the disc filter. The backwash ratio during the course of piloting is shown in Figure 16. In the figure, the average backwash ratio during each sampling time is shown. Clearly, PAC accumulated on the filter panels, causing the backwash time to continuously increase. Evidently, backwash was not sufficient in removing PAC accumulation from the filters. According to Figure 16, the coarser AquaSorb® PAC-C did not clog the filters as much as the finer Norit SAE Super. However, the filter panels were not chemically cleaned after trial runs with PAC-C, and therefore it is difficult to compare the effect of the two PAC types on the backwash ratio.

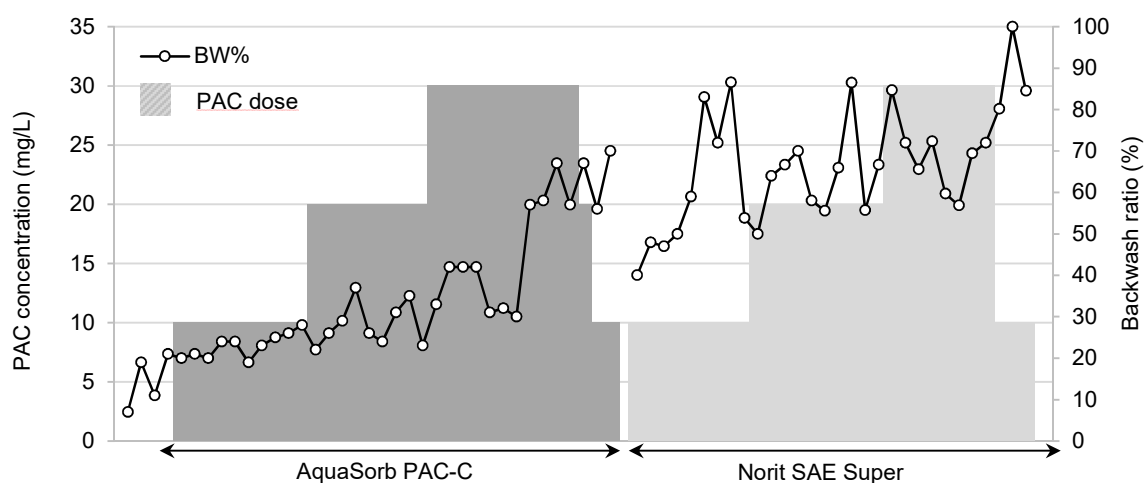


Figure 16. Backwash ratio during the PAC trial runs with microsieve.

Figure 17 shows how the filter panels looked at the end of piloting, when they were chemically cleaned. A dramatic difference in colour can be seen between the washed and unwashed panels. PAC accumulated on the filter panels during 15 days of piloting with PAC, after which chemical cleaning was needed. However, there would have been less PAC accumulation, if optimal doses of coagulant and polymer had been constantly applied. The backwash ratio ranged from 23% with low doses of AquaSorb® PAC-C, to 60 % with high doses of Norit SAE Super, when the optimal chemical doses were applied.



Figure 17. Unwashed filter panel after trial runs, compared to chemically cleaned filter panels above.

In addition to the PAC accumulation seen on the filter panels, PAC deposited also on the backwash nozzles and the backwash waste strainer, as shown in Figure 18.



Figure 18. Backwash nozzles (left) and backwash water strainer (right) after trial runs.

3.4 Filtration tests

Filtration of samples with 0.5 μm glass fibre filters (MN GF-2) was done to further estimate the amount of PAC breakthrough. The 0.5 μm glass fibre filters retain finer solids than the 1.6 μm filters (GF/A) used in the analysis of suspended solids by Metropolilab Oy. The purpose of the filtration tests was mainly to visually compare PAC breakthrough between different chemical dosages. The results mainly support the results of laboratory analyses for turbidity and SS.

Figure 19 compares the filtration test results for the two different PAC types dosed at 20 mg/L, to a blank glass fibre filter (with only clean water filtered). No other chemicals were dosed, which means that Figure XX visualises how much the microsieve can remove PAC without coagulation and flocculation. Evidently, coarser PAC-C is better captured than the finer SAE Super. This can also be seen from the laboratory results: the

corresponding effluent SS was 5.0 mg/L for PAC-C and 10 mg/L for SAE Super, and the corresponding effluent turbidity was 7.0 FNU for PAC-C, and 16 FNU for SAE Super. Both SS and turbidity results display the higher amount of PAC breakthrough with SAE Super, although the wider range between the turbidity results seems to better match the filtration results.

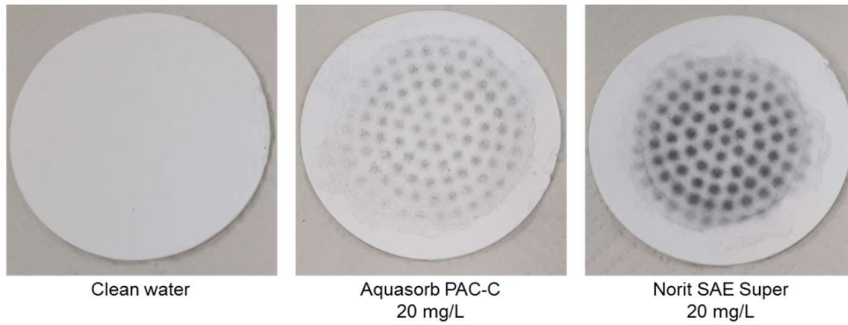


Figure 19. Comparison for the results of filtration tests for clean water and the microsieve effluent with the two PAC types dosed at 20 mg/L.

4 Discussion

4.1 Amount of PAC breakthrough

4.1.1 Effect of PAC particle size

From the results it is clear that PAC particle size had an effect on the effluent quality. The microsieve was better able to retain the coarser AquaSorb® PAC-C (d50 35-50 µm) compared to the finer Norit SAE Super (d50 15 µm). However, both PAC types had high breakthrough.

PAC breakthrough can partly be explained by the wide range of particle sizes in PAC. The particle size distribution graph for SAE Super (Figure 4) reveals that 30 % of the particles in Norit SAE Super are smaller than 10 µm (see Chapter 2.1.2). No particle size distribution graph was available for PAC-C from the manufacturer. However, it can be assumed that also PAC-C and most likely every other PAC type contains some portion of particles smaller than 10 µm, which is the smallest pore size of Hydrotech microsieves.

Consequently, the success of PAC retention by microsieve depends on how well PAC is integrated into flocs. The optimisation of coagulation and flocculation has therefore major importance in the separation of PAC from wastewater.

4.1.2 Effect of coagulant and polymer dosing

Different doses of coagulant and polymer were applied to optimise the integration of PAC into flocs. Best effluent quality was achieved with the dosing of coagulant at 2.0 mg Al/L, and polymer at 1.0 mg/L. Higher dosing of coagulant did not improve PAC retention. Increasing the polymer dose to 1.5 mg/L increased the backwash ratio and did not improve the results.

Best results were obtained by first optimising flocculation, and only then starting the dosing of PAC. Even with the optimal coagulant and polymer doses, PAC could not be flocculated very well, and PAC always passed through the microsieve.

4.2 Practical experiences

4.2.1 PAC dosing

The dosing of PAC turned out to be challenging. PAC was dosed from a 30 g/L PAC suspension first with a membrane pump, but it was soon replaced with a peristaltic pump. The reason was that in addition to the generally abrasive properties of PAC, the coarse AquaSorb® PAC-C contained larger nuggets of PAC that quickly clogged the membrane pump. The peristaltic pump did not clog, but it was not as reliable because it had no flow measurement. As a result, ensuring the stable dosing rate of PAC was sometimes difficult.

4.2.2 Assessment of PAC breakthrough

It is challenging to estimate the amount of PAC breakthrough. A particle counter could best monitor the amount of PAC in the effluent, but this kind of equipment was not available for the trial runs. It was also desired to test low-technology alternatives to assess PAC breakthrough that are easily available to WWTPs of all sizes. In the study by Langer (2013), turbidity was found to correlate with particle counts, so it was selected as one of the parameters to follow.

Three types of laboratory analyses were applied: turbidity, suspended solids and chemical oxygen demand. Of these, COD_{Cr} was the least informative. Between turbidity and suspended solids, turbidity seemed to better

represent the breakthrough of Norit SAE Super, and suspended solids the breakthrough of AquaSorb® PAC-C. This observation is supported by the results of the filtration tests (see Chapter 3.4).

4.3 Further tests needed

This study produced the first results for integrating PAC treatment with disc filtration at Viikinmäki WWTP. The tests should be continued to properly evaluate the suitability of the microsieve in the separation of PAC from wastewater. Possibly, better results could be achieved by using a different polymer. Improved flocculation would most likely reduce the amount of PAC breakthrough. Different polymers should be tested with both PAC types to see which polymer works best.

After optimising the flocculation and the PAC retention, the stability of PAC breakthrough and the development of the backwash ratio should be tested in a long run. This would allow to properly test the effect of PAC on the filter panels and see how often the panels need to be chemically washed. Additionally, the recycling of PAC from the backwash discharge pipe could be tested. This would reduce the consumption of PAC, which in this case was produced from coal. Other PAC types produced from more sustainable raw materials could also be tested.

5 Conclusions

In this study, the separation of PAC from wastewater was tested with a microsieve. Two types of PAC were applied: the finer Norit SAE Super and the coarse AquaSorb® PAC-C. Different doses of coagulant and polymer were tested with each PAC type to see what doses are needed to separate PAC from wastewater, and to see if the PAC particle size has an effect on the results.

The results of the trial runs show that successful coagulation and flocculation are essential in PAC retention by disc filtration. The smallest pore size of microsieves is 10 µm, while over 30% of PAC particles can be smaller than 10 µm. Effluent quality from PAC treatment therefore depends on how well PAC particles can be integrated into flocs before disc filtration. The results show that both coagulant and polymer are needed for the flocculation of PAC.

The optimal dosing of chemicals was 2.0 mg Al/L for coagulant and 1.0 mg/L for polymer, with both PAC types and most PAC concentrations. However, even with the optimal chemical doses, a significant portion of PAC escaped through the microsieve. Possibly, better results could have been achieved with a different polymer. The finer Norit SAE Super had higher breakthrough compared to AquaSorb® PAC-C. The assessment of PAC breakthrough turned out to be challenging. Turbidity seemed to better reveal the breakthrough of SAE Super, while suspended solids seemed to work better with PAC-C.

The microsieve was affected by PAC, which could be seen in the increasing backwash ratio and the PAC deposits on the backwash nozzles and strainer. PAC was dosed for 15 days, after which the disc filter had to be thoroughly cleaned. The accumulation of PAC on the disc filter would however be reduced if only optimal chemical doses were applied. To properly see the effect of PAC on the microsieve, it would be necessary to have a long test run.

6 References

Johanna Castrén. 2016. Haitta-aineiden poisto jauhemaisella aktiivihieillä. Laboratoriokokeet 2015. Internal report, Helsinki Region Environmental Services Authority. 25 p.

Philip Isgaard and Elias Thörnqvist. 2016. Integration of powdered activated carbon in tertiary disc filtration of wastewater. Master's thesis, Lund University Department of Chemical Engineering. 48 p.

Victor Kårelid, Gen Larsson and Berndt Björleinius. 2017. Pilot-scale removal of pharmaceuticals in municipal wastewater: Comparison of granular and powdered activated carbon treatment at three wastewater treatment plants. *Journal of Environmental Management* 193, pp. 491-502.

Margarethe Langer. 2013. Feasibility of the microsieve technology for advanced phosphorus removal – Additional trials. Project acronym: OXERAM 2b. Kompetenzzentrum Wasser Berlin gGmbH. 15 p.

