Summary of preliminary results on wastewater filtration

Av Eilen Arctander Vik

Eilen Arctander Vik er siv.ing. fra NTH 1975.
Hun er ansatt som forsker på NIVA.

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Objective of Research

The project started as a preliminary investigation in the Spring of 1977. A literature review about different types of granular filters and their operation was made (1). Based on this survey, further research on filtration of primary and secondary treated wastewater was decided. The objective of the projekt on filtration was the following:

1. To establish design criteria for filtration plants.
2. To gain experience with operation of full scale unit.
3. To gain practical experience with different types of filters, used for filtration of primary and secondary treated wastewater.
4. To gain experience with problems connected with biological growth in the filters. Especially looking at effluent water quality and effectiveness of backwashing.
5. To establish costs of filtration units.

Test Equipment

To obtain data under controlled conditions in addition to operation experiences on different treatment plants, the project was divided in two parts.

Part I: Pilot plant research at NIVA's research station at Kjeller.

Part II: Investigation of 4 full scale treatment plants in Norway, using filtration.

The work on Part I started in August 1977 and is expected to be finished in January 1979.

The work on Part II started in August 1977 and is expected to be finished in december 1979.

Part I Includes:

1. Pilot plant research using three types of filters, diameter 330 mm, namely downflow sandfilter, upflow sandfilter, and downflow dual-media filter (anthracite + sand). Two types of treated wastewater were used; secondary precipitated using Al^{3+}, and simultaneously precipitated, using Fe^{2+}. (The latter was just used for a short

period of time and this work will be continued this autumn.)

Three different types of filters were used, Figure 1. More specific data are given in Table 1.

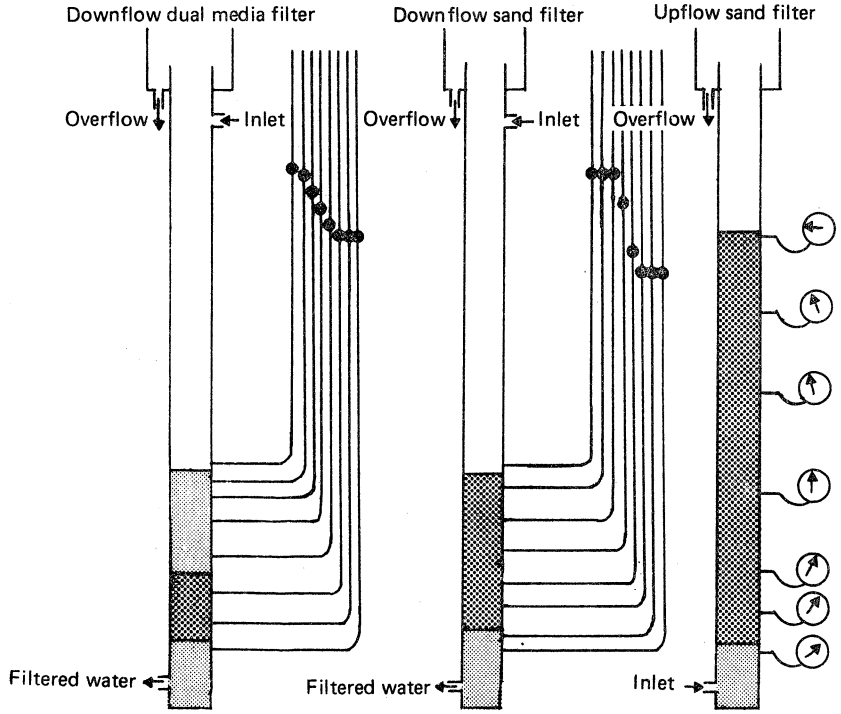

Figure 1. *The three filter types used at the pilot plant research at Kjeller.*

Table 1. *Filter data for the three filters used at Kjeller.*

Filter type	*Particle size mm*		*Depth of filter bed m*
Downflow dual media filter	Anthracite:	1.6—2.5	0.6
	Sand:	0.4—0.8	0.4
	Gravel:	2.0—32	0.4
Downflow sandfilter	Sand:	0.4—1.0	1.0
	Gravel:	2.0—32	0.4
Upflow sandfilter	Sand:	0.4—2.0	2.5
	Gravel:	2.0—32	0.4

2. Laboratory scale research using two downflow sandfilters (diameter 100 mm) identical except regarding the backwashing procedure. One filter was backwashed with water alone, the other with water and air.

Part II

In the study, it was planned to build 4 different types of granular filters at 4 existing wastewater treatment plants. The plants represent different treatment processes and are also varying in size. The plants had following specifications:

Table 2. *Treatment Plants around Mjøsa connected to the filtration project.*

Name of Treatment plant	*Size pe*	*Process*	*Filter Types*
Hovemoen	2000	Simultaneous precipitation using $Al^{3}+$	Dual Media Pressure Filter (Alfsen & Gunderson A/S)
Sjusjøen	1000	Secondary precipitation using $Al^{3}+$	Continuously backwashed Sandfilter (Thune Eureka A/S)
Jølstad	400	Post-precipitation using $Al^{3}+$	Continuously backwashed Sandfilter (Alwatech A/S) (known as Tenten filter)
Snertingdal	300	Simultaneous precipitation using $Fe^{2}+$	Contactfilter (AIB)

Unfortunately, different circumstances have delayed the construction of two of the filter plants. Two of the full scale plants will therefore not be included in the project.

In connection with Part II, an experiment was made at Hovemoen treatment plant (2). A dual media pressure filter was used to filter simulaneously ($Al^{3}+$) precipitated water (see Figure 2).

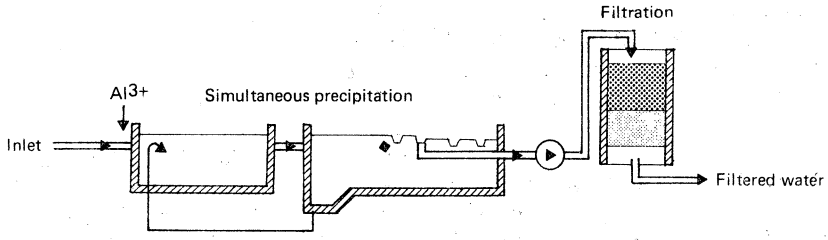

Figure 2. *The pilot plant experiments at Hovemoen wastewater treatment plant.*

Experimental Program

Part I

1. *Pilot plant research at Kjeller*

The filtration experiments using secondary precipitated wastewater (Al^{3+}) were run for about two months, while the experiments using simultaneously precipitated wastewater (Fe^{2+}) were run for one month.

The filtration rate was varied during the period.

The backwashing of the two downflow filters was made every 24 hours.

The upflow filter was backwashed more infrequently.

Different kinds of observations were made: The turbidity was measured once an hour on inlet — and outlet water of the filters. A picture was taken every hour to read the change in pressure at different depths of the filter. (Colunms showing water level were used in the downflow filters, while manometers were used in the upflow filter.) During the first part of the experiment, composite samples were taken every day and following parameters were measured; Suspended solids (SS), total phosphorus (Tot P), orthophospate (Ortho-P), and fecali coliforms. The oxygen concentration at different filter depths was measured now and then.

During the last part of the experiment (simulanteous precipitation, using Fe^{2+}) the turbidity and pressure were the only parameters measured.

2. *Laboratory scale research at Kjeller*

During the pilot plant experiments the filter run was gradually shortened. The initial pressure drop (measured one hour after every backwashing) increased during this period. One also measured an increasing oxygen uptake over the three filters due to biological activity.

These observations made us especially interested in looking at the influence of biological activity on the filter run.

Two filters (100 mm, diameter) identical except connected with the backwashing procedure, were used filtering secondary precipitated (Al^{3+}) wastewater. One filter was backwashed with water alone, the other with water + air.

Turbidity and pressure drop were measured every hour. Dissolved oxygen concentration and oxygen uptake were measured. ATP, TTC and total plate count were used to measure biomass.

Part II

So far, Jølstad wastewater treatment plant is the only one in operation. The plant was started in Spring 1978. The investigation started in June 1978. The treatment plant is designed for a flow of 6 m^3/h (the filter for 9 m^3/h), although the flow at the present time is only 1 m^3/h.

For one month experiments on filtration was made at Hovemoen treatment plant in Lillehammer. The municipality was going to decide whether one should build a post-precipitation plant or complete the simultaneous precipitation with a filtration step. The municipality was primarily interested in what quality of the effluent one could reach (based on total phosphorus).

Test Results and Discussion

Part I

1. *Pilot plant research at Kjeller.*

The water quality of the influent showed a great variation. Figure 3 gives the turbidity of the influent and effluent of the filters during the period. The Figure shows a great difference in results from the part filtering secondary treated wastewater ($Al^{3}+$), compared with the part filtering simultaneously precipitated wastewater ($Fe^{2}+$).

As shown in Figure 4, the three filters did not seem to give any difference in effluent water quality.

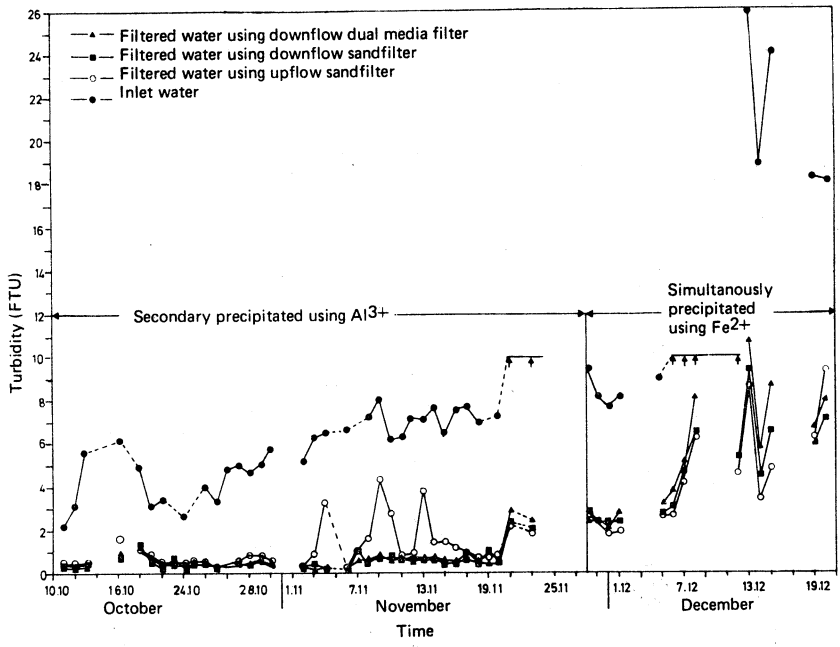

Figure 3. *Turbidity measured on inlet and effluent water of the filters during the pilot plant research at Kjeller.*

The concentration of the coliforms was measured every hour during one filter run (the dual media filter). As seen in Figure 5, a better hygienic quality of the water can be obtained.

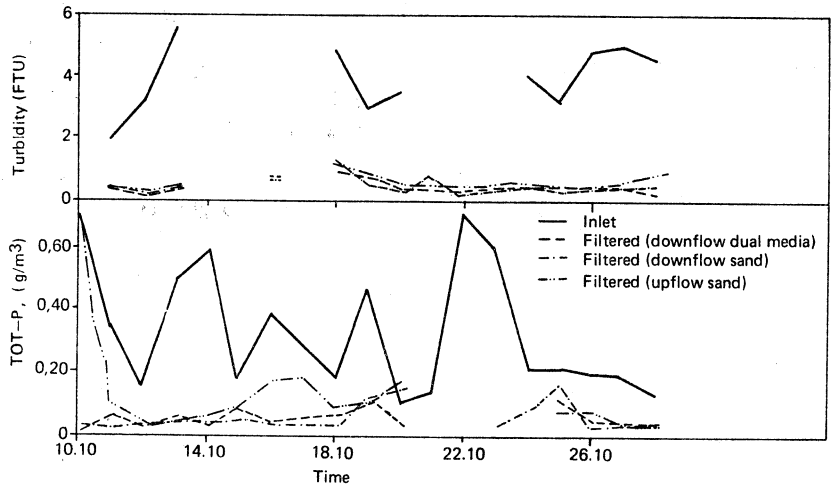

Figure 4. *The reduction in turbidity and phosphorus by filtration.*

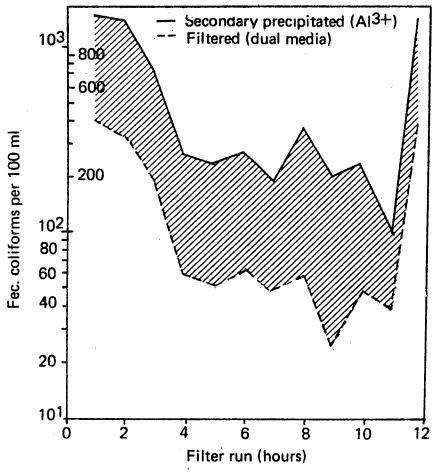

Figure 5.

Coliforms reduced over the dual-media filter during one filter run.

2. *In the laboratory scale research at Kjeller*

we wanted mostly to look at the influence of the biological activity on the filter run. The turbidity and pressure drop during two filter runs in the start of the period and during two runs later in the period are presented in Figure 6.

The Figure shows a difference in length of filter run for the two filters. The difference is increased during the experimental period. The filter being backwashed with water alone has got the shortest filter run.

The oxygen uptake after backwashing was measured during the whole experimental period. The result is presented in Figure 7. As we can see from the Figure, the uptake has increased during the period, especially for the filter where

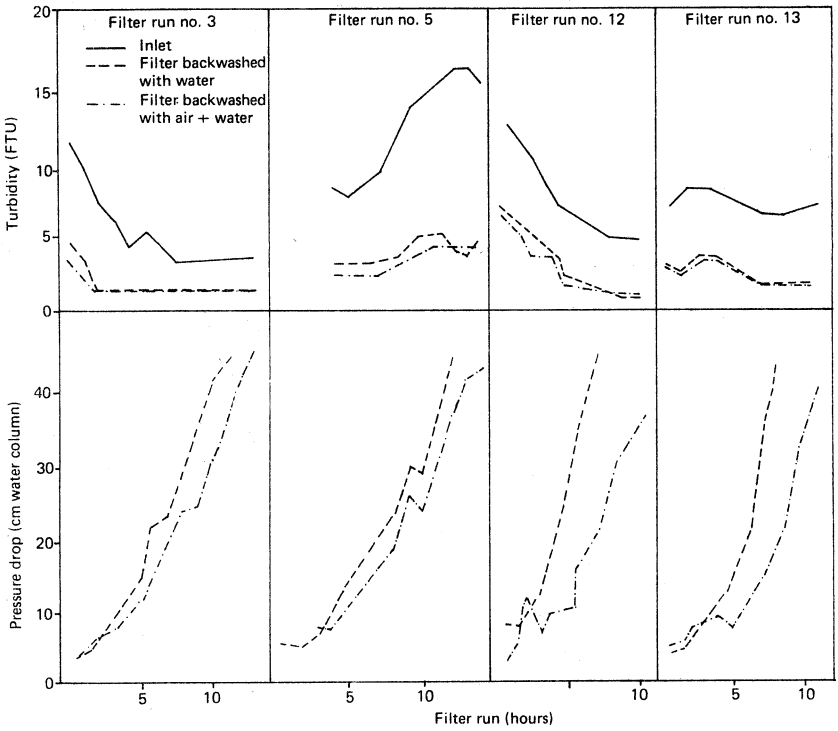

Figure 6. *Turbidity and pressure drop during filter runs early and late in the experimental period.*

water alone has been used for backwashing.

Visually, after every backwashing, particulate material has been observed on top of the filter just after backwashing with water, while the other filter seemed to be clean.

Part II

The study at Jølstad treatment plant has not given too many results yet. The low flow has given continuously operational problems. The problems have been so severe that all the water entering the filter has been used for the continuous backwashing of the sand, and at times essentially no water was leaving the filter. In spite of this, the sand gradually clogged and the overflow went into operation. To meet the problems caused by the intermittent pumping to the filter, a recirculation of water through the filter will be installed at Jølstad. The filtration principle is shown in Figure 8.

The experiment at Hovemoen treatment

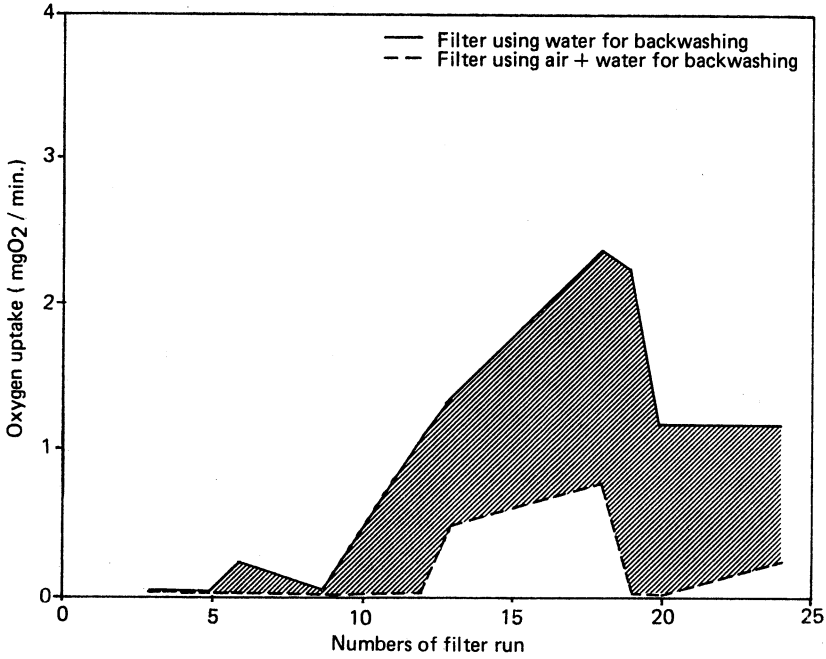

Figure 7. *The oxygen uptake over the two filters measured after backwashing.*

plant where a pilot filter was used, went on for a month. The reduction in suspended solids and phosphorus is presented in Figure 9. During the first week, the amount of chemicals used was reduced, which caused higher outlet concentrations of total phosphorus. As long as the precipitation was optimal, the outlet concentrations were low.

Initial Conclusion

— The filtration process gives a more even quality of the effluent.

— Different types of filters seem to give the same quality of effluent.

— High effluent concentration of total-phosphorus is often caused by high influent concentration of ortho-phosphate.

— Reduction of Fec. Coli content will be obtained through filtration.

— The bakwashing system is of great importance to all types of filters.

— Water alone seems not to be effective enough for backwashing.

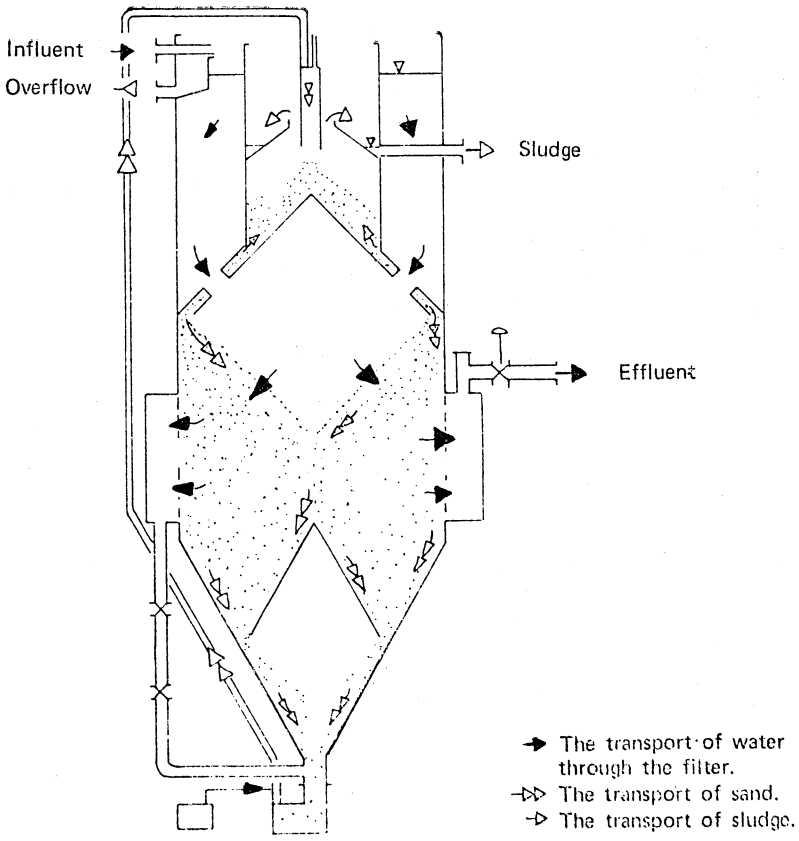

Figure 8. *The continuously backwashed sandfilter used at Jølstad wastewater treatment plant.*

— A combination of air and water for backwashing of a downflow filter seems to be an effective method.

— Intermittent operation of continuously backwashed filters due to low flow causes operational problems.

— An ineffective backwashing gives an increasing amount of biological growth in the filter, which results in decreasing filter run.

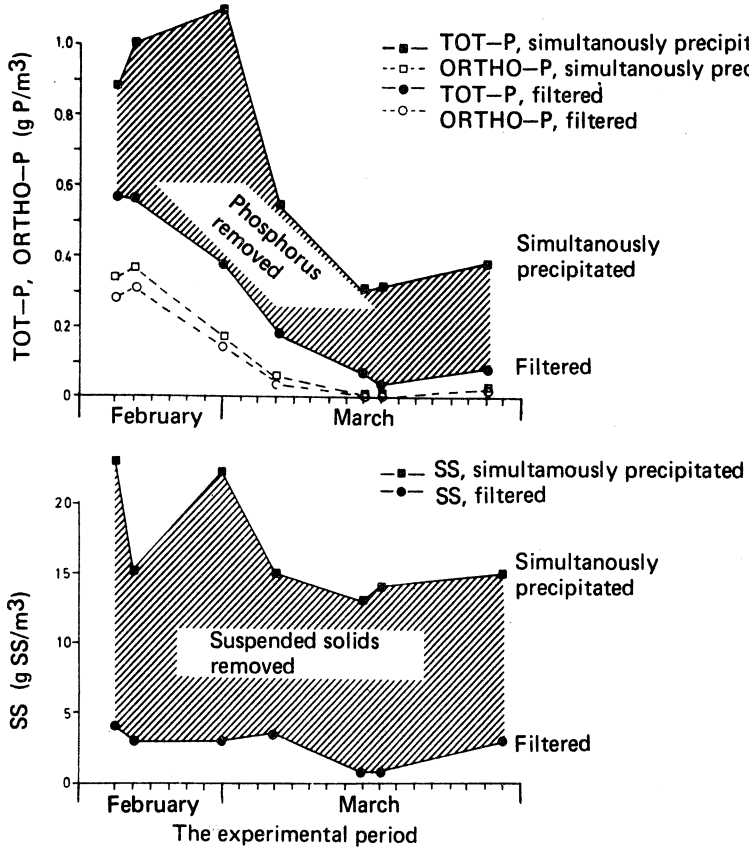

Figure 9. *The reduction in suspended solids and total phosphorus during the experimental period at Hovemoen 1978.*

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1. *Balmér, P. Filtrering av avløpsvann* fra kommunale kloakkrenseanlegg. NTNF, April 1977.

2. *Vik, E. A.,* Filtrering av avløpsvann fra kloakkrenseanlegg. Resultater fra pilotforsøk på Hovemoen renseeanlegg. NTNF, April 1978.