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Prefiltration pilot study with drum filters

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ABSTRACT

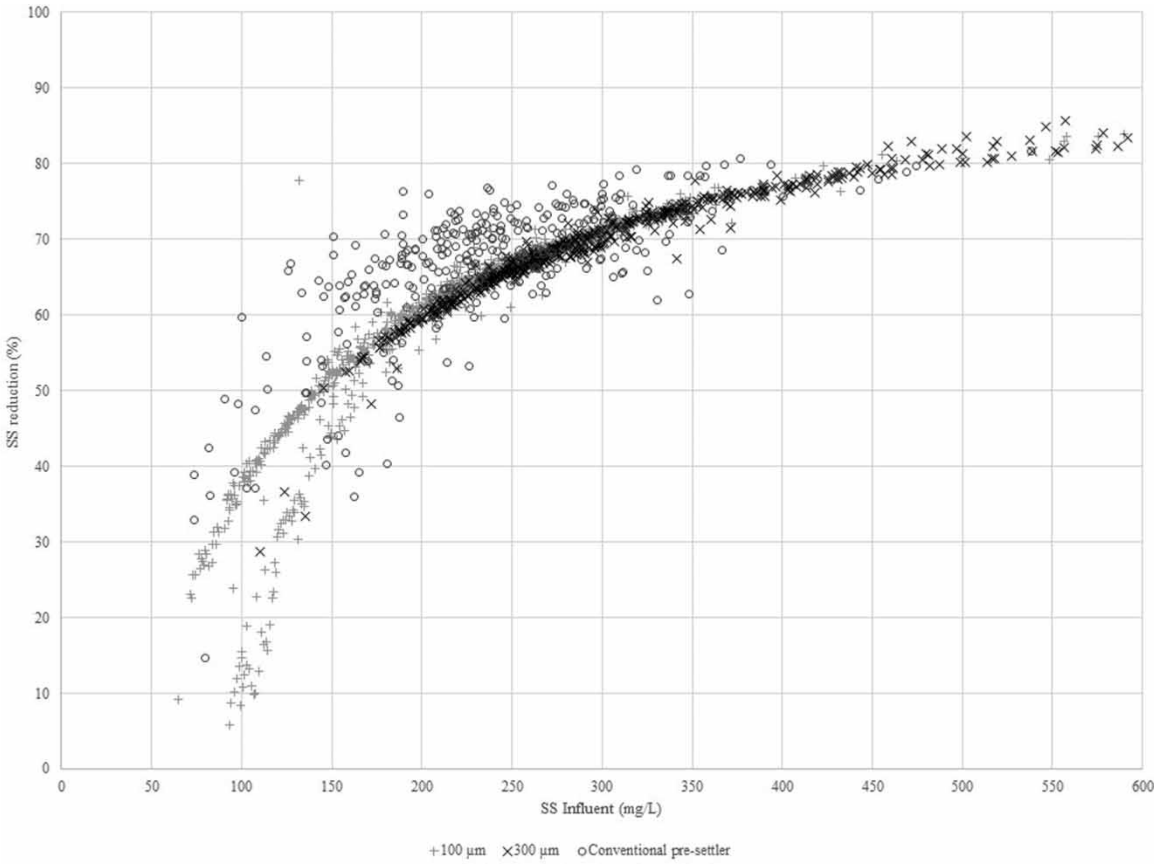
The Rya wastewater treatment plant (WWTP) in Gothenburg, Sweden, is facing new and stricter effluent requirements and an increased predicted flow and population. A pilot study was done to evaluate drum filters as a possible space-efficient pretreatment compliment to the conventional pre-settling tanks. The pilot trials proved that the drum filter was able to reduce organic materials and phosphorus at different loads. The reduction was similar between two different pore sizes (100 and 300 μm) and the suspended solids (SS) effluent concentrations (35–200 mg/L) was similar to the conventional pre-settling tanks (40–130 mg/L). The two pore sizes had similar maximum flow capacities but the 300 μm was able to maintain that capacity for a longer time and higher influent SS concentrations. Chemical precipitation was able to increase the reduction of both SS and phosphorus. The drum filters could handle higher SS peaks during tunnel flush events while maintaining similar effluent SS concentrations as during normal operation. It became clear when analyzing the results that daily average data did not capture bypass events caused by momentaneous peaks in either influent SS or flow. Hourly data analysis is needed to correctly design and dimension a pre-filtration process with drum filters.

Key words: drum filter, hourly average data, microscreening, particle removal, phosphorus removal, primary treatment

HIGHLIGHTS

- Evaluation of drum filters as space-efficient complement to conventional pre-settling tanks.
- Chemical precipitation increased reduction of suspended solids and phosphorus.
- Hourly data were important for analysis of bypass events. Bypass events are important to consider for dimensioning full-scale applications and how much momentary load would be feasible for the subsequent biological treatment.

GRAPHICAL ABSTRACT



INTRODUCTION

The Rya wastewater treatment plant (WWTP) in Gothenburg, Sweden, is facing new and stricter effluent requirements, and at the same time, a continued increase in population is expected in the coming years. Expansion of the current WWTP on new areas is necessary and a project, Nya Rya, started in 2021 which aims to complete this expansion and be fully operational by 2036. The project is also evaluating the capacity of the current WWTP and how to co-exist with the new processes. A technology screening in 2021 led to the decision to run a pilot study during 10 months with a drum filter as a possible efficient pretreatment step in addition to the conventional pre-settling tanks. The pilot study included chemical dosing of both polymer and polyaluminum chloride (PAC) prior to the drum filter, testing periods with higher suspended solids (SS) loads in the influent and two different pore sizes (100 and 300 µm).

The aims of this pilot study were to conclude if micro screening in drum filters is a viable complement or alternative to the existing conventional pre-settling tanks, to gain knowledge of reduction of organic materials and phosphorus (P) at different loads, give input to the Nya Rya project for possible dimensioning of pretreatment steps and to gain practical experience with drum filters in terms of operation and maintenance.

Surface efficient complements or alternatives must be considered if the current pretreatment at Rya WWTP requires increased capacity in the future or in case parts of the area currently occupied by the pre-settling tanks would be needed for other processes. The pretreatment alternatives also need to be able to handle momentaneous peaks in SS and flow during tunnel flush events. Micro screening in drum filters could be a potential pretreatment compliant at the Rya WWTP due to its smaller footprint. Previous studies have concluded that different types of microscreens can be competitive alternatives to conventional pre-settling, especially if available space is an issue (Ljunggren 2006).

Current wastewater treatment at the Rya WWTP

The Rya WWTP is a regional plant that treats wastewater from Gothenburg and seven nearby municipalities with approximately 800,000 people connected. The plant was originally commissioned in 1972 as a high loaded activated sludge plant and later expanded with pre-settling, increased aeration and simultaneous precipitation with ferrous sulfate in the 1980s. The plant was expanded for nitrogen removal with pre-denitrification in the activated sludge and nitrification in trickling filters in the late 1990s. Starting in 2005, parts of the pre-settling tanks are used as parallel chemical treatment during high loads when the total influent flow is greater than the capacity of the biological treatment steps. The plant was further expanded with post-denitrification in a moving bed biofilm reactor (MBBR) and microscreening in 15 μm disc filters as a final polishing step in 2010. During 2017, additional MBBR reactors were taken into operation for post-nitrification and for sludge liquor treatment, by deammonification.

The current 12 conventional pre-settling tanks make up a total volume of 22,500 m^3 and an area of 5,800 m^2. The influent water passes through 20 mm bar screens, a sand trap and finally 2 mm step screens before reaching the conventional pre-settling tanks. Six out of 12 pre-settling tanks can be used for direct chemical precipitation with polymer and PAC to avoid overloading the biological treatment steps during rain weather flows. Tunnel flush events are performed weekly to flush sediment in the tunnel system close to the WWTP. These events cause momentary higher peaks of SS and flow to the plant.

Microscreening with drum filters

The influent water is led to the inside of the drum where the water is filtered through the filter elements to the outlet with gravity since there is a level difference inside and outside the drum (Figure 1). The water level inside the drum rises over time as the separated solid particles gradually reduce the water flow through the filter elements. The drum rotation and backwashing start when the level inside the drum reaches the level sensor. The backwash nozzles spray clean water from the outside of the filter elements and the solid particles that have accumulated on the inside are washed away to the sludge channel as the drum rotates.

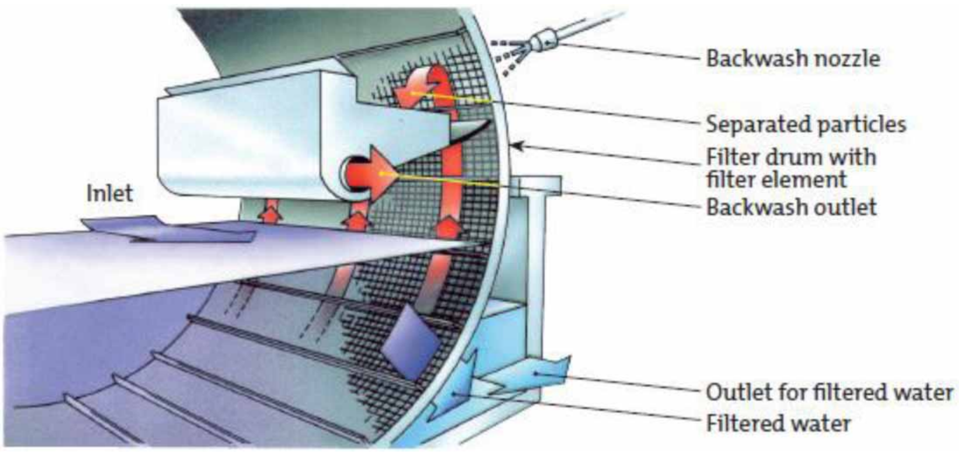


Figure 1 | Overview of the drum filter technology. Provided by Hydrotech Veolia.

METHODS

The drum filter

The drum filter pilot was a HDF1604 (Hydrotech Veolia) and the total tested surface area was 2.4 m^2. The installed pilot filter area was too large compared to the rest of the pilot system, so only one-third of the total available area in the pilot was tested in this study. Therefore, it was determined by the supplier prior to the pilot trials that two-thirds of the filter area needed to be plugged to keep the hydraulic retention time (HRT) of the chemical precipitation within the correct time interval to achieve enough coagulation prior to the filter. Using two-thirds of the filter area would correspond to the provided design of the hydraulic capacity of the drum filter that the study aimed to evaluate. Using the whole available filter area would result in operation with too low backwash frequencies resulting in no possibility to test the filter in the design operating conditions. Two different pore sizes for the filter elements were tested, 100 and 300 μm.

The wastewater to be treated was pumped into stirred coagulation- and flocculation tanks prior to the drum filter, regardless if chemical precipitation occurred or not. Those tanks were used as buffer tanks if there was no on-going chemical precipitation (Figure 2). The HRT of the coagulation- and flocculation tanks was in the range of 0.7–3 min and 2.4–10.6 min respectively. Coagulant was dosed to the wastewater in the pipe connecting the influent pump and the coagulation tank. The polymer was prepared in a separate mixing station and then dosed into the effluent weir from the coagulation tank to utilize the turbulence for satisfactory mixing. The wastewater was then led to the flocculation tank before entering the drum filter. Treated effluent from the Rya WWTP was filtered through a 1.19 mm mesh strainer before being used as backwash water. Sampling points were placed in the influent before the coagulation- and flocculation tanks, in the water effluent and in sludge effluent.

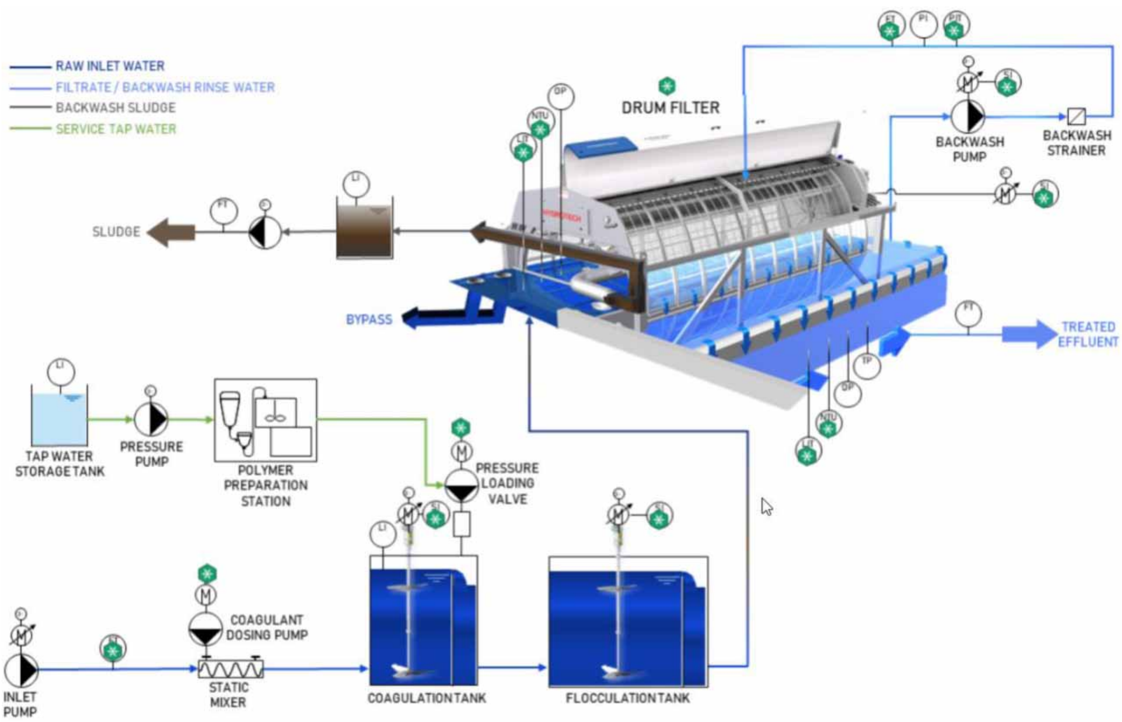


Figure 2 | Overview of the pilot drum filter process including coagulation and flocculation tanks. Note that this pilot study did not use treated water from the drum filter effluent as backwash water, instead treated effluent from the Rya WWTP was used. Provided by Hydrotech Veolia.

Chemicals

The study used a cationic polymer (H6358 from Hydrotech) and PAC (PAX XL 100 7.5% Al from Kemira). A cationic polymer was chosen over an anionic one based on the recommendation from Hydrotech Veolia who had prior experience with drum filters where cationic polymers resulted in stronger flocs and clearer effluent. A dosage of 10–15 mg Al^{3+}/L is normally required to reach a total P concentration of 0.2–0.3 mg/L in the effluent according to prior experience (Hydrotech Veolia). Dosing set-points in the range of 5–8 mg Al^{3+}/L were used during this pilot trial to see how close to this range effluent P concentrations the drum filter would be able to achieve. The dosing set-point for the polymer was set in the range of 3–5 mg/L.

Modes of operation

Two different modes of operation were tested, a level-controlled mode and a flow-proportional mode. The level-controlled mode adjusted the influent flow to keep it as high as possible to maintain a level set-point inside the drum (390 mm). This mode did not have any chemical precipitation and no bypass was possible since the level inside the drum was set. The flow-proportional mode controlled the influent flow to the pilot based on the influent flow to the full-scale Rya WWTP. A scaled signal from the Rya WWTP's process control system adjusted the influent flow to the pilot. The chemical precipitation to the drum filter started automatically at a typical rain weather flow, which was determined to be above 6.5 m^3/s to the Rya WWTP, corresponding to influent flows to the pilot above 73 m^3/h and surface loading rates approximately 31 $m^3/(m^2, h)$. Direct chemical precipitation of the conventional pre-settling tanks usually starts at influent flows around 8–10 m^3/s to the Rya WWTP. Influent flows above 6.5 m^3/s was chosen over 8–10 m^3/s to get longer periods with chemical precipitation to evaluate in the pilot study. Five different chemical precipitation campaigns were carried out during the 10 months pilot study in total testing different dosing set-points, flocculation with only polymer and chemical precipitation with both polymer and coagulant.

Sampling and analytical methods

Weekly 24-h composite samples were taken by automatic samplers from the influent and the effluent at rotating days. If the sample was taken on a Tuesday one week, the sample was taken on a Wednesday the following week. The composite samples were not flow-proportional. Weekly grab samples were taken from the sludge effluent. Both total and filtered fractions were analyzed; total fractions were analyzed without any handling prior to the analysis and filtered fractions were filtered through a 0.45 μm filter (Table 1).

Table 1 | Overview of the sampling

Sampling point	Total fraction	Filtered fraction
Influent	SS, BOD_7, COD, TOC, Total P, Total N	BOD_7, COD, TOC, Total P, PO_4-P, Total N, NH_4-N
Effluent	SS, BOD_7, COD, TOC, Total P, Total N	BOD_7, COD, TOC, Total P, PO_4-P, Total N, NH_4-N
Sludge	TS, VS	

Total fractions were analyzed without any handling prior to the analysis and filtered fractions were filtered through a 0.45-μm filter.

SS, PO_4-P, TS and VS were analyzed by the internal laboratory at the Rya WWTP, and the remaining analyses were sent to an external laboratory (Eurofins). The samples to be analyzed externally were stored in cooled containers and sent for analysis the same day. The analytical methods used at both laboratories were according to the Swedish Institute of Standards (Table 2).

Table 2 | List of analytical methods used

Analysis	Method
BOD_7	SS-EN ISO 5815-1:2019, ISO 17289:2014
Total P	SS-EN ISO 15681-2:2018
Total N	ISO 29441:2010
COD	ISO 15705:2002
TOC	SS-EN ISO 20236:2021
NH_4-N	ISO 15923-1:2013 Annex B
PO_4-P	SS-EN 872:2005
SS	SS-EN ISO 6878:2005
TS	SS-EN 15934:2012
VS	SS-EN 15935:2021

Sampling campaigns for chemical dosing of polymer and coagulant as well as tunnel flush events, (periods with short but very high influent SS), were conducted by taking 12 grab samples during a 24-h period. These grab samples were then analyzed the same way as the regular 24-h composite samples. The chemical precipitation campaign started dosing of both polymer and coagulant in the afternoon the day before the first sample was taken to prevent any initial disturbance, the dosing set-point for the polymer set to 3 mg/L and the dosing set-point for the PAC was set to 5 mg Al^{3+}/L. Tunnel flush events are done routinely at the Rya WWTP to remove as much as possible of grit and other various suspended particles that sediments in the tunnel system.

The sampling started a few hours before the start of the tunnel flush and continuously sampled every other hour for 24 h. Both sampling campaigns used the level-controlled mode of operation.

Maintenance

The pilot had two level sensors (one inside the drum and one outside), two turbidity sensors (one for the influent and one for the effluent) and a combined temperature/pH sensor. Each sensor was cleaned weekly my manual wiping and spraying with mild detergent. The backwash strainer was removed and cleaned weekly or more often based on need. The backwash nozzles were visually inspected weekly and cleaned when needed.

Filter elements will clog up over time and needs to be washed regularly to maintain capacity. The filter elements in the pilot were manually cleaned monthly with a pressure washer that sprayed clean water (drinking water quality) on the outside of the filter elements. The filter elements were also cleaned chemically every 3 months. A service technician (Hydrotech Veolia) performed the chemical cleaning with 4–5% hydrochloric acid (HCl) followed by 1–2% sodium hypochlorite (NaClO). HCl was sprayed first after which the first automatic washing was started. NaClO was sprayed after the first automatic washing was completed and a second automatic washing was started. A risk assessment of the chemical washing was performed (Hydrotech Veolia). Full-scale installations are equipped with automatic chemical washing systems.

RESULTS AND DISCUSSION

Maximum capacity

The maximum capacity of the drum filter was tested during the level-controlled mode, where the water level inside the drum filter was kept constant. The maximum influent flow, around 75 m^3/h, was similar for 100 and 300 μm at lower concentrations of SS in the influent but 300 μm was able to maintain higher flows as the SS concentration increased during test periods with level-controlled mode. The level-controlled mode kept the influent flow as high as possible to maintain a level set-point inside the drum. The influent flow was then at the maximum possible without any bypass or chemical precipitation. Larger pore sizes in the filter elements took longer to clog so the flow capacity was larger with larger pore sizes. The flow capacity is also related to the open area fraction which can differ depending on the thickness of the threads. The 100-μm filter was able to reach the same maximum flow capacity as the 300 μm but would likely require too frequent chemical washing to maintain the capacity and would hence not be sustainable long term. The average SS concentration in the influent was higher overall during the test periods with 300 μm compared to the period with 100 μm (Table 3).

Table 3 | Average influent flow, SS concentration in the influent, surface load rate and SS load rate with standard deviation during level-controlled operation without any chemical precipitation or bypass

	$Q_{influent}$ (m^3/h)	$SS_{influent}$ (mg/L)	Surface load rate (m^3/(m^2,h))	SS load rate (g/(m^2,h))
100 μm	42.5 ± 20.3	219 ± 77.6	21.7 ± 4.14	4,557 ± 1,295
300 μm	56.8 ± 16.0	354 ± 139	23.4 ± 7.37	7,905 ± 3,709

The surface loading rate had similar trends as the influent flow during testing periods with the level-controlled mode, the maximum influent flow possible without forcing any bypass or chemical precipitation. The maximum capacity, approximately 31 m^3/(m^2, h), was similar between filters with 100 and 300 μm pore size but 300 μm was able to maintain higher capacity at increasing SS concentrations in the influent (Figure 3). Hydraulic capacities during low influent SS concentrations in drum filters may also be limited by the pump used or the construction of the filter. Full-scale applications might therefore have larger differences in hydraulic capacities at low influent SS concentrations between different pore sizes than what was observed in these pilot trials.

The SS load rate was higher for 300 μm compared to 100 μm during testing periods in the level-controlled mode (Figure 4). Another pilot study using 100 μm pore size in drum filters achieved solids loading capacities of 3,000–10,000 g SS/(m^2, h) (Väänänen *et al.* 2016), which is in line with the results from this pilot study where 100 μm achieved around 2,000–6,000 g SS/(m^2, h). Increasing the pore size to 300 μm increased the SS load rate to around 5,000–10,000 g SS/(m^2, h). The maximum SS load rate was higher for 300 μm compared to 100 μm, unlike the flow capacity and surface loading rate where the maximum capacity was similar between 100 and

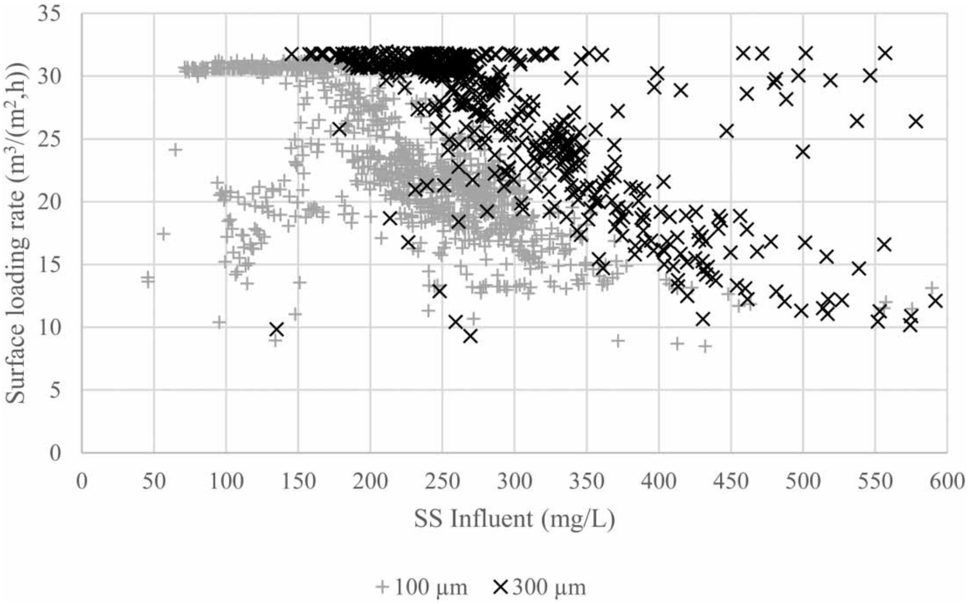


Figure 3 | Surface loading rate plotted against influent SS concentrations based on a turbidity sensor during level-controlled operation without any chemical precipitation or bypass.

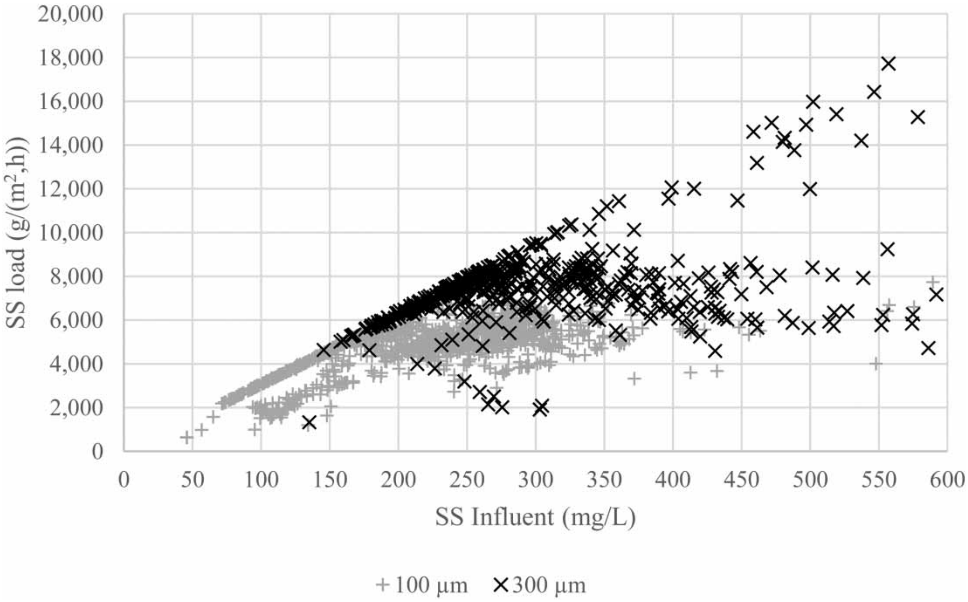


Figure 4 | SS load plotted against influent SS concentrations based on a turbidity sensor during level-controlled operation without any chemical precipitation or bypass.

300 μm. There are large variations in the SS load rate due to varying influent wastewater characteristics and the 300 μm had some SS load rates that kept increasing linearly with increasing SS concentrations in the influent.

Concentrations and reductions

The average effluent concentration of SS was similar to the conventional pre-settling tanks, just below 100 mg SS/L during operation with the level-controlled mode (Figure 5). The drum filter reduced the SS concentration to approximately the same level even with up to 600 mg SS/L in the influent, with both 100 and 300 μm pore size. A previous study with other micro screens, rotating belt filters, also observed stable effluent concentrations just below 100 mg SS/L with more varying influent concentrations and an average of around 240 mg SS/l, though rotating belt filters build up filter mats over time to achieve SS reductions while drum filters like the type tested in

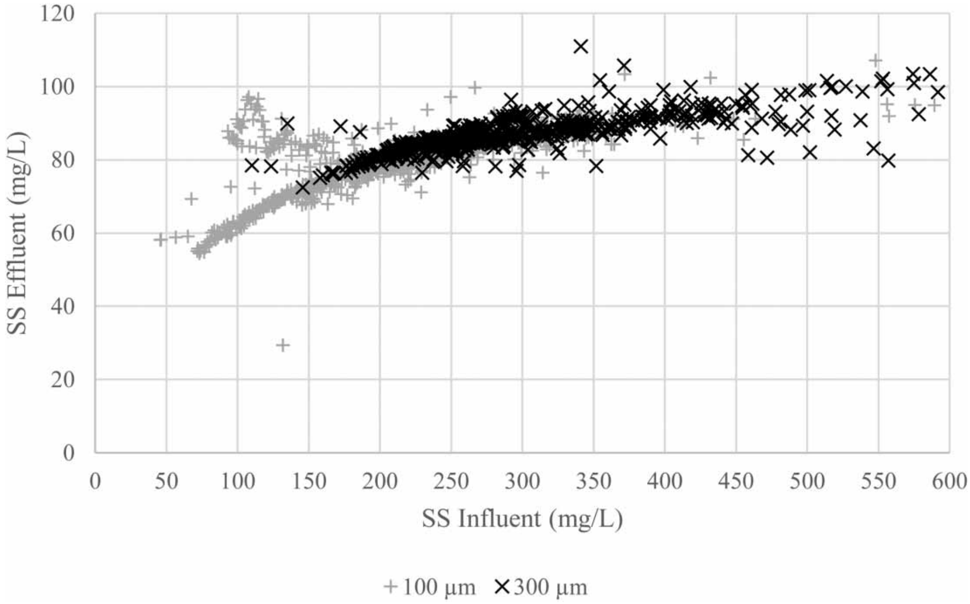


Figure 5 | Effluent SS concentrations plotted against influent SS concentrations both based on a turbidity sensor during level-controlled operation during, without any chemical precipitation or bypass.

this pilot trial does not to the same degree (Ossiansson *et al.* 2023). This makes direct comparisons between rotating belt filters and drum filters slightly difficult but both technologies achieved stable effluent concentrations while the variations in influent concentrations were significant. It is possible that most of the suspended particles in the wastewater were larger than 300 µm. In that case, most particles would separate from the water regardless if the pore size was smaller than 300 µm. Smaller pore sizes would not remove much more SS from the wastewater but would clog up faster and need more frequent back washing. Larger pore sizes with higher capacities would be preferable if the SS concentration in the effluent is similar. A particle size distribution analysis of influent water was not done during the pilot study. The 100 µm filter had some periods during the level-controlled mode of operation with very low influent concentrations that 300 µm did not have since there was a period with heavier rain causing the influent to be more diluted than during dry weather flows.

The SS reduction of the drum filter was around 65% on average for the whole test period while the conventional pre-settling tanks had 67% average reduction. The SS reduction leveled out at around 70–80% even as the concentration in the influent further increased above 300 mg SS/L during operation with the level-controlled mode (Figure 6). Since the drum filter reduced the influent SS to a steady effluent level, higher peaks in influent SS just led to momentaneous high peaks in reduction but not higher peaks in effluent SS. Another study on rotating belt filters also indicated that the pore size of the filter had little influence on the reduction results (Rusten & Ødegaard 2006). The SS reduction in this pilot study was larger than a previous similar pilot study using pore sizes of 40–100 µm, which achieved average SS reductions of 45–50% (Väänänen *et al.* 2016). The SS reduction of the drum filters in this study is also comparable to similar studies with rotating belt filters as micro sieves with pore sizes ranging in 100–350 µm that were able to achieve around 30–65% SS reduction (Franchi & Santoro 2015; Rusten *et al.* 2017). The SS reduction is highly dependent on the influent SS concentration. Different pilot trials at different WWTPs will experience different reduction rates due to the varying nature of influent wastewater.

Sludge

The average TS of the sludge was around 0.5% and the VS was around 78% on average for most of the pilot study (Figure 7). There are a few points with higher TS, between 1–1.8%. The primary sludge from the conventional pre-settling tanks had an average TS of 2.5% during this period for comparison. The drum filter pilot had plugged 2/3 of the filter elements and spray nozzles but it is still possible that the plugged filter elements pulled water that contributed to diluting the sludge as the drum rotates. A previous study with similar drum filter trials achieved total solids content in the range of 0.5–2%, which is in line with this study which was on the lower end of that range (Väänänen *et al.* 2016).

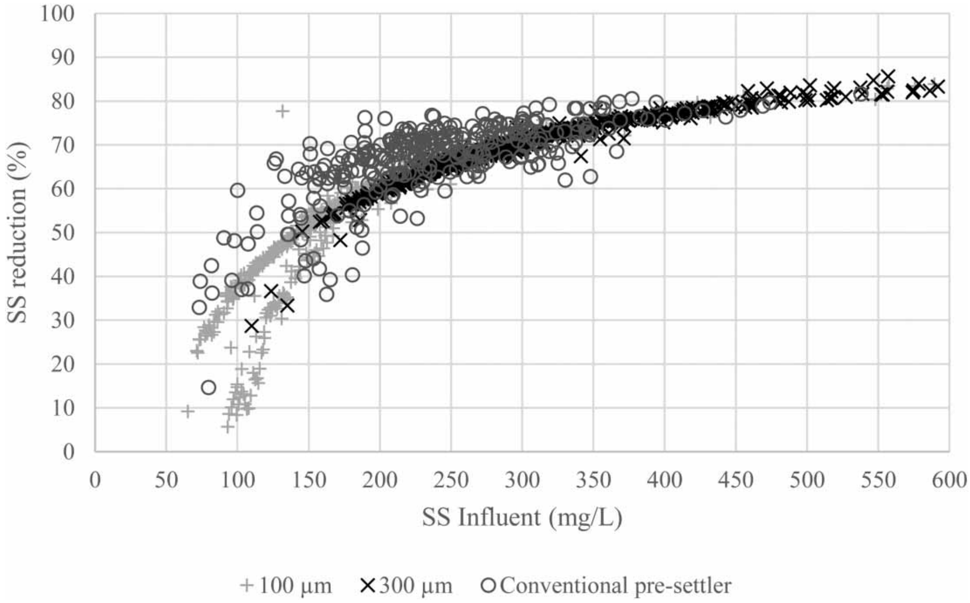


Figure 6 | SS reduction plotted against influent SS concentrations both based on a turbidity sensor during level-controlled operation with a duration, without any chemical precipitation or bypass.

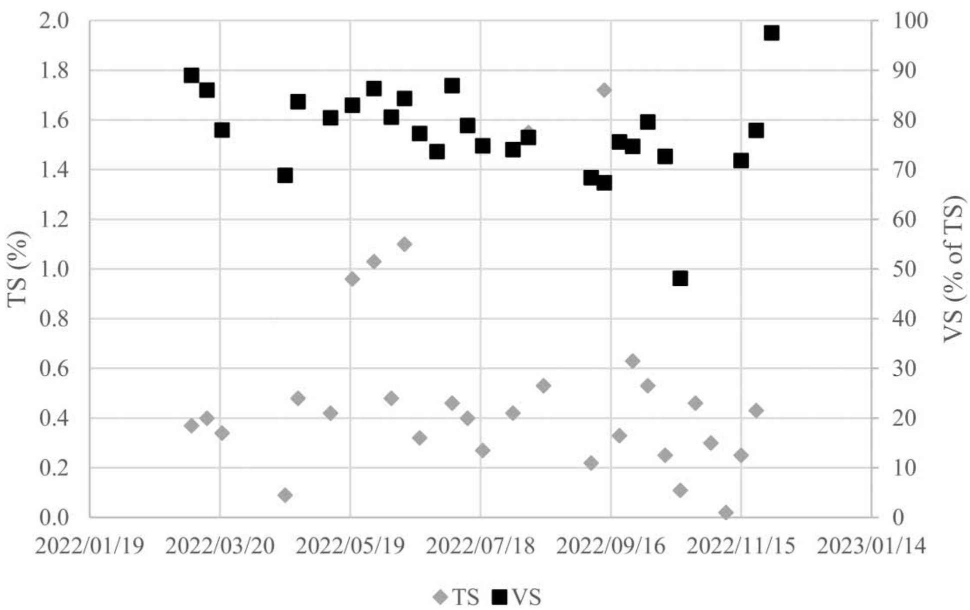


Figure 7 | TS and VS grab samples over time during the whole pilot trial.

Chemical precipitation campaigns

Dosing polymer and coagulant prior to the drum filters, increased the reduction of SS concentrations in the effluent wastewater. The 12 grab samples taken in one of the chemical precipitation campaigns were taken every other hour during a 24 h period and was not flow-proportional (Figure 8). The average concentration in the effluent was around 35 mg SS/L with an average reduction of 86% and a maximum reduction of 94% (Figure 8(a)). Previous pilot trials using drum filters with 100 μm filter elements achieved a mean SS reduction of 95% (Remy *et al.* 2014; Väänänen *et al.* 2016). The total P reduction was approximately 72% on average and just below 1 mg P/L in the effluent with chemical precipitation including both polymer and coagulant (Figure 8(b)). To compare, the average reduction of P without chemical precipitation was approximately 22% and the average effluent concentration was 3.4 mg P/l during the whole pilot trial and with both modes of filter pilot operation. Previous pilot trials achieved

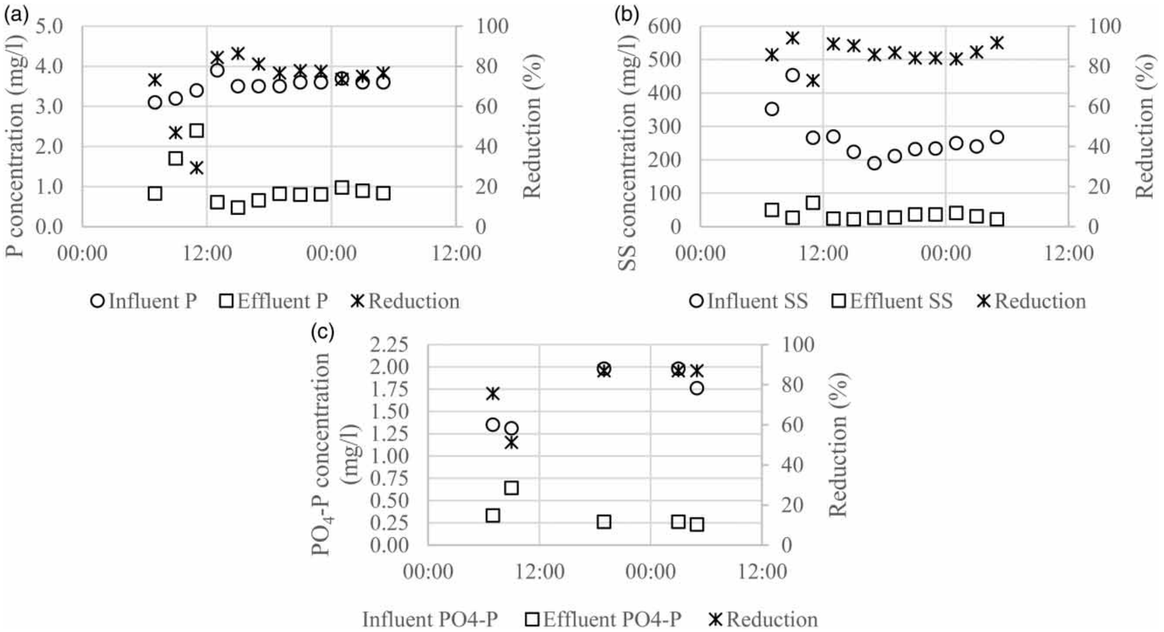


Figure 8 | (a) Grab samples of influent and effluent SS concentration during a chemical precipitation sampling campaign with level-controlled operation. (b) Grab samples of influent and effluent total P during a chemical precipitation sampling campaign with level-controlled operation. (c) Grab samples of influent and effluent PO_4-P concentration during a chemical precipitation sampling campaign with level-controlled operation.

70–90% total P reduction with 2–3 mg P/L in the effluent (Remy *et al.* 2014). Another similar previous pilot study achieved a total P removal rate above 95% and less than 0.3 mg P/L in the effluent using chemical dosing set-points of 1–5 mg polymer/L and 5–20 mg Al^{3+}/l (Väänänen *et al.* 2016). This pilot study used chemical dosing set-points in the middle of that range for polymer and in the lower range for PAC. It is possible that further fine tuning of dosing set-points could yield higher removal rates and lower effluent concentrations as the addition of chemical dosing proved to greatly improve P reductions. It would then be important, in full-scale, to carefully control the chemical dosing to avoid P limitations in subsequent biological processes. Phosphate (PO_4-P) was reduced to a greater extent with chemical precipitation, 77% on average with chemicals compared to 15% on average during the whole test period and both modes of operation without chemical precipitation (Figure 8(c)). The effluent concentration was down to 0.3 mg PO_4-P/l on average compared to 1.5 mg PO_4-P/l without chemical precipitation and both modes of operation.

Tunnel flush campaigns

There can be momentaneous and very high peaks of influent SS in the wastewater at the Rya WWTP during routine flushing of the tunnel system close to the plant. The influent SS concentration peaked at approximately 1,300 mg SS/L, but the effluent concentration was steady at around 100 mg SS/L throughout the campaign (Figure 9). The drum filter was able to maintain regular effluent SS concentrations despite the very high peak in the influent. The drum filter was operated in the level-controlled mode during this campaign and was able to maintain the level set-point inside the drum by lowering the influent flow fast enough as the influent SS quickly peaks and the level inside the drum rises, avoiding any bypass of the filter.

Bypass events during flow-proportional operation

A few bypass events occurred during the pilot trial with the flow-proportional mode. Bypass of the drum filter happens automatically when the level inside the drum rises above the maximum level, 490 mm. Such bypass events can happen due to two main reasons: One of the reasons is that the influent flow becomes too large, and the filter is not able filtrate water fast enough so the level inside the drum rises too fast. The other reason is that the filter elements become too clogged due to high influent SS concentrations forcing the level to rise faster than what the drum filter can filtrate even if the influent flow is lower. The daily average data had one

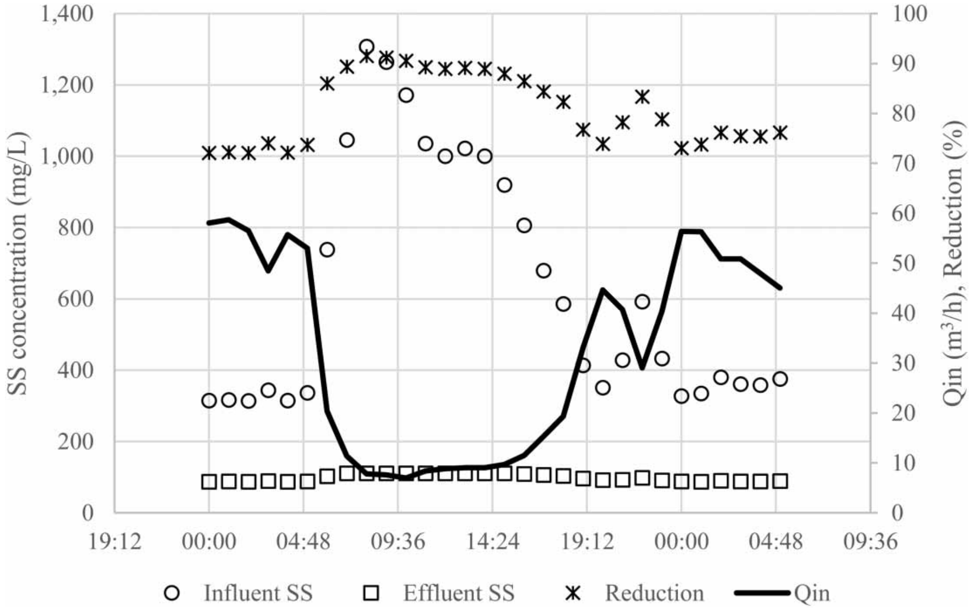


Figure 9 | Influent and effluent SS concentrations both based on a turbidity sensor during a tunnel flush campaign with level-controlled operation without any chemical precipitation or bypass.

bypass event in June 2022 where 30% of the total influent flow to the pilot was bypassed that day, there was a big peak in influent flow which caused the bypass (Figure 10).

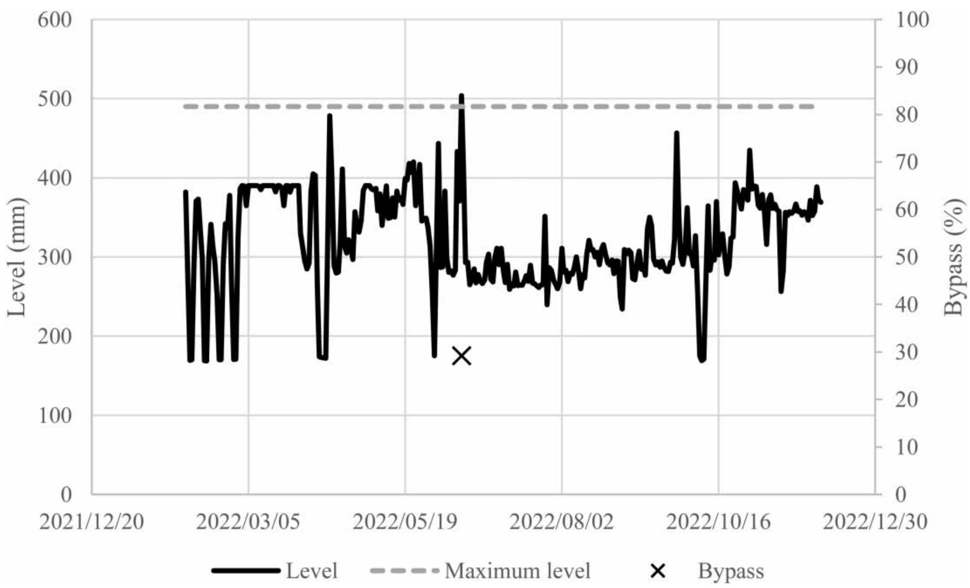


Figure 10 | Level inside the drum filter with one bypass event for the whole test period.

However, the daily data retrieved from online measurements could not capture all bypass events. There was for example a period with the flow-proportional mode of operation in November 2022 where there were two events of 10–15% bypass of the flow that hour (Figure 11). The first event had a very large peak in influent SS clogging the filter elements faster than what the back wash was able to keep up. The second bypass event also had peaks in higher influent flow. Overall, the average hourly bypass during these types of shorter events was 23% of the influent flow that hour during the whole test periods with flow-proportional operation. The bypass was similar between 100 and 300 μm pore size in the filter elements.

A large filter capacity is needed to avoid bypass completely, which would result in an unreasonable amount of filter units. Therefore, it is important to consider the degree of bypass at specific times and what level would be acceptable to momentarily load subsequent biological treatment steps. Daily average data did not capture bypass

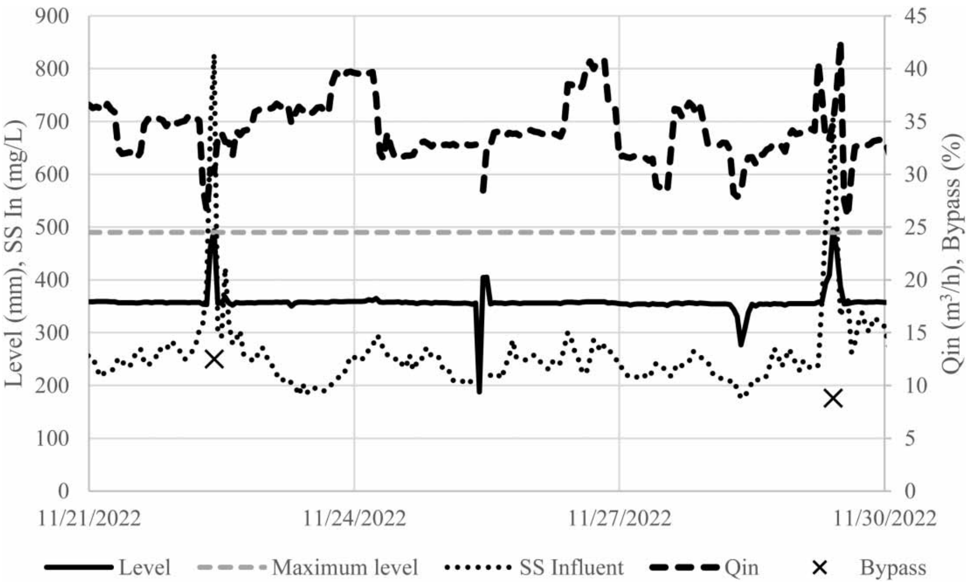


Figure 11 | Level inside the drum filter and influent SS based on a turbidity sensor together with influent flow during a test period in November 2022 with flow-proportional operation.

events caused by momentaneous peaks in either influent SS concentration or flow. Hourly data would then be important during design when calculating how much of the flow to the drum filters would be reasonable to bypass.

CONCLUSIONS

The pilot trials proved that the HDF1604 drum filter (Hydrotech Veolia) was able to reduce organic materials and P at different nutrients and flow loads, the reduction was similar between 100 and 300 μm in pore size for the influent water tested. The effluent SS concentration was similar to the conventional pre-settling tanks at the Rya WWTP and the trials provided practical experience with operation and maintenance of the filter. The filter, 100 and 300 μm in pore size, had similar maximum flow- and surface load capacities at lower influent concentrations, but 300 μm was able to maintain that capacity for longer and at increasing influent SS concentrations. The sludge from the drum filter had lower TS than the primary sludge from the conventional pre-settling tanks. Chemical precipitation with polymer and coagulant was able to significantly increase the reduction of both SS and P. Chemical precipitation prior to micro screening can then be a way to further reduce particles, if necessary, to limit area requirement as the flocculated particles in the wastewater allows the drum filter to maintain higher hydraulic capacities and without clogging up. The drum filter was able to handle higher peaks in influent SS during tunnel flush events while reducing the SS to similar effluent SS concentrations as during dry weather flow. High flow or SS peaks, either in combination or separately, can cause momentary bypass of the filter like as for the conventional pre-settling tanks during dry weather flow. Daily average data did not capture bypass events caused by momentaneous peaks in either influent SS or flow. Hourly data analysis is needed to correctly design and dimension a pre-filtration process with drum filters.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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