Novel processes for reducing phosphorus and SS levels down to tertiary discharge standards

By Martine Lanoue, Janin Michaud and Ross Garbett

Large population increases in rural areas, stricter discharge regulations, blue-green algae blooms and high phosphorus loads in watersheds are forcing wastewater treatment plants (WWTP) to consider upgrading their systems to include tertiary treatment of phosphorus.

Even when land is available for the upgrade of the system, it is often not economically feasible to do so. Fortunately, a combination of smaller footprint technologies is now available, that can provide efficient tertiary treatment of phosphorus and suspended solids.

This article will present two case studies, where a high-rate sand-ballasted clarification process, combined with cloth filtration, yielded a modular, flexible, tertiary treatment plant in just a fraction of the space required by conventional treatment technologies.

ACTIDisc® process train

The ACTIDisc process train for tertiary treatment is composed of two successive processes: the ACTIFLO® high-rate ballasted flocculation, and the HYDROTECH Discfilter cloth filtration.

The ACTIFLO process is a patented technology based on a high-rate settling process that combines the advantages of ballasted flocculation and lamella clarification.

The HYDROTECH Discfilter is a mechanical, self-cleaning filter, specially designed for achieving high performance in systems where it is essential to prevent coagulated flocs from fragmenting. The cloth filter works without pressure.

Effluent to be treated flows by gravity, or through pumping, into the filter segment from the centre drum. The media mounted on both sides of the partially-submerged discs separates solids from the effluent; the effluent flows through the disc media (microscreen cloth) into the collection tank. Once solids have accumulated on the inside of the media, the discs are cleaned by the counter-current backwash system.

Pilot testing and results

During the first half of 2009, performance of the ACTIDisc process for tertiary treatment was assessed in two pilot scale tests: in Henderson, Colorado, and in Innisfil, Ontario.

The purpose of the testing in Henderson was to prove the suitability of this process train to achieve a low level of total suspended solids (lower than 5 mg/L), low turbidity (lower than 2 NTU) and low phosphorus concentration (lower than 0.1 mg/L) in non-clarified water after a secondary reactor.

In the Innisfil study, the objectives were stricter and were applied on clarified water. The objectives were to obtain a total phosphorus concentration of less than 0.01 mg/L, and a turbidity lower than 0.2 NTU.

Pilot scale test - Henderson, Colorado

The ACTIDisc treatment train was tested on effluent coming from the Henderson City WWTP. The wastewater feed was located prior to the secondary clarifier. Both ACTIDisc components were tested and optimized separately. During the optimization period for the high-rate ballasted flocculation process, the removal efficiencies were studied at different flow rates. A rise rate of 61 m/h was optimal at the pilot scale level, and was used for the rest of the tests with the cloth filter.

The cloth filter process was tested, following the ballasted flocculation process. The filter panel material (polyester) was woven to a pore size of 10 µm. The average influent turbidity and TSS ranged from 130-150 NTU and 110-140 mg/L respectively. The objective was to achieve less then 10 mg/L of TSS coming out of the ballasted flocculation process and then treating that flow with the cloth filter. Test results are presented in Table 1. It can be seen that a three-fold increase in filtration rate did not significantly influence the effluent TSS of the cloth filter.

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Filtration rate (m/h)	Total suspended solids after cloth filtration (mg/L)	Number of data points (mg/L)
4.9	5.0	4
7.3	5.8	4
9.7	5.5	2
12.2	5.5	2
14.7	5.0	2

Table 1. Cloth filter – Effluent TSS performance (Henderson, CO).

Flow rate (m^3/h)	11.35
Rise rate on cloth filter (m/h)	7.3
Turbidity(NTU)	
Raw water	130
Clarified water	2.79
After filtration	1.87
Total phosphorus (mg/L)	
Raw water	6.44
Clarified water	0.239
After filtration	0.097

Table 2. ACTIDisc® performance on turbidity and phosphorus removal (N=3) in Henderson, CO.

Flow rate (m^3/h)	N	Rise rate (m/h)	Turbidity (NTU) Raw water	Turbidity (NTU) Clarified water	Total phosphorus (mg/L) Raw water	Total phosphorus (mg/L) Clarified water
15	1	20	n/a	0.89	0.26	0.036
30	5	40	7.1	1.73	0.56	0.052
45	3	60	12.5	1.00	0.72	0.034
60	9	80	6.1	1.12	0.28	0.031
75	4	100	8.1	0.94	0.29	0.040
90	12	120	6.3	0.98	0.29	0.042

Table 3. Average results vs. flow rate in the ACTIFLO® pilot unit (Innisfil, Ontario).

One of the objectives during testing was to achieve less than 0.1 mg/L of total phosphorus using the ACTIDisc process. To achieve this low level of TP, coagulant and polymer were dosed to the high-rate ballasted flocculation process, inline, before the first mixing tank. Coagulant and polymer were also dosed to the cloth filter. Data for turbidity, TP, and OP removal is presented in Table 2.

Treatment objectives for final effluent turbidity were to be less than 2 NTU, less than 5 mg/L of TSS, and less than 0.1 mg/L total phosphorus. Tests showed that, at the optimal coagulant dose in the ACTIFLO and in the discfilter, the final effluent rates were 1.68 NTU turbidity, 3 mg/L TSS, and 0.075 mg/L TP.

Pilot scale test - Innisfil, Ontario

Fed by wastewater from the town of Innisfil, the ACTIDisc process train was tested at different flow rates. The ACTIDisc process in this pilot study was used as a tertiary treatment (after secondary clarifier). Due to physical space constraints, both the high-rate ballasted flocculation process and the cloth filter were analyzed separately for their performance.

The high-rate ballasted flocculation process pilot unit was tested for flow rates between 15 m^3/h and 90 m^3/h. Coagulant dosing was added to the raw water, before the coagulation tank and a polymer was added in the injection tank. Table 3 presents the average results on samples collected at the outlet of the high-rate ballasted flocculation clarifier with the associated flow rate. Average clarified effluent TP concentration was 0.039 mg/L.

Throughout the pilot testing program, overall TP removal achieved by the high-rate ballasted flocculation clarifier alone

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Filtered water flow (m^3/h)	Filtration rate (m/h)	Turbidity (NTU) (average)	Total Phosphorus (mg/L)	
		After filtration	Raw water	After filtration
15	4.9	1.8	0.18	0.015
20	6.8	1.6	0.23	0.024
25	8.1	1.9	0.23	0.023
30	9.7	1.95	0.23	0.017

Table 4. Effluent turbidity and total phosphorus vs. filtered water flow on cloth filter (best results) in Innisfil (Ontario).

was 85%. Clarifier efficiency was not affected significantly by variations in the condition of the raw water.

Effluent from the ballasted flocculation process was partly sent to the cloth filter, where coagulant and polymer were added. Table 4 presents the different flow rates applied on the cloth filter and the corresponding average results.

Total phosphorus removal was efficient from 15 m^3/h to 30 m^3/h. During the test, most of the grab samples were measured below the 0.024 mg/L TP objective. Average total phosphorus in the effluent is presented in Table 5.

Total phosphorus (mg/L)		
Raw water	After Actiflo® (N=30)	After Discfilter (N=45)
0.29	0.039	0.024

Table 5. phosphorus in the effluent.

The ballasted flocculation process alone was capable of treating effluent to a turbidity of less than 1 NTU, and a TP removal close to 85%, which correspond to an average effluent concentration of 0.039 mg/L TP. The combination with the cloth filter was able to produce effluent with turbidities in the range of 1.5 - 2.0 NTU. TP removed by the cloth filter approached 40%, which corresponds to an average effluent concentration of 0.0235 mg/L TP.

Conclusions

Recent research and development efforts have made it possible to extend the phosphorus removal capacity of the high-rate ballasted clarification process by linking it with cloth disc filtration. The ACTIDisc process is aimed at achieving an effluent with a low level of total phosphorus and suspended solids discharge.

Both pilot tests have confirmed the efficiency of this combination of technologies, to achieve discharge values as low as 0.023 mg/L in total phosphorus, turbidities of 1.6 NTU, and 5 mg/L in suspended solids.

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