

Small (wastewater treatment plant) is beautiful

By Robert Lafond and Christian Scott, Veolia Water Solutions & Technologies Canada

Population growth and stricter discharge regulations are forcing wastewater treatment plants (WWTPs) in urban and high-growth areas to consider expanding or upgrading their treatment systems. These plant expansions often require extra land, where, sometimes, none is available. Also, expanding the WWTP may mean infringing on pristine land or already occupied land (farmland, reserve, etc.), making the expansion a bureaucratic nightmare. Fortunately,

some high-rate treatment technologies requiring a small physical footprint have been developed and can help bridge this gap. For example, the combination of novel biological treatment and novel high-rate physico-chemical treatment will yield a very flexible wastewater treatment plant in just a fraction of the space required by conventional treatment technologies. The following article will present two case studies highlighting such situations.

Biofilm processes for wastewater treatment

Wastewater treatment using biofilm processes has become popular in recent years as an alternative to conventional biological systems. One such method, the AnoxKaldnes™ Moving Bed Biofilm Reactor (MBBR) technology, is a continuously operating, fully-biological treatment process based on biofilm processing. Typically, the process occupies a fraction of the space required by comparably rated conventional systems.

The processes use plastic media to grow the biofilm, which is retained in reactors using media retention sieves while an aeration system is used to provide aeration to allow the bacteria/biofilm to provide the treatment required. Effective biomass within the bioreactor is augmented through growth on the media, and nearly all of the biomass is resident on the media

The carrier elements provide a large protected surface area for the biofilm as well as optimal conditions for the bacteria culture to grow and thrive in the reactor tank. The process can be designed for any shape or size tank and can also be retrofitted into existing tanks. Because the biofilm created around each carrier element provides a more stable environment for the bacteria to grow, less footprint space is required compared to other biological systems. Figure 1 shows an example of media used for the MBBR technology.



Figure 1. Example of media used in AnoxKaldnes MBBR installations

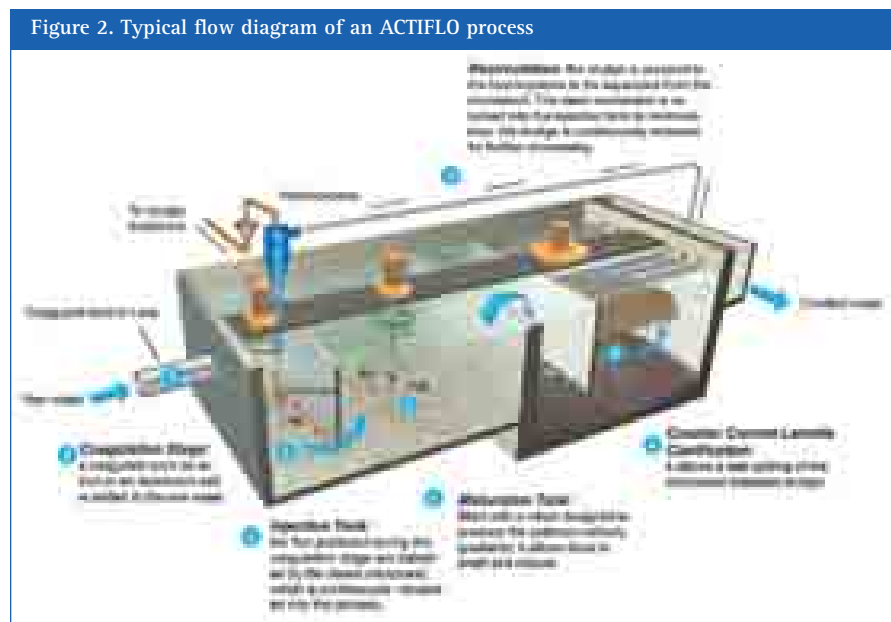


Figure 2. Typical flow diagram of an ACTIFLO process



Figure 3. The Skreia (Norway) WWTP surroundings

The MBBR biofilm carriers are suspended and thoroughly mixed throughout the liquid phase where they move freely in the tanks. Excess biofilm is continuously sloughed from the media and carried out with the effluent.

It is designed to handle extremely high loading conditions, yet function within a relatively small footprint. MBBR systems have been successfully implemented in more than 500 locations worldwide. The first MBBR, installed 20 years ago, is still using its same media and aeration system.

High-rate sand-ballasted clarification and flocculation

The high-rate, sand-ballasted clarification and flocculation treatment process, called ACTIFLO®, provides increased capacity without the large surface area requirements of traditional flocculation/sedimentation systems. These systems are typically 5-20 times smaller than conventional clarification systems offering similar capacity. Figure 2 presents a flow diagram of the ACTIFLO process.

In the sand-ballasted flocculation process, raw waste water is first mixed with a coagulant in a high-shear environment. In the next tank, the waste water is injected with a polymer and microsand and mixed aggressively before it enters the 'maturation zone,' where gentle shear is applied. The microsand-ballasted flocs increase in size, trapping smaller flocs before the wastewater enters the sedimentation tank, where the large flocs immediately begin to settle.

At this stage, the clarified wastewater then counterflows upward through lamellar settling tubes to collection troughs, where it can be diverted to various applications. The microsand and other solids in the ballasted flocs that settled in the bottom of the tank are then pumped to a hydrocyclone, where the microsand is cleaned and reinjected for reuse, and the waste solids are removed.

The technology has proven both flexible and versatile. The coagulation phase works on total suspended solids (TSS), as well as on chemically active contaminants. The polymer flocculent ensures that the microsand bonds strongly to the flocculated solids. The flocs, by themselves, are typically at or near the density of water, so they cannot settle rapidly without the added

Figure 4. Flow diagram for the Skreia WWTP

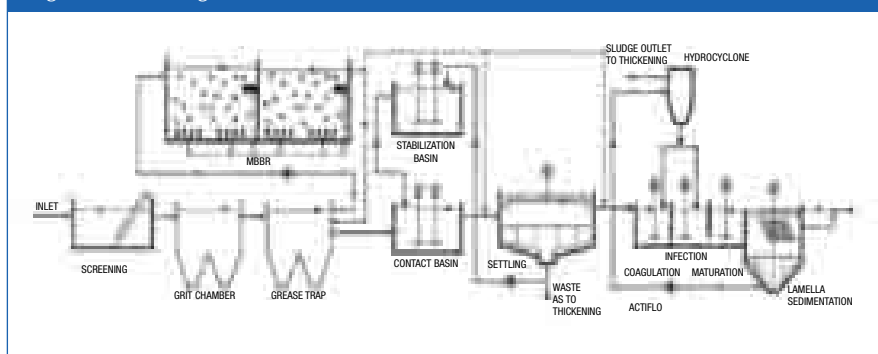
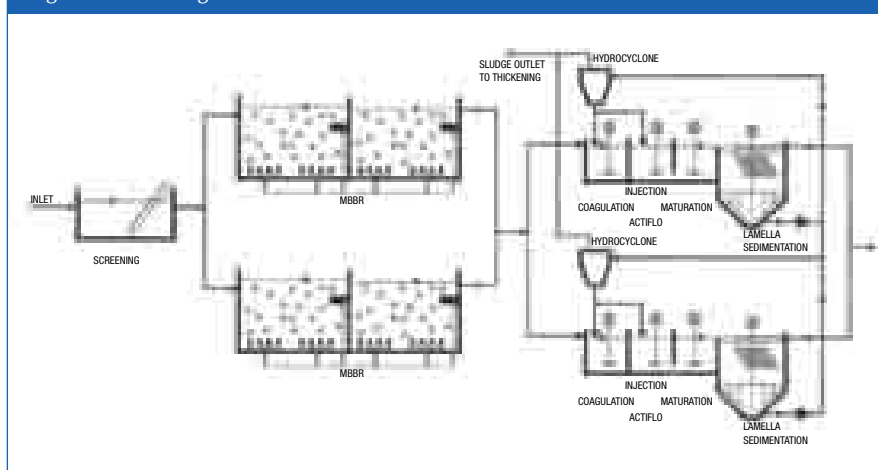


Figure 5. Flow diagram for the Handeland WWTP



weight of the microsand (specific gravity of 2.65). Once ballasted with the tiny microsand particles, the flocs sink immediately in the settling tank.

High-rate ballasted flocculation is a multi-task technology, serving as an effective high-rate clarifier and as a highly versatile chemical reaction vessel. Depending upon pH conditions, colloidal and particulate pollutants in the influent can be precipitated using classic and familiar chemical methods for efficient, sand-ballasted removal in the settling step. Virtually any constituent of raw feed water or wastewater that can be coagulated through chemistry can be effectively processed through the system.

Combining high-rate technologies for compact wastewater treatment

Space limitation for wastewater treatment plant expansions is an ongoing challenge for urban areas or constrained peri-urban installations. Being able to combine two high-rate wastewater treatment technologies can prove a major benefit to municipal decision makers.

Skreia WWTP (Norway)

Two municipal plants in Scandinavia are leading by their example. Water treatment officials in Skreia (Norway) wanted to upgrade their 20-year-old conventional activated sludge treatment plant to increase capacity by 80%, in order to accept a pollution load increase from a local potato processor. However, the plant is situated close to Lake Mjosa and the area available for facility expansion was restricted by farmland and a wildlife reserve, as shown in Figure 3. Therefore, it was necessary to look for a compact treatment solution that could be easily retrofitted within the existing land.

The use of these high-rate technologies in the existing Skreia WWTP not only allowed for wide variations in both hydraulic and organic loads, but also enabled a harmonious integration into the surrounding environment. Figure 4 presents the flow diagram for the Skreia WWTP. The design flow rate of 195 m³/h can be cranked up to a peak hourly flow of 300 m³/h using this treatment train. The MBBR technology was chosen for its high-rate biological treatment, to remove

Table 1. Effluent discharge efficiency for the Skreia WWTP during the 2005-2008 period

Parameter	Results from 2005-2008	
	Average removal efficiency (%)	Average effluent concentration (mg/L)
BOD5	98.6	4
COD	89.4	78
Total P	98.6	0.12

Values based on composite samples.

Table 2. Effluent discharge efficiency for the Handeland WWTP during the 2007-2008 period

Parameter	Results from 2007-2008	
	Average removal efficiency (%)	Average effluent concentration (mg/L)
BOD5	89.0	15.6
COD	82.3	62.8
Total P	85.3	0.83
TSS	86.7	20.2

Values based on composite samples.

soluble organic matter, and to increase and enhance the biological treatment capacity. This reduced the load to the activated sludge. The effluent from the MBBR treatment was then routed to the high-rate ballasted clarifier for final sludge separation and high quality effluent discharge. The plant also has the option of routing MBBR effluent to the plant's settling tank. Installed in 2002, the use of the two high-rate, small-footprint technologies has resulted in excellent removal efficiencies as is shown in Table 1,

where the 2005-2008 effluent data are shown. In fact, this WWTP reached an average discharge concentration of 4 mg/L in BOD₅ over this three year time frame.

Handeland (Norway)

The rural area of Handeland, also in Norway, has a small residential population, but expects increasing tourist growth in the near future, not unlike many towns in British Columbia that may see their population grow in the summer months. To meet this

challenge, the municipality chose to build a new treatment plant to serve the entire community.

Completed in 2004, the new wastewater treatment plant consists of fine screening, an MBBR for biological wastewater treatment, and a high-rate sand-ballasted clarification and flocculation technology for sludge separation as shown in Figure 5. The new plant is meeting the needs, requirements and expectations of the municipality as shown in Table 2, reaching an effluent discharge concentration of 15.6 mg/l in BOD₅ (objective of 25 mg/L) and COD of 62.8 mg/L (objective of 125 mg/L). The average design flow of 82 m³/h can be doubled to reach a peak hourly flow of 164 m³/h, which provides operational flexibility in handling large variations in flow and load. In addition, having two interchangeable and parallel treatment trains gives the municipality a lot of flexibility.

Conclusions for Canadian municipalities

Canadian municipalities across the country are confronted with the need to expand their treatment systems to obtain higher removal rates and, at the same time, handle highly varying loadings, while meeting ever more stringent discharge requirements. As shown through these European case studies, it is possible to integrate high-rate wastewater treatment technologies into wastewater treatment plant design to achieve this performance in very limited spaces, yet yielding a very flexible wastewater treatment plant. 💧

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