Nutrient removal

Are lagoons still a viable wastewater treatment option?

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Upgraded Hecla wastewater treatment facility.

Lagoons have been a viable wastewater treatment option for many decades. Many lagoon facilities were constructed in the 1960s and early 1970s with a 20 to 30 year capacity for future growth. Facultative lagoons (stabilization ponds) were the treatment system of choice for most small to medium sized towns and cities. In many cases, mechanical treatment plants were not a viable option considering the high capital and operational costs in addition to minimal regulated treatment requirements. Facultative lagoons with winter storage presented a cost effective method for basic primary and secondary treatment and ultimately some level of pollution protection for effluent receiving streams.

There are numerous problems facing the conventional "facultative lagoon with effluent storage" design approach today. Factors such as potential odour generation, development limitations within valuable setback zones, and most importantly the introduction of effluent nutrient limits, are driving the engineering community away from conventional lagoons towards mechanical treatment systems on an increasingly frequent basis.

Unfortunately for small to medium sized communities, implementation of a fully mechanical plant is not only a large capital investment, but more importantly it is a massive long-term operation and maintenance commitment (no provincial or federal funding), both financially, as well as retaining qualified operators.

Over the last 10+ years, Nelson Environmental Inc. has been committed to providing turnkey wastewater treatment solutions for small to medium sized communities, not only increasing the capacity of existing lagoon systems but also for improving effluent quality and reducing energy costs. Many of the lagoon upgrade projects completed to date consist of converting old facultative or aerated lagoons into high efficiency fine bubble aerated systems. As the value of land continues to escalate at a break-neck pace, some new aerated lagoon projects are being designed to continuously discharge effluent.

As regulatory bodies across North America re-evaluate their wastewater treatment guidelines and implement more stringent receiving stream protection measures, conventional primary and secondary treatment, even for small communities, is often no longer adequate.

In order to address these increased pollution control measures, Nelson Environmental has evolved the conventional aerated lagoon system into the OPTAER® process. This process is specifically designed to meet basic wastewater effluent requirements such as BOD and TSS removal, or adapted to meet the most stringent phosphorus and ammonia limits, in all climates, including extreme northern environments.

By thinking outside of the box, existing lagoon infrastructure has been salvaged, saving capital as well as operation and maintenance costs for clients that might have considered abandoning their lagoons and starting over with a new mechanical treatment plant.

In its most basic form, a continuous discharge OPTAER® system achieves effluent $CBOD_5$ less than 15 mgL and TSS levels of less than 25 mg/L. Systems are typically designed to require desludging only once every 20 to 25 years.

By implementing an alum dosing system, total effluent phosphorous levels of less than

Submerged attached growth reactor demonstration site.

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1 mg/L are comfortably achieved. If total phosphorous limits are more stringent than 1 mg/L, a tertiary gravity sand filter based phosphorus removal system can be incorporated to meet limits of 0.1 mg/L.

For enhanced ammonia removal the system can incorporate a post-lagoon Submerged Attached Growth Reactor (SAGR) achieving limits less than 5 mg/L in winter and less than 1 mg/L in summer.

Upgrade of the Hecla/ Grindstone Provincial Park Wastewater Treatment Plant

Manitoba's Lake Winnipeg is currently under close scrutiny as high nutrient loading in the lake has been demonstrated to be a major contributor to massive algae blooms that pose a severe risk to the overall health of the water body. While the focus has been on larger urban centers such as Winnipeg to reduce nutrients in wastewater effluent, small communities that discharge wastewater effluent directly to the lake watershed are not exempt.

Hecla/Grindstone Provincial Park wastewater treatment facility is located on an island in Lake Winnipeg. The facility was originally constructed in 1972 and designed to operate as an oxidation ditch. Some improvements were made to the process in 1998. Several conditions including requirements; for desludging and liner reconstruction, phosphorous removal, increase in design flow and the failure of an existing baffle wall prompted a need for an upgrade in 2006. A mechanical treatment plant option was considered, but an upgrade of the existing oxidation ditch was chosen as the most cost effective solution. A lagoon-based approach was also favored due to its ability to handle highly variable seasonal flows produced by the park without upset.

Nelson Environmental worked together with Wardrop Engineering to convert the existing oxidation ditch into a continuous discharge OPTAER® lagoon process. Construction was completed in the spring of 2007.

The upgrade design included dividing the "donut" shaped pond into four distinct zones using floating impermeable flow diversion baffles. The baffles create separate treatment zones, while minimizing short-circuiting to maximize the effective hydraulic retention time of the system.

Hydraulic retention time was a limiting factor considering the increase in design flows. In order to increase the reaction kinetics and the rate of treatment, a complete-mix fine bubble aeration system was installed in the first zone. The second and third zones were converted to operate in aerated partial mix mode to further facilitate BOD_5 removal as well as enhance solids settling.

The fine bubble aeration system presented significant energy cost savings over the existing coarse bubble process. The fine bubble diffusers selected were able to operate efficiently at a wide range of design flows that not only allowed for future expansion but allowed for blower turndown during off-peak winter months. With the increase in oxygen transfer efficiency, the existing blowers could be reused even though the design oxygen requirements were increased due to the higher design flow.

The fine bubble diffusers were suspended below a floating HDPE lateral, allowing them to be accessed from the water surface by boat. This set-up allowed for system maintenance without dewatering. A lateral self-tensioning system was implemented to allow for automatic lateral expansion and contraction adjustment.

Phosphorous removal was achieved by adding alum in a mixing chamber between zones 3 and 4 and allowing floc to settle in zone 4.

The fourth and final zone of the lagoon was designated a settling cell. In order to minimize algae in the system effluent, a cover composed of 100 mm hollow HDPE balls was installed on zone 4. The cover blocks sunlight to prevent algae growth.

Effluent from the settling cell is disinfected prior to direct discharge to Lake Winnipeg.

The upgraded lagoon meets the effluent discharge requirements of 20 mg/L of CBOD and 20 mg/L of TSS, with total phosphorus levels of less than 1 mg/L, with continuous discharge. The lagoon is fully compatible with future upgrades for biological ammonia removal, and further enhanced phosphorus removal, should future regulations so require.

Algae control cover on setting zone.

What is the future for lagoons?

It is anticipated that effluent limits for wastewater treatment systems across Canada will continue to become more stringent, particularly in regions where treated effluent is discharged to environmentally sensitive water bodies such as Lake Winnipeg.

Technologies such as gravity sand filters with ferric chloride addition have demonstrated that total phosphorous levels of 0.1 mg/L and total suspended solids levels of 5 mg/L are readily achievable when preceded by a well design aerated lagoon system. Modular insulated covers can be installed to retain process heat and enhance winter treatment rates.

In the past, ammonia removal has been the key limitation for cold climate continuous discharge lagoon systems. Through strategic alliances and in-house research, Nelson Environmental has advanced the OPTAER® process to include the SAGR (Submerged Attached Growth Reactor) tertiary treatment system.

The SAGR is a simple-to-operate aerated gravel bed. The coarse gravel in the SAGR provides a stable media for growth and retention of nitrifying bacteria, allowing for full ammonia removal through nitrification.

Nelson Environmental is currently operating a 38,000 L/d post aerated lagoon SAGR system near Winnipeg, Manitoba. At full design load and flow the ammonia removal rates are exceeding 99% at water temperatures below 4 C. Effluent $CBOD_5$ levels are less than 2 mg/L.

Conclusion

Lagoons are no longer just a low cost secondary wastewater treatment option for small communities. With significant advances in understanding of the function of these processes in cold climates, lagoons can now also be considered to be low cost tertiary treatment systems capable of providing nutrient removal. While advanced lagoon systems are slightly more complex then stabilization ponds they still maintain the basic desirable qualities of; low capital cost, ease of operation, excellent flow and loading buffering, and low ongoing operation and maintenance costs.