Wastewater treatment

Pond technology – an evolving wastewater treatment option

Pond technology, by many names, has been around for many decades. **Andy Shilton** and **Nick Walmsley** look at new approaches and opportunities for such systems.

As pond technology has developed over the decades numerous names, such as sewage lagoons or oxidation ponds, have been used to describe the same thing. Thankfully in the last decade the work of various leading researchers, such as the design manual produced by Mara and Pearson (1998), has brought clarity to this confusion. Today there is a reasonably well-established terminology and design procedures for what might be called the 'standard pond system'.

Figure 1 illustrates two variations of standard pond systems. In the first of these, the wastewater enters a facultative pond and then a series of maturation ponds. Because there is no prior treatment (with the exception of screening and, in some cases, grit removal) the term primary facultative pond is used.

In the second illustration, the pond system first incorporates an anaerobic pond, which can substantially decrease the size required for the following ponds. In this case, the term secondary facultative pond is used as the wastewater is pre-treated in the anaerobic pond. At the end of both these systems is a series of maturation ponds. The main function of the maturation ponds is to provide the required level of pathogen removal. In the illustration three maturation ponds are shown, but in reality the number required is determined by an iterative design procedure.

Adaptations and variations

A number of adaptations and variations to these 'standard pond systems' exist. These are described below.

Fermentation/digestion pits

The concept of fermentation pits, as discussed by Oswald et al (1994), has been one innovation. Built within a facultative pond, this is a semi-enclosed pit operating under anaerobic conditions like a low-rate digester. The pit receives the raw influent and has a retention time of around one day. This design is reported to remove solids and organic waste more effectively than conventional anaerobic ponds. Because the anaerobic pit is overlaid by the oxygenated facultative pond, it has been noted that these systems minimise any potential for odour release. The term 'advanced facultative ponds' is commonly used to describe this integrated pond/pit system.

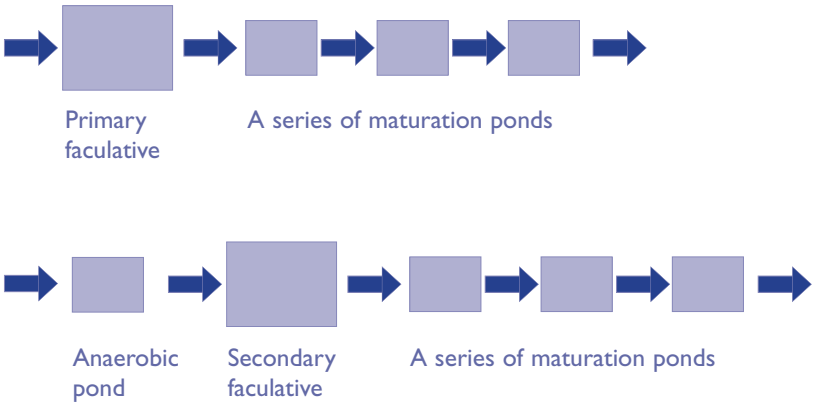
Hi-rate algal ponds

Originally developed by Oswald at the University of California in the 1960s (Shelef and Azov, 1987), these systems are shallower than a facultative pond (0.2m to 0.8m) and operate at shorter hydraulic retention times of around a week or less. A paddle wheel is incorporated to drive the water around a 'race-track' shaped pond. The oxygen production is reported to be significantly higher than in typical facultative pond designs, and the algae produced in these systems are reported to have good settling properties (Green et al., 1996).

Advanced pond systems

There is increasing interest in the use of an integrated pond system that integrates an advanced facultative pond (with a built in fermentation pit) followed by a high rate algal pond (with recycling back to the facultative pond) followed by a series of maturation ponds. While there are few of these installations compared to the more standard pond systems previously discussed, this system is one of the most popular areas of current research in the pond technology area.

Figure 1



A wastewater treatment and storage reservoir in Israel.

The PETRO process

The term PETRO stands for 'Pond Enhanced Treatment and Operation'. The PETRO concept basically involves using a waste stabilisation pond as a first stage to tackle the bulk of the organic load and then using a second stage process, such as a trickling filter or an activated sludge system for 'polishing' to improve the final effluent for removal of solids and nutrients. This technique has been particularly useful for upgrading overloaded trickling filters and activated sludge treatment systems.

Integrated ponds and wetland systems

Like ponds, wetland wastewater treatment systems are another type of 'natural' treatment technology. Wetland treatment technology developed after it was found that natural wetlands receiving wastewater discharges were actually able to provide significant treatment. Today, artificial wetlands are constructed either as a 'surface flow system' (like a planted pond) or as a subsurface flow system (essentially a planted filter operated with either horizontal or vertical flowpaths). While not as widespread in application as pond systems (the ratio is approximately 1:10), wetlands have a great deal of public appeal and are rapidly growing in number. Because ponds and wetlands have the similar advantages of offering simple operation they are often used together to provide an integrated wastewater treatment solution.

Aquaculture ponds

Throughout Africa and Asia it is common to add a fish or 'aquaculture' pond to the end of a pond wastewater treatment system. The basic idea is that the fish will graze the algae, thereby reducing solids, with subsequent harvesting of the fish to provide a source of protein and a means of recovering nutrients.

Storage ponds/reservoirs

There can be advantages in storing effluent within a pond instead of allowing it to continuously discharge. For example, effluent may be stored during winter periods when treatment is less effective due to the colder temperatures. Other applications include avoiding discharges to a sensitive waterway such as a small stream at times when the stream flow is too low or during periods when algal blooms are present in the ponds. Apart from storing pond effluent for environmental reasons, storage is also used when the nutrient-rich effluent is valued as a resource for irrigation during dry periods. In order to provide adequate storage volume, these ponds are deeper and are often referred to as 'reservoirs'.

Stormwater ponds

There is increasing awareness that stormwater

7th IWA Specialist Group Conference on Waste Stabilization

The 7th IWA Specialist Group Conference on Waste Stabilization Ponds – Advances in Pond Technology and Management, will take place on 25-27 September 2006. It will be held at the Asian Institute of Technology Conference Center, Klong Luang, Pathumthani, Thailand.

Conference themes will include:

- Integrated pond/wetland systems
- Models and kinetic development
- Advanced pond systems
- High-rate algal ponds
- Removals of nutrients and toxic chemicals
- Pond behavior and hydraulic patterns
- Pathogens removal
- Microbiology and molecular techniques
- Anaerobic pond systems
- Design models and case studies
- Pond rehabilitation/upgrading and effluent reuse
- Agriculture and industrial wastewater treatment

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flushed off an urbanised catchment is not simply clean rainwater, but contains a range of contaminants such as solids and heavy metals. Ponds, often supplemented with wetland plantings, are increasingly being installed to treat stormwater. Stormwater ponds have short retention times, typically of just a few days. They provide buffer storage to reduce runoff peaks, and also provide enhancement of stormwater quality by various treatment processes such as settlement of solids. As part of their design, strong emphasis is also placed on the creation of recreational and habitat amenities.

A sustainable energy technology

In recent decades, environmental engineers and scientists have been very focused on protecting our waterways. However, as we look to the future it is clear that, in addition to managing our water resources, much greater consideration of our energy resources and the associated issues of carbon management must also be a key concern.

Pond technology offers some important advantages and interesting possibilities when we view it in the light of sustainable energy, for example it offers:

- low cost biogas generation from anaerobic ponds
- solar powered aeration via algal respiration
- solar powered pH increase and resultant disinfection, and improved nutrient removal via algal respiration
- significantly lower (or even zero) energy consumption compared to other energy-intense wastewater treatment technologies.

With regard to controlling greenhouse gases, algal growth essentially 'scrubs' carbon dioxide from the atmosphere. If this biomass is then removed and sequestered, the mechanism represents a carbon sink. While building ponds for this purpose alone would seem expensive, consider that these ponds are already in widespread existence for wastewater treatment (in some cases with subsequent algal removal). When this opportunity is compared with other alternatives being proposed for carbon dioxide removal, this pond-based approach deserves further investigation.

It is not suggested that pond technology shoulud necessarily be implemented as a sustainable energy or carbon sink option in its own right. However, the fact that these issues are of rapidly growing importance to our societies clearly presents a new angle to pond technology that has perhaps previously been overlooked, or understated, when assessing the feasibility of various treatment options.

The Arman pond system in Jordan.

Pond Treatment Technology, edited by A Shilton

This book offers a comprehensive review of the pond technology field including the newest ideas and latest findings. Topics covered include:

- The physical, chemical and biological characteristics of the pond environment;
- A detailed review of pond treatment mechanisms and performance;
- Comprehensive guidance on pond design, operation and upgrade options;
- A range of chapters summarising new and emerging pond technologies;
- The integration of ponds with wetlands and aquaculture systems and their use as storage reservoirs;
- Special applications of pond technology in cold climates, for agricultural wastes and for treatment of stormwater.

The objective of this book is to get this wealth of knowledge 'out there' to the users to ensure the continuous improvement and ongoing success of this crucial technology.

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