NUTS & BOLTS

Options for effluent treatment

Discharges from hatchery & recirc facilities can have significant impacts on the environment. Here are some ways to mitigate the impacts.

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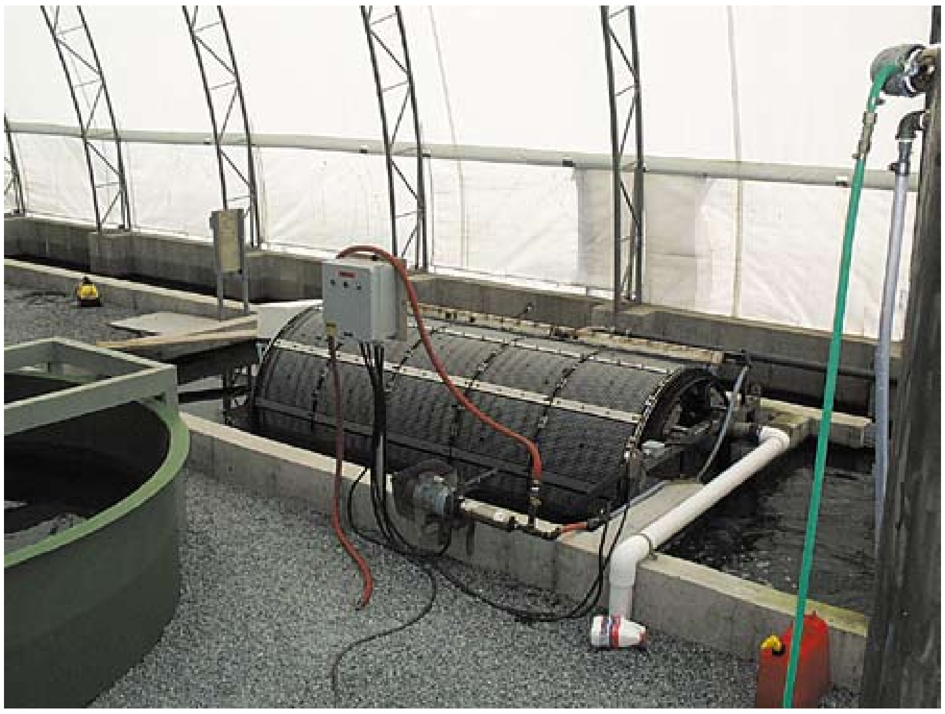
This is the first of a two-part series dealing with discharges from aquaculture facilities. The topic of this article is dilute liquid wastes. The second article will review methods of handling and disposing of concentrated solid wastes.

The liquid effluent discharge from aquaculture facilities can have significant environmental impacts. High volume flows containing high organic loads can overwhelm receiving waters, changing their ecology. The contaminants of concern are usually BOD, TSS, TAN, and phosphorus. Similarly, discharge requirements are often concerned with the possible discharge of pathogens and parasites and the escape of non-native aquatic organisms.

Definitions and explanations:

- BOD or biological oxygen demand measures the amount of organics in the water in terms of the amount of oxygen that the bacteria breaking down the organics would consume (COD is a chemical method of approximating the BOD).
- TSS is total suspended solids. In practice, this includes any inorganic solids, but at aquaculture facilities it usually means organic particulate loading. Because organic particles contain BOD, nitrogen and phosphorus, controlling the concentrations of TSS is usually the most important tool in controlling these other contaminants.
- TAN stands for total ammonia nitrogen. TAN is important since ammonia is toxic to aquatic life if concentrations get too high.
- Phosphorus is an essential nutrient for all organic life. By limiting this one essential nutrient, aquatic vegetation, such as algae, cannot grow. Excessive algal growth can cause eutrophication (which leads to oxygen depletion) and must be avoided. Limiting algal growth will give the other nutrients a chance to disperse without impact on the local environment.

Flow-through aquaculture systems generate large volumes of wastewater where the wastes are relatively dilute. Effluent treatment processes for such facilities must be low-intensity and have a low operating cost to be economical. When more extensive treatment is required to meet discharge requirements, the incorporation of recirculation or partial reuse technologies into the culture system's design may significantly reduce effluent volumes and the associated cost of effluent treatment.



Microscreen drum filter at a large salmon hatchery (file photo).

Solids Removal

Solids removal is a critical component of effluent treatment systems, regardless of whether flow-through, partial reuse or recirculation technologies are being used.

Gravitational settling may be used for removal of particles that have a density greater than that of water. The greater the density of the particles, the more quickly they will settle and the less susceptible they will be to re-suspension due to turbulence. However, most of the particles in aquaculture wastes are waste feed and feces, and being only slightly denser than water may require long settling times.

Settling ponds have traditionally been the standard for removal of particulate waste from aquaculture effluent water, and although settling ponds provide acceptable reduction of TSS, over-long retention of the solids can result in their decomposition, which may further degrade water quality. Other disadvantages include the large space requirement, challenges related to freezing in cold climates, and the management and removal of accumulated sludge.

Designed wetlands are a variation on a settling pond, where biological activity mitigates some of the negative impacts. Submerged wetlands (where the water flows underground through media) can also act as slow sand filters for improved particulate removal.

Swirl separators and radial flow settlers are smaller, more efficient gravity settling vessels that are specifically designed to maximize capture of waste particles. They are suitable for use where operators can purge the accumulated solids routinely before decomposition can become a problem.

Filtration is also an important tool in removing suspended solids. Filtration technologies can be separated into broad categories, which include media filtration and screening. Media filtration is not usually employed in effluent systems because of the tendency for the media to foul, and because of the relatively high-energy requirements. However, screening is commonly employed on dilute aquaculture wastes.

Microscreen drum filters and belt filters are automated, self-cleaning screen filters that are ideal for the quick, continuous removal of suspended solids. They are especially well-suited for pre-filtration upstream of disinfection processes. In screen filtration systems, opening sizes can vary. Fine screen systems typically require a much larger filter area than coarse screens, as the percentage of the area that is actually open for water to pass through is typically much smaller. In aquaculture systems, microscreen drum filters, with screen openings (mesh size) ranging from 30 to 120 microns, are the most commonly used.

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A SPECIAL SECTION ON WATER RE-USE AND RECIRCULATION

Flotation systems like **Foam Fractionators,** or DAFs (dissolved air flotation) are used in some effluent treatment systems. These capture the smallest and least dense particles which typically make up the smallest fraction of TSS (by mass).

Precipitants like lime, alum, and ferric chloride can be used to precipitate dissolved phosphorus. Ozone can also be used to enhance filtering efficiency since it can cause organic particles to clump together. The precipitated solids must then be captured using solids settling or some sort of filter.

Designed wetland. Wastewater is discharged to a small stream near where the observers are standing (file photo).

Disinfection

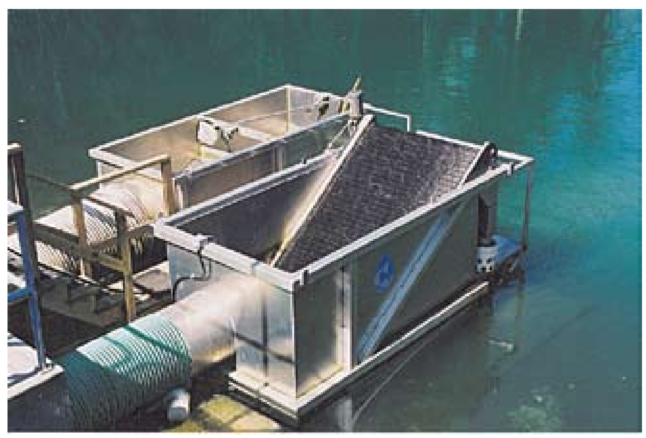
Disinfection may be required to prevent the discharge of pathogens into receiving waters where they could infect native species. Ozone and other oxidants are effective tools for disinfection of effluent waters. UV light can also be used.

Ozone is an aggressive chemical oxidant that is a highly effective disinfectant in aquaculture applications. Ozone will react non-discriminately with almost any contaminant or microorganism in the water. Its effectiveness is dependant on the dosage, the length of contact time, and the presence of other materials, which may consume the ozone. Because ozone may cause fish health problems at higher concentrations, it is important that residual ozone is not present after the treatment process. In addition to its disinfective properties, ozonation may offer other benefits such as in controlling dissolved solids, and the removal color and odour. As a result, ozone is highly effective in the optimization of water quality, though it does present some difficult challenges in terms of handling and safety. Material selection, process control, installation location, and alarm systems must be considered carefully in the design of ozone systems.

Hydrogen peroxide and chlorine are also very powerful oxidants and can be effective disinfectants. However, they are also more stable and therefore more likely to persist in the water. Chlorine can combine with some organics to form carcinogenic compounds. Safe storage and handling of these powerful chemicals can also be of concern.

Ultraviolet light is a clean, safe and fish-friendly disinfection technology for aquaculture applications. UV irradiation does not produce toxic by-products or residuals, therefore there is no risk of overdosing fish as there is with chemical oxidants. UV irradiation disinfects by penetrating the cell wall of an organism, damaging the organism's genetic material (RNA and DNA) and destroying its ability to reproduce. A very important consideration when sizing a UV system is the transmissivity of the water. This is a measure of the ability of the germicidal UV light to pass through the water and it is heavily influenced by dissolved substances and by the size, type, and concentration of particles present. Pre-filtration is usually required to achieve optimum transmissivity and effectiveness of treatment.

Although each of the above mentioned disinfection methods may be used alone, they are often used in combination for improved effectiveness, or as a multi-barrier approach. Ozone and UV, when used together, have been documented to provide greater protection from pathogens than either technology on its own. Also, when UV irradiation of appropriate dosage and wavelength is located downstream of the ozonation, it can provide protection from any ozone residuals remaining in the water.



Moving belt filter screens water prior to its entering a settlement pond.

Exclusion of Aquatic Organisms

Preventing fish from escaping in the effluent from the facility is also an issue of growing importance.

Traditional static screen systems have typically had high hydraulic head requirements or have had significant labour requirements to keep the screens clean. Self-cleaning screen systems, such as conveyor-style belt filters, are now being increasingly used to completely exclude fish and eggs from any discharged water, while requiring only minimal head and little maintenance.

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