NUTS & BOLTS

Waste Solids Treatment

Part 2: Handling waste solids

By Stephen K. Piggott, M.Eng., P.Eng.

In the first of this two-part article, I discussed effluent handling systems, focusing particularly on solids removal. This second part will consider the options available for handling and disposal of these waste solids.

Depending on fish husbandry practices, feed characteristics, and the water handling systems, etc, the total suspended solids (TSS) in drum filter waste discharges typically range in concentration from 600 to 1500 mg/l. TSS concentrations from swirl or radial flow separators are similar. Since one litre of water weighs one kilogram, this means that there is approximately 600 to 1500 mg of solids for every 1,000,000 mg total mass. In other words, barely 1% of the total waste exiting the filter is solid matter, the other 99% is water. When disposal costs for waste solids are proportional to weight or volume, thickening and concentrating the solids makes economic sense.

The disposal method for the liquids that are separated from the solids must also be considered. If the process is slow, organic solids in the wastes will continue to degrade releasing nutrients into the water. If the nutrient concentrations in the liquid phase become too high, disposal back into either the culture water or effluent system becomes unacceptable, and an alternative method of disposing of the liquid wastes becomes necessary. Treatment systems such as an engineered wetland may be required for disposal of the supernatant, as the biological degradation that occurs in the settling pond can result in high nutrient loadings. Tile fields can sometimes be employed to accept the discharge of nutrient rich liquid wastes. Sizing such a disposal field will be based primarily on soil characteristics and permeability tests. Local regulations can have a considerable impact on design of an appropriate septic tile field system.

Composting solid fish farm wastes after de-watering. The pipes deliver air for aerating the compost.

Passive waste thickening systems

Some facilities use settling basins for thickening waste solids, and given enough time, even fine particles will settle. Periodic dredging, or a bottom drain, may be used to remove the concentrated solids. Gravity thickening systems are totally passive, but are also one of the least effective methods of thickening the solids. Biological activity in the accumulating sediments can generate gases that lift solids into the supernatant discharge flow. Degradation of the solids may also contribute to high nutrient loads in the supernatant.

Settling basin. Concentrated slurry is drawn off at the bottom.
(Photo courtesy The Freshwater Institute)

Many facilities rely on solids digestion, which can vary in size from large holding tanks to smaller septic tank systems. A digester/septic tank system employs two waste handling technologies:

1. The tank acts as a settling chamber, concentrating the solids while allowing the supernatant to discharge

2. Bacteria living inside the vessel digest the organic solids, reducing the mass (while generating gases such as carbon dioxide, carbon monoxide, nitrogen and hydrogen sulfide). The bacteria can also degrade or destroy any pathogens or parasites that enter the septic system.

The internal baffles in a septic tank prevent short circuiting and minimize the discharge of solids. The supernatant from these systems may also be rich in dissolved nutrients, but like any septic tank outflow, can usually be discharged into the soil around a tile field. Quantifying the volume reduction potential of a digester/septic system is very difficult and will depend on the chemistry of the wastes, the ambient temperature within the septic system, as well as the net retention time.

Drying beds are another low-energy method of thickening waste solids. A drying bed typically involves a large pad complete with an under-floor drainage system. A containment system is usually required to prevent discharge of the solid wastes overland. Liquids drain to the bottom of the bed where they are collected and returned to the water treatment system while the solid wastes are allowed to air dry. Drying beds are not particularly practical where rainfall levels are high or where the potential for freezing exists. A roof and walls, and, therefore, a ventilation system, are frequently required.

A variant of the drying bed is the Geotube® by Ten Cate Nicolon which are essentially porous bags into which the waste solids are pumped. The solids are retained in the bag while the liquids are allowed to drain away. To operate properly, the bags require cyclic filling

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with a period for drainage in between. To provide a continuous disposal system, more than one bag may be required. Once full, the bags must be disposed of and replaced. Research performed at the Freshwater Institute shows that, with addition of an appropriate polymer, the solids concentration can be raised to 11-14% (i.e. mass reduced by 90+%). Performance may degrade somewhat if high pressure pumping systems are used to fill the bags. Degradation of solids within the bag over time will also change the nutrient concentration in the filtrate. Bag systems like Geotubes® simultaneously contain the waste and minimize odour and insect problems.

Mechanical systems for concentrating solid wastes

Higher concentrations can be obtained using mechanical equipment, often in conjunction with chemical treatment. They are also much faster, resulting in the separation of liquids from solids before substantial degradation can occur. This reduces the nutrient concentrations in the supernatant making its disposal easier.

One of the simplest mechanical systems is a belt filter. The solids are laid gently on a moving screen, which lifts the solids out of the solid waste slurry while allowing the filtrate to pass through the screen by gravity. Polymers, which bind the particles together, and the gentle handling of the solids which reduces shear, permit the use of coarser screens than in other filtration systems.

Belt presses are a significant variation on this equipment. In a belt press, the slurry is deposited on a belt, and a second belt is laid over the top. The paired belts are then passed through a series of rollers, which squeeze the water from the solid waste and out through the screens.

Centrifugal thickeners settle the solids while they are spinning. They include solid bowl types where the solid cake is discharged out of the bottom, and the perforated basket type where the solids accumulate on the outside of the screen and the liquids inside. The solid bowl type of centrifuge tends to be used in continuous processes while the perforated basket type tend toward batch processing. Centrifuges will produce wastes containing 10 to 15% solids. Additional thickening can sometimes be achieved by gravity draining of the thickened solids to achieve concentrations as high as 20%.

Solid waste disposal

Historically, most solid wastes have been disposed of in landfills. However, fish farm wastes have been recognized as being nutrient rich, and recently some research has been done on transforming them into usable products: composting is the most common approach. During composting, bacteria break down the organic matter consuming oxygen and emitting carbon dioxide and heat. However, solid wastes directly from de-watering equipment are not immediately suitable for composting. Typically the moisture content is too high and the particles too fine to permit air circulation through the material. Consideration must also be given to the carbon:nitrogen ratio which in fish waste is typically about 20:1. Composting proceeds better when the C:N ratio is closer to 30:1. Additives such as cardboard, sawdust, peat moss, or shredded paper can be used to balance the nutrients and improve the physical properties of the materials.

Geotextile bag used for collecting waste solids at North Carolina State University *(Photo courtesy James Ebeling)*

Vermicomposting is another way to convert fish wastes into marketable products, namely worms and worm castings. The worms will die if added to fresh fish-farm wastes due to the high concentration of ammonia. However, with aging, the material becomes suitable for growing worms. Ideally, the solids should be thickened to approximately 20% solids before they are used.

It is apparent that the range of solid waste handling technologies is more extensive than currently used to dispose of aquaculture wastes. Many of these technologies originated in other forms of wastewater treatment facilities and have been adopted for use in aquaculture. Some are adaptations of traditional farming techniques. Since few aquaculture facilities have the financial resources of large modern wastewater treatment facilities, adapting low cost technologies for aquaculture wastes to satisfy treatment and handling requirements remains the challenge.

Stephen Piggott is a professional engineer with PRAqua, Nanaimo, BC, Canada. For more information contact him at: stephen@praqua.com

Farmers and fishermen work together to restore salmon stocks on Scotland's west coast *continued from page 29*

received planted fry. A programme to catch and remove any escaped farmed salmon in the rivers has also been successful and ongoing work through the AMA is aimed at reducing the frequency of these escapes. Alan shares the trust's office with the aptly named Lucy Fry who is the Regional Development Officer for the Argyll AMA's and this lends itself to a more "joined up" approach in this type of initiative.

Hatchery challenges

Lucy Fry, the Regional Development Officer for the AMA's in Argyll, at her desk in the offices of the Argyll Fishery Trust.

Issues and challenges for the hatchery part of the restoration programme are that there are very few wild broodfish; there is limited information on the remaining genetic variation; there is an intermittent presence of farmed escapees and there is a possible presence of 1st generation farmed/wild crosses. A study to investigate all of these issues is soon to be initiated using the expertise afforded by Eric Verspoor at the Freshwater Fisheries Laboratory and will involve genotyping both wild and farmed fish within the Loch Fyne area. This will enable the trust to identify the best broodfish and crosses to use for each particular river, to monitor the genetic variability and to design and use spawning protocols to minimise the loss of variability in such small populations.

In Loch Fyne at least, the farmers and fishermen are working together, and instead of hurling insults and blame at each other they, along with other stakeholders, are spearheading an initiative which just may reverse the decline of the Atlantic Salmon in the Argyll area if not the whole of the west coast. A small unprepossessing hatchery by the banks of the River Aray fitted out with second hand donated equipment and run by dedicated individuals with a passion for what they believe is worth fighting for may just be what will turn the tide.

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