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Responsible Seafood ADVOCATE

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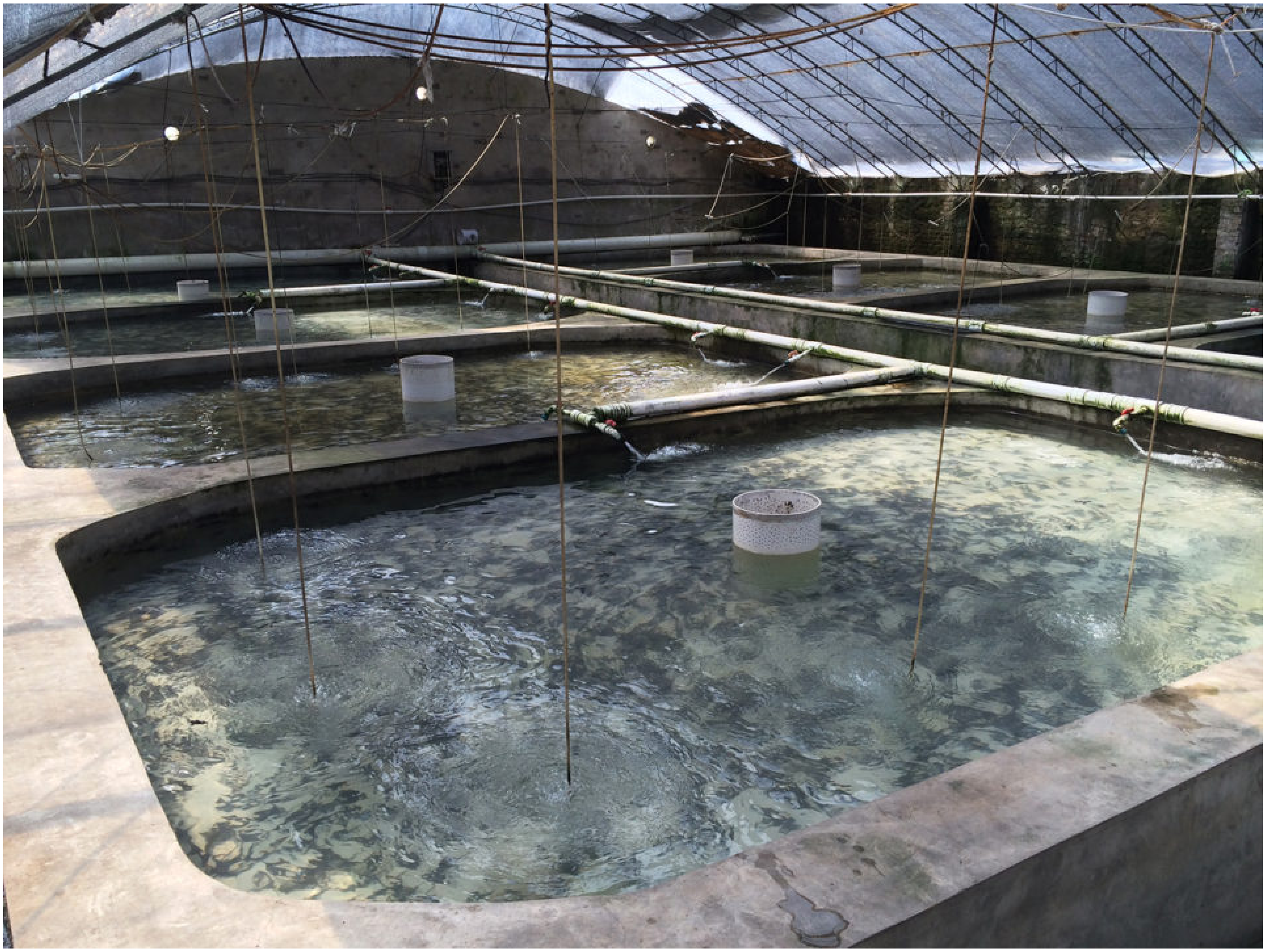
Waste in aquaculture, Part 2

Responsible Seafood Advocate logo

2 March 2020 Dr. Akeem Babatunde Dauda Abdullateef Ajadi, M.S. Dr. Adenike Susan Tola-Fabunmi Dr. Ayoola Olusegun Akinwole

Removal of solid and dissolved wastes in different culture systems



More intensive aquaculture production systems (including recirculation and biofloc systems) like this RAS fish farm in China, can be more efficient producers of fish and generate less waste. Photo by Darryl Jory.

Solid wastes

Solid wastes have been reported as the most harmful waste in fish culture systems. The two major sources of solid wastes in aquaculture are uneaten feed and various undigested substances, which are passed through as fecal waste. The amount of solid wastes in fish culture systems and those finally released to the environment varies with the type of fish culture system, the amount of feed supplied, and how effective feed management and feeding are.

Pond culture systems are static and usually have no water treatment; they rely mainly on internal processes where solid wastes settle on the bottom of the pond and accumulate over time. The microbes in the system act on the settled waste and convert it to less-toxic materials. However, if the settled waste has accumulated over time, any natural activities like bank erosion can cause the mixing of the highly nutritious pond bottom with the water column and may lead to algal blooms. Removal of solid waste from the pond bottom is typically done after two or more fish production cycles. A relative lack of adequate waste management techniques in pond culture systems has limited their use to mostly semi-intensive culture operations. The production capacity of ponds depends on the amount of feed that can be added daily without affecting water quality. Various authors have reported a daily feeding rate of 30 to 50 kg per hectare (ha) and this limits the annual production to 2,000 to 3,000 kg per ha.

Unlike the static pond systems, where the solid waste is settled within the system, the flow-through systems have high rates of water exchange and most of the wastes produced are discharged from the culture unit. If properly designed, flow-through systems collect and concentrate the solid wastes before they fragment. The major problem of solid waste management in these systems is that the wastes are difficult and expensive to manage because of a high flow rate of weakly-concentrated effluents.

Recirculating aquaculture system (RAS)

RAS systems reuse fish culture water and are more efficient at removing solids than the flow-through systems, and reportedly have the potential of reducing environmental impacts from aquaculture waste when compared with flow-through systems. RAS remove solid wastes through sedimentation and screen filters, and although these systems take away a large portion of solid wastes through sedimentation, they are not effective in removing fine solids, so supplementary screening is needed. Effective removal of solid wastes may ensure reduction of some other nutrients in culture water, especially phosphorus and organic matter, which are released largely as particulate matter. RAS systems reportedly can remove 85 to 98 percent of organic matter and suspended solids, and 65 to 96 percent of phosphorus through effective removal of solid wastes.

Dissolved wastes

Dissolved organic wastes in fish culture systems are primarily nitrogen and phosphorus. There are different techniques for nitrogen removal in fish culture systems but not for readily removing phosphorus. This may be partly due to the fact that phosphorus is not toxic to cultured fish, unlike nitrogen, which has toxic forms like ammonia and nitrite. Phosphorus levels are reduced in culture systems through their decrease in aquafeeds; by the inclusion of phytase to increase the bioavailability and utilization of dietary phosphorus; or through efficient and quick removal of solids, since larger amounts of phosphorus are released in particulate form.

Nitrogen removal

The pond systems rely on natural processes – mostly their microbial communities working on oxidizing organic matter and converting ammonia to other forms – to maintain water quality. The ammonia is converted to the less toxic nitrate, and together with phosphate are nutrients for the phytoplankton and macroalgae in the pond ecosystem. The phytoplankton are fed upon by the zooplankton and finally consumed by many fish species. However, the ability of the pond system to manage aquaculture waste is limited and depends directly upon the amount of waste that can be recycled by the pond daily. Any amounts beyond this limit may lead to excessive nutrient enrichment of the pond, eutrophication and the death of fish in the culture unit.

Flow-through systems depend on the expedited removal of the solids and water with the dissolved nutrients from the culture units. Recirculating aquaculture systems (RAS) use biological processes to manage nitrogen, through nitrification to convert toxic ammonia to the less toxic form of nitrate. Research on the nitrification processes of aquaculture effluents has led to the development of various media (biofilters) with different properties, advantages and disadvantages.

Though reduced water use is an important advantage of denitrification systems, it may also be considered a disadvantage. Reduced water exchange in the system may lead to the accumulation of growth-inhibiting substances such as bacterial metabolites.

Biofloc technology systems

Biofloc technology (BFT) is fast-emerging in fish culture systems, where water is treated in situ in the production units. BFT is a water quality management technique that is based on the development and control of heterotrophic bacteria within the culture system with minimal or zero water exchange.

The microbial community (cellular protein) contains a heterogeneous mixture of microorganisms (floc formers and filamentous bacteria), particles, colloids, organic polymers, cations and dead cells. The suspended heterogeneous protein particles are available as food to the cultured organisms and contribute high-quality protein. BFT helps ensure the maintenance of adequate water quality through the uptake of ammonia to produce microbial proteins, and it also makes available food for the cultured fish through the utilization of the microbial protein produced, thus increasing the efficient utilization of the aquafeed applied, improving food conversion ratios and decreasing the cost of feeding in aquaculture.

Perspectives

The development of aquaculture as a source of affordable animal protein is essential to feed a growing human population. However, restrictions in some parts of the world, especially the developed world, require a continuous effort to develop sustainable production methods that will not negatively affect the environment.

The use of pond systems for extensive and semi-intensive aquaculture should be maintained at a level where their effluents can be efficiently treated and disposed of. But production from these systems cannot substantially help achieve the additional output needed from aquaculture. More intensive systems, using conventional RAS and denitrification-incorporated RAS systems, can produce larger volumes of fish, including high-value species, and reduce environmental pressure.

The proper development and operation of zero to minimal water exchange systems like BFT will go a long way to enhance sustainable aquaculture production. These systems can produce both high- and low-priced fish species, do not generally require a high investment cost, can be efficiently managed, produce minimal waste and have minimal environmental impact. Their increased use should be promoted and encouraged.

References available from original publication.

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