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Geotextile bag, flocculant technology capture RAS waste

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System effective in removing suspended solids, nitrogen and phosphorus

A geotextile bag (on left) rests on a rock-filled effluent containment system that collects the clarified effluent on a rubber liner and directs it to a clarified effluent sump.

Recirculating aquaculture systems (RAS) have often been referred to as green and environmentally friendly technology. This is in fact true, as long as the effluents from these systems are dealt with adequately and responsibly.

Unlike pond or flow-through tank technology, RAS technology concentrates the waste created in the aquaculture production system. While this makes the wastewater easier to capture and treat, it does not make the waste any less harmful to the environment if it is released without further treatment. In fact, given that it is a concentrated point source, the effects could be more harmful to the local environment than releases from less-intensive technologies.

RAS waste

Commercial RAS designs typically waste 5 to 15 percent of their system volume as wastewater. The wastewater comes from the automatic backwashing of drum screen filters, draining of waste from media filters such as in bead filter technology or the wasting of sludge from swirl separators or radial-flow settlers.

To put that into perspective, a RAS production facility carrying a biomass of 100 mt of fish and an average culture density of 80 kilograms per cubic meter will typically waste and replace 60 to 180 m3 of water daily.

As an example, wastewater volume and quality from a 230-day RAS production study were collected and evaluated at the North Carolina State University Fish Barn. The system studied consisted of two, 60-m^3 aquaculture tanks stocked with tilapia fed a commercial 40 percent protein, 10 percent fat diet. The average daily feed rate was 52.4 ± 26.7 kg with a maximum of 90 kg. A total of 12.1 metric tons (MT) of feed was added to the system.

Wastewater was produced by a drum filter with 40-µm screen size and two sludge collectors that settled waste from particle traps on the bottom of each tank. The daily average flow from the drum screen filter, the major flow contributor, was 12.1 ± 6.2 cubic meters.

Geotextile bag, flocculant aid treatment

Effluent from the drum screen filter and sludge collectors flowed by gravity to a small primary effluent sump on the exterior of the production building. When the sump filled up, a level switch activated a submersible sewage pump and a chemical flocculant aid-dosing pump to mix and pump the waste to a nearby geotextile bag. The geotextile bag was 7.6 meters in length and 4.5 meters in diameter, with an effective pore size of 400 µm.

The geotextile bag was placed on a basin constructed of wood with a synthetic rubber liner and connected to an effluent sump and water containment system. When operating, the flow rate from the effluent sump to the geotextile bag was approximately 40 Lpm. The polymer dose rate was 175-200 mL/minute. The final dilution of the polymer with effluent yielded 10-12 mg polymer/L effluent.

While the pore size of the geotextile bag was 10 times that of the screen on the drum screen filter, the use of a high-molecular-weight, cationic polyacrylamide polymer flocculant aid mixed with the RAS effluent caused the fine solids in the effluent to coagulate and flocculate out of solution within the geotextile bag. In simple terms, the polymer served as a “liquid Velcro” that bound the fine suspended solids together in large clumps.

It is important to match the polymer used in the system with the waste characteristics. Different polymers are required at varying salinities and waste types. Before start up, be sure to work with a polymer provider to select the proper chemical. Failure to do so will clog the pores of the geotextile bag, and it will cease to function properly.

Effluent characteristics

Effluent from the RAS as input to the geotextile bag and the geotextile bag effluent were sampled 22 times over a 230-day study period (Table 1). The RAS effluent characteristics indicated the wastewater could be classified as low-volume but high-strength. Clearly the water required more treatment before discharge.

Parameter	RAS Effluent	Geotextile Bag Effluent	Removal
Total suspended solids (mg/L)	1,176 ± 473 (448, 1991)	44 ± 20 (17, 106)	96%
Total nitrogen (mg/L)	187 ± 34 (141, 267)	93 ± 27 (52, 162)	50%
Nitrate-nitrogen (mg/L)	143 ± 24 (105, 182)	73 ± 29 (34, 147)	49%
Total phosphorus (mg/L)	28 ± 9 (15, 47)	18 ± 4 (12, 28)	37%
Chemical oxygen demand (mg/L)	1,589 ± 453 (908, 2,442)	188 ± 65 (135, 422)	88%
Alkalinity (mg/L)	185 ± 42 (104, 280)	454 ± 94 (330, 710)	+145%

The geotextile bag system was very effective in removing 96 percent of the suspended solids in a single pass. Much of the chemical oxygen demand was removed with the suspended solids. Additionally, 50 percent of the total nitrogen and 37 percent of the total phosphorus were removed.

It was notable that almost 50 percent of the nitrate-nitrogen was removed on a single pass through the geotextile bag system. As this is a dissolved form of nitrogen, the mechanism for this decline was most likely biological denitrification within the geotextile bag sludge blanket.

Also notable was the rise in the alkalinity of the geotextile bag effluent. This was likely a byproduct of the ongoing denitrification process within the bag. If this water were treated further to allow reuse within the RAS, the recaptured alkalinity would largely offset the loss of alkalinity created by the biological nitrifying filtration process.

Sludge analysis

At the completion of the study, the geotextile bag was taken offline for 70 days and allowed to dewater in place while sheltered from rain. When the bag was opened, 4,545 kg of sludge were removed. The sludge consisted of 13.9 percent dry-weight solids, yielding approximately 632 kg of sludge on a dry-weight basis, or 5.8 percent of the 10,889 kg of dry-weight feed fed to the fish. Results of the sludge analysis are shown in Table 2.

Losordo, RAS dewatered sludge characteristics, Table 2

Parameter	Sludge (wet weight)
Total organic carbon (g/m^3)	8,407.0
Volatile solids (%)	85.0
Total nitrogen (g/m^3)	7,453.0
Total ammonia nitrogen (g/m^3)	1,710.0
Nitrites and nitrates (g/m^3)	0.8
Total phosphorus (g/m^3)	2,602.0
Chemical oxygen demand (g/m^3)	297,000.0
Potassium (g/m^3)	100.0

Table 2. Summary of RAS dewatered sludge characteristics.

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