Evaluating Geotextile Technology To Enhance Sustainability Of Agricultural Production Systems In The U.S. Virgin Islands

By Jason Danaher

In the U.S. Virgin Islands, rainwater harvesting is a source of freshwater for intensive aquaculture production systems. The Aquaculture program at the University of the Virgin Islands (UVI) has developed a biofloc system for intensive production of tilapia that has been shown to produce the equivalent of 155,600 kg/ha/yr. Biofloc production systems rely on the mixing of suspended solids, which provide substrate for nitrifying bacterial populations to metabolize toxic ammonia to non-toxic nitrate. Intensive, recirculating fish production systems treat and reuse a major portion of their production water, but rely on the removal of nutrients and organic matter through biological and mechanical processes to ensure system sustainability. Discharged aquaculture effluent is comprised of organic matter and high levels of nitrogen and phosphorus which can pose an environmental threat; thus, increasing waste production through intensification will require novel methods for managing aquaculture effluent. To abate the environmental impact new management practices need to be adopted to reuse the nutrients and water.

The ideal concept for farmers in the U.S. Virgin Islands would be to grow tilapia (*Oreochromis niloticus*) first and then use discharged aquaculture effluent to irrigate and fertilize agronomic crops. UVI horticulture experiments have used the aquaculture effluent on land crops, such as leafy vegetables, bell peppers, cucumbers, and hay. Past UVI experiments found that nutrient-rich aquaculture sludge performed as well or better than other organic or inorganic commercial fertilizers; thus, aquaculture effluent should be treated as a resource management and not as a disposal problem. UVI researchers found further removal of solids from aquaculture effluent would be necessary for drip irrigation application. The high organic solids content (Picture 1) in aquaculture effluent can clog drip irrigation systems.

Technologies now exist to reclaim aquaculture effluent and possibly make it more functional for drip irrigation systems. Geotextile bags or a Geotube® is made of high strength woven polypropylene fabric and have been studied for dewatering agricultural waste discharged in the dairy, swine, and aquaculture industries. Nutrient rich animal waste is injected with a polymer or long carbon chain, which causes the organic matter in the effluent to coagulate. The treated effluent then proceeds into the Geotube®, which retains the solid matter and allows the liquid filtrate to exit free of solids. A Geotube® was found to increase options for transportation and land application of animal wastes by separating liquid filtrate from solid matter.

A project using Geotube® technology for integrating aquaculture effluent with agronomic crops was conducted at UVI. Researchers wanted to characterize the filtrate exiting the Geotube® and the solids retained by the Geotube® for nutrient content. The Geotube® was filled multiple times and allowed to dewater between each filling (Picture 2). Initial results have shown the Geotube® was indeed effective in reducing the amount of solids present in the aquaculture sludge (Picture 3). Eventually the Geotube® volume reached maximum capacity with retained solid waste and was allowed to dewater for several weeks. The Geotube® was then cut open and analyzed for moisture content and nutrients.

Results of the Geotube® solid and filtrate analyses are presented in Table 1. The Geotube® technology reduced total suspended solids (TSS) concentration 99% to an average concentration of 115.0 mg/L; thus, allowing filtrate to travel through a T-tape® drip irrigation system without clogging emitters. Although macronutrient concentrations decreased in the filtrate, they were retained in the solids captured by the Geotube®. Results found the Geotube® retained solids contained a higher NPK value than either the pond sludge or Geotube® filtrate. The analysis of the retained solids showed it was composed of 59.3% organic matter with 86.4% moisture content after four weeks of dewatering.

Geotube® technology was highly effective in reducing the concentration of TSS in fish effluent. A very low average NPK value for Geotube® filtrate was found, but the source of aquaculture effluent was an anaerobic lagoon containing two-year old aquaculture effluent. In an anaerobic environment a large amount of nutrients, especially nitrogen, can be lossed. It is hypothesized NPK values would have been higher if the sludge was stored for a shorter period of time in an aerobic environment or treated immediately upon being discharged. Nitrate levels in the UVI biofloc system have been recorded as high as 700 mg/L.

Top: Picture 1. Aquaculture effluent from tilapia biofloc tanks mixing prior to being pumped into the Geotube®.
Middle: Picture 2. The Geotube® full of aquaculture effluent after several hours of pumping. It is now beginning to dewater and clean filtrate is exiting for irrigation purposes.
Bottom: Picture 3. Comparison of aquaculture effluent prior to entering the Geotube® (left-side) and after passing through the Geotube® (right-side).

An on-going cucumber experiment at the UVI Agricultural Experiment Station is comparing Geotube® retained solids to a commercial inorganic, slow release fertilizer. Treatment one used Osmocote® as a fertilizer and was irrigated using rain water. Treatment two used Geotube® retained solids and was irrigated using rain water. Treatment three used Geotube® retained solids and was irrigated using Geotube® filtrate. Fertilizers were incorporated directly into the soil at recommended rates based on soil analysis and irrigated water was delivered using T-tape® drip lines. Final results will be analyzed soon, but preliminary findings show that Geotube® solids and filtrate are performing equal to the commercial, inorganic fertilizer with rainwater. Additional research trials will be conducted, but Geotube® retained solids appear to be a potential source of nutrients and organic matter to improve soil quality and health. Geotube® filtrate also appears to be a quality source of irrigation water.

Table 1. Averages of water quality parameters and nutrient concentrations measured during experiment for pond effluent, Geotube® filtrate, and Geotube® retained solids.

	Pond Effluent Mean ± S.D.	**Geotube Filtrate** Mean ± S.D.	**Percent Removal**	**Geotube Solids**
pH	7.6 ± 0.3	7.7 ± 0.4		8.1
Temperature	24.5 ± 0.5	24.5 ± 0.5		
Alkalinity (mg/L)	860.0 ± 34.6	801.3 ± 90.5		
TSS (mg/L)	22,525.0 ± 3,892.2	115.0 ± 68.7	99	
Macronutrients (mg/L)				
NPK (%)	0.09 : 0.15 : 0.03	0.02 : 0.04 : 0.03		3.6 : 6.0 : 0.2
Total Nitrogen	898.7 ± 27.3	244.5 ± 59.7	73	36,400.0
Phosphorus	670.3 ± 550.1	155.7 ± 207.5	77	60,026.0
Potassium	248.4 ± 151.1	225.8 ± 151.3	9	1,852.0
Calcium	3,404.5 ± 2,878.4	417.3 ± 333.4	88	136,242.0
Magnesium	127.0 ± 62.1	66.3 ± 69.4	48	2,447.0
Micronutrients (mg/L)				
Iron	33.3 ± 14.1	14.5 ± 19.9	56	2,028.0
Copper	8.0 ± 7.0	8.3 ± 10.5	- 4	112.0
Zinc	23.8 ± 22.0	22.3 ± 15.9	6	1,195.0
Boron	5.5 ± 3.7	13.5 ± 19.1	- 73	48.0
Manganese	13.0 ± 9.0	5.8 ± 10.8	55	773.0
Molybdenum	7.3 ± 9.0	13.3 ± 20.0	- 82	0.0

For small farmers or large commercial operations, the reuse of filtrate and solids could improve the on-farm nutrient cycle. Having a reliable and consistent water source could improve growth, marketable yield, and quality of agronomic crops during times of drought. Solids recovered from aquaculture effluent via Geotube® technology could prove to be useful source of organic fertilizer to replenish available nitrogen, organic matter, macronutrients and micronutrients. The research was funded through a Water Resource Research Institute (WRRI) grant (2007VI90B) at the University of the Virgin Islands.

About the Author: Jason Danaher is an Aquaculture Research Specialist at the University of the Virgin Islands, Agricultural Experiment Station. He can be reached by email at: jdanahe@uvi.edu

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