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THE COST AND EFFECTIVENESS OF SOLIDS THICKENING TECHNOLOGIES FOR TREATING BACKWASH AND RECOVERING NUTRIENTS FROM INTENSIVE AQUACULTURE SYSTEMS

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Intensive aquaculture systems utilize solids capture mechanisms such as settling basins and microscreen filters to remove uneaten feed, feces, and biofloc from fish culture water. Although effective in solids removal from fish production systems, backwashing of these mechanisms produces a waste stream that still contains too much water to remain cost-competitive for most traditional manure disposal methods. Further treatment of the semi-concentrated solids in the backwash flow, along with their associated nutrients and biological oxygen demand is necessary to attain strict effluent discharge standards and to recapture the nutrients.

The cost and effectiveness of three solids thickening processes, i.e., gravity thickening settlers (GTS), inclined belt filters (IBF), geotextile bag filters (GBF), were individually evaluated with the biosolids backwash produced in intensive aquaculture systems equipped with microscreen drum filters and radial flow settlers. Backwash flows applied to each technology assessed ranged from 0.1-0.2% total solids. The GTS was assessed with no coagulation / flocculation amendment. However, backwash flows applied to the GBF and IBF were amended with alum (50 mg/L) and polymer (25 mg/L) to maintain flow through the geotextile's approximately 425 µm openings and belt's 300 µm openings. Results indicate that all processes removed 94-96% of the TSS applied. The IBF produced the cleanest discharge and highest treatment efficiencies, whereas the GBF was the least effective, i.e., leaching into the GBF permeate created the highest concentrations of total phosphorus, total nitrogen (primarily ammonia), and carbonaceous biochemical oxygen demand. Treatment across the GTS was intermediate between the IBF and GBF. However, the GTS did not require any alum or polymer to achieve this level of performance and was the least complicated process and required the least labor to maintain. Belt filter operation was more complicated and time consuming than the other processes. However, GBF was most effective for sludge volume reduction; final solids concentrations of dewatered sludge were 22 ± 1%, 14%, and 11 ± 0% for the GBF, GTS, and IBF. The higher nitrogen, phosphorus, potassium concentrations (i.e., retention in the biosolids) observed in the IBF biosolids cake likely reflected the rapid efficiency with which solids are separated from wastewater and the increased nutrient leaching that occurred in the GTS and GBF.

A cost comparison estimate for installation of large scale GTS, IBF, and GBF treatment systems was determined using a hypothetical recirculating culture facility producing 454 mt of fish annually (1,000,000 lb/year). For each kg of feed applied to the culture systems, approximately 0.2 kg of biosolids would be captured by rotating microscreen drum filters (assuming a feed conversion ratio of 1.4) resulting in 127 mt of TSS produced annually. And, assuming a recirculating flow of approximately 100,000 m^3/day

through the culture tanks with microscreen drum filter discharge of 0.5% of that total flow, approximately 500 m^3 of backwash would require dewatering through the GTS, IBF, or GBF treatment systems. Loading rates used to size each of the dewatering systems, which were determined based upon this research, were 28,500 L/min per unit for the GTS, 132 L/min per unit for the IBF, and 65 L/day per m^2 fabric area for the GBF.

Capital costs related to installation of a GTS to dewater fish culture wastewater would total US $255,697. Major equipment included in this total include an equalization station / lift basin, two 3.3 m (11-ft) diameter 60º cone-bottomed GTS, a 150 m^3 (40,000 gallon) cast-in-place tank for storing thickened biosolids, and solids pumping system to transfer settled solids to the storage basin. Major equipment required for installation of a GBF system would include an equalization station / lift basin, first year of geotextile bags, alum and polymer dosing system, gravel pad and drain piping, and permeate pumping, resulting in total capital costs of US $391,289. Finally, capital costs associated with the installation of an IBF system would total US $696,201. Major equipment required for IBF dewatering include an equalization station / lift basin, three IBF's (mixing tank and inclined belt), alum and polymer dosing system, permeate pumping system, solids pumping system, and cast-in-place tank for storing thickened biosolids. Each estimate includes costs associated with site mobilization, preparation, and installation, including sales tax and overhead and profit. Cost multipliers associated with design fees, administration costs, contingency funds, and bond fees result in total capital costs of US $399,462 for the GTS, US $612,929 for the GBF, and US $1,087,113 for the IBF.

Operating costs for the GTS result from electricity consumption (assuming an electricity cost of $0.10/kWh) associated with pumping biosolids to the settling units and total US $27.83 annually. Operating costs for the GBF result from electricity consumption related to pumping biosolids to the treatment unit, alum and polymer reservoir mixers, and alum and polymer dosing pumps. Additional costs for replacement geotextile bags and purchase of alum and polymer bring total annual operating costs for the GBF to US $122,186.83. The IBF system also incurs electrical usage related to pumping biosolids to the treatment unit, alum and polymer reservoir mixers, and alum and polymer dosing pumps, but also for operation of the continuous belt motor, mixing tank mixers, and clarified water pump. Additional IBF costs linked to purchase of alum and polymer bring total annual operating costs to US $8,726.17.

Based upon this cost analysis the GTS system provided effective solids dewatering and nutrient reduction at the lowest capital and operating costs. Also, the GTS system's low maintenance requirements and lack of chemical amendment use are a cost benefit. The IBF had the highest capital expenditure, but also produced a filtrate with the best water quality. The GBF performed well in terms of solids volume reduction (although significant nutrient leaching was observed), but had a total annual operating cost that were orders of magnitude higher than the GTS or the IBF. More details are provided in:

Sharrer, M.J., Rishel, K., Taylor, A., Vinci, B.J., Summerfelt, S.T. (2010). The cost and effectiveness of solids thickening technologies for treating backwash and recovering nutrients from intensive aquaculture systems. *Bioresource Technology* 101, 6630-6641.