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# Aerobic treatment of gravity thickening tank supernatant

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**Abstract**

Aerobic treatment of the supernatant overflowing an aquaculture manure-thickening tank was studied in replicated circular tank reactors (500 L) at hydraulic residence times (HRT) of 1, 3, and 6 days under cool (mean temperature = 13.5 °C) and warm (mean temperature = 19.3 °C) water conditions. Influent characteristics differed between temperatures, most likely reflecting changes in microbial activity occurring within the material contained in the gravity thickeners. Organic carbon and carbonaceous substances were the most readily removed during aerobic treatment. Soluble carbonaceous biological oxygen demand (cBOD) concentrations were decreased an average 91% across all HRTs at the warmer temperatures and 82% during the cool temperatures. Whether measured as soluble chemical oxygen demand (COD), or dissolved organic carbon (DOC), organic constituent removal efficiency ranged from 75 to 87% at all HRTs during both study phases. Total suspended solids (TSS) concentrations increased within the aerobic treatment vessels as soluble wastes were converted into heterotrophic and/or algae biomass. The increase in TSS concentration within the aerobic treatment vessel indicates that a solids capture process will be necessary to meet effluent suspended solids standards when employing the aerobic basin strategy. Total ammonia nitrogen (TAN) removal efficiency increased with increasing HRT, with an 87% removal efficiency achieved at the 6-day HRT under warm water conditions. During the cool temperature phase, the highest TAN reduction, 57%, was observed at the 3-day HRT. With respect to nitrite and nitrate concentration, effluent from the 1-day HRT treatment possessed the lowest concentrations under both temperature conditions. Dissolved phosphorus concentrations were reduced by an average 22% following treatment at the cool temperature. Under warm water conditions, phosphorus concentrations were reduced by 16.6, 42.6, and 64.7% for the 1-, 3-, and 6-day HRTs, respectively.


*Keywords:* Effluent treatment; Aerobic lagoon; Recirculating aquaculture; Solids thickening; Supernatant

## 1. Introduction

Effluent regulations for aquaculture facilities are becoming increasingly stringent at the state and local levels. In addition, EPA has developed national

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discharge standards focused on the implementation of Best Management Practices for the aquaculture industry (EPA, 2004). The objective of this action is to reduce nutrient loads to receiving waters. Most aquaculture facilities reduce their potential nutrient discharge through solids removal from their waste water (Bastian, 1992; IDEO, 1998).

Mechanical filters and/or gravitational separators are used to remove suspended and settleable solids from intensive aquaculture systems (Cripps and Kelly, 1996; Chen et al., 1997, 2002; Bergheim et al., 1998; Cripps and Bergheim, 2000; Ebeling et al., 2003, 2004; Davidson and Summerfelt, 2005). With microscreen drum filters, for example, the solids laden backwash flow produced is approximately 0.2–2.0% of the volume of the bulk flow filtered (Bergheim et al., 1998; Summerfelt, 1999). Whereas the solids stream produced from settling basins is periodic and associated with cleaning the basin. In such basins, the concentrated solids are often diluted by the water volume above the solids layer, reducing solids concentrations from between 3 and 5% to less than 500 mg/L.

The solids contained in the backwash from the mechanical filters or settling basins are often captured and stored in an off-line solids thickening basin until final disposal (Cripps and Kelly, 1996; Chen et al., 1997, 2002; Bergheim et al., 1998; Cripps and Bergheim, 2000; Ebeling et al., 2003, 2004; Adler and Sikora, 2005). Thickening in such vessels is used to reduce the volume of solids that require treatment. In doing so, more treatment options become viable as well as potentially reducing the transportation costs for additional processing or final disposal (Chen et al., 1997; Summerfelt et al., 1999; Cripps and Bergheim, 2000; Michael, 2003).

The organic solids tend to degrade and mineralize during storage (Cripps and Kelly, 1996; Summerfelt, 1999; Chen et al., 2002; Summerfelt and Vinci, 2003; Adler and Sikora, 2005). For example, monitoring conducted by personnel at the Conservation Fund Freshwater Institute revealed after 4 weeks of storage in a gravity thickening tank, supernatant (approximately 8 L/min) exiting the tanks possessed approximately 7–8 mg/L of total ammonia nitrogen (TAN), 6–10 mg/L of soluble phosphorus, and 80–140 mg/L of soluble carbonaceous biological oxygen demand (cBOD). These nutrient constituent concentrations, which resulted from biosolids degradation and nutrient leaching, were approximately 7-, 8.5-, and nearly 20-times higher than their respective concentrations in the backwash from the effluent drum filter. Therefore, this relatively small supernatant flow from the off-line gravity thickening tank will almost always contain the highest concentration of dissolved pollutants at a given recirculating facility (Summerfelt and Vinci, 2003). In fact, the waste concentrations found in this relatively small flow are more similar to the concentrations in wastewaters entering secondary treatment at publicly owned treatment works (POTWs) (Metcalf and Eddy, 2003). Therefore, many secondary treatment options used at POTWs can be used to treat thickening tank supernatant, as the daily volume produced is relatively small compared to the recirculating system processes flow, e.g., less than 0.2–2.0% of the recirculating system flow. If removal of particulate wastes and phosphorus are the goal, then the supernatant can be treated using coagulation–flocculation aids such as alum, ferric chloride, or polymers followed by settling or filtration (Ebeling et al., 2003). The tank overflow can also be reused for irrigation (Chen et al., 1997, 2002) or hydroponics (Adler et al., 1996, 2000). Removal of soluble cBOD and inorganic nitrogen compounds can be achieved with more traditional treatment processes, including: aerobic or anaerobic lagoons, created wetlands, anaerobic filters, or other suitable technologies. However, reducing effluent TAN levels, either through conversion to an oxidized form or algal assimilation, requires aerobic conditions, thereby eliminating most anaerobic treatment processes.

Lagoons have been successfully applied to reduce the nitrogen and phosphorus concentrations in the primary effluent streams from intensive aquaculture facilities (Chen et al., 1997, 2002). However, much of this work has focused on the efficacy of treating the full process flow (Bergheim and Brinker, 2003; Porrello et al., 2003a) and is often based on designs used for treating bovine and swine manure in lagoon treatment systems (Bastian, 1992). These basins tend to be oversized allowing for solids settling, accumulation and storage, and removal of nutrients, which are much higher in bovine and swine manures with respect to solids and cBOD than those observed in the primary waste stream from an aquaculture facility. While this design criteria is suitable for treating a concentrated