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Nutrient cycle and sludge production during different stages of red tilapia (*Oreochromis* sp.) growth in a recirculating aquaculture system

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Abstract

The nutrient cycle of input feed and sludge production was evaluated for five stages of red tilapia growth in a recirculating aquaculture system. Five weight groups of red tilapia, 20±0.00 (20), 39.70±0.44 (40), 80.38±0.41(80), 113.62±1.92 (120), and 177.67±1.81 (180) g in triplicates were selected as treatments and randomly introduced to the experimental units (75 fishes/unit) and cultured for a 3-week period. The body weight and biomass of the fish were correlated with the assimilation rates of some minerals supplied by the input feed. It was estimated that red tilapia could capture on average, 11.46% Fe, 13.43% Zn, 6.81% Mn, 3.55% Cu, 26.81% Ca, 20.29% Mg, 32.53% N, 7.16% K, and 15.98% P of input feed during a culture period (from 20–200 g). The sludge settled over the hydroponic troughs could capture average rate of 23.93% Fe, 86.05% Mn, 46.17% ZN, 21.49% Cu, 15.71% Ca, 88.87% Mg, 5.55% N, 5.85% K, and 17.90% P of input feed in each experimental unit. The dry matter of sludge showed significant differences ($P<0.05$) among treatments and ranged from 5.00% to 10.00% of dried input feed. The concentrations of total nitrogen, phosphorus, and magnesium in water were not significantly different ($P>0.05$) among experimental fish groups at the end of experimental period and continuously increased during the 21-day experimental period. The electroconductivity (EC) of water continuously increased during the experimental period. The pH of water decreased in all treatments at the end of experiment. The results of this study predicted the fate of input feed nutrients in a representative recirculating system where the particular diet was used. It was also demonstrated that the aquaculture effluent carries out a large amount of nutrients, including solids form which can be accumulated in the hydroponic(s) troughs.

Keywords: Nutrients cycle; Input feed; Sludge production; Red tilapia; Recirculating system

1. Introduction

The natural feeding strategy of fish species (i.e., herbivore, carnivore, omnivore, and filter feeder,

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etc.), fish stocking density, total fish biomass, input feed rate (fertilizer/feed used quantity and application method), water quality, and water management influence the assimilation of nutrients by fish and wastewater production (Tacon, 1995). Wastewater accumulates while feed is continuously added in a fish culture system. Wastewater effluent comprises mainly faeces, uneaten food, and bacterial biomass which are organic and rich in nutrients (Gloger et al., 1995). The total dissolved solid (TDS) generates (produces) due to feed leaching and bacterial degradation of faecal materials. Total suspended solid (TSS), including faecal materials and biomass of bacteria, is typically separated from water by the solid separation unit, which is then discharged from the culture system in the form of sludge (Coffin, 1993). These wastes, in one hand, can negatively impact on the adjacent environment owing to release of output effluents into the surrounding area. On the other hand, aquaculture wastes can be used to irrigate and fertilize terrestrial plants and reduce the use of inorganic fertilizer in agricultural lands, for example, in the climatic Mediterranean region (Maria et al., 1996). Wastewater processing or purification by plants in greenhouses or specific treatment systems has also become increasingly popular in response to water shortages (Gloger et al., 1995). Over the past 3 decades, in aquaculture practices, the hydroponic(s) plant compartments with different experimental design were integrated in the aquaculture systems in both warm and moderate climates to alleviate the accumulation of nutrients especially, N compounds in the culture system (Naegel, 1977; Lewis et al., 1978; Sutton and Lewis, 1982; Pierce, 1980). Closed recirculating systems appeared to be the most appropriate aquaculture system for integration with hydroponics since nutrients can be maintained at the concentrations which are sufficient for hydroponics plant culture (Nair et al., 1985; Rakocy et al., 2000). In aquaponic research, there has been strong interest to normalize the ratios between plants, fish, daily input feed, as well as the kind of integrated plant biofilter into the system (McMurtry et al., 1990; Rakocy, 1994). In some works, raft hydroponics itself has been integrated and made the main compartment for waste removal in the culture system without use of the bacterial biofilters (Gloger et al., 1995). In this respect, contribution of lettuce to waste treatment compartment have been well addressed (Rakocy, 1995). During fish development (growth), the stand biomass of fish is increased per unit of the experimental system. It is generally accepted that the rate of sludge production and feed nutrients assimilation in a culture system, depending on the life cycle of the fish, which can be varied during the time in an experimental culture system. Therefore, identification of such items can be crucial in this sense. At this study, it was tried to qualify and quantify the fate of input feed nutrients associated with physical and biological factors involving in a recirculating fish culture system. Thus, the main objective of this study was to evaluate the cycle of feed nutrients and sludge production, with an emphasis on characterization of wastewater production in different stages of red tilapia growth.

2. Materials and methods

The fate of nutrients that come from input feed was evaluated in different stages of red tilapia growth in a representative recirculating aquaculture system. Five weight groups of red tilapia, 20±0.00 (20), 39.70±0.44 (40), 80.38±0.41(80), 113.62±1.92(120), and 177.67±1.81 (180) g with 75 pieces of fish were selected as treatments in triplicates and randomly introduced to experimental units. It was estimated that the mean individual fish weight in each group would reach the next mean individual weight group after a 21-day culture period. For example, 20-g fish would grow to 40 g after a 3-week culture period. Therefore, the duration of the study was a 3-week experimental period. The experimental system consisted of a fiberglass tank (110 W×84 L×100 H cm) equipped with three raft hydroponic troughs (110 L×30 W×5 D cm) and a submersible water pump (Model Aqua, 1500). The water pump was used for recycling the water from the fish tank through the hydroponic troughs and finally to the fish tank (Fig. 1).

The hydroponics troughs were used to limit penetration of light to the fish tank and reduce algal growth and as a bed for water recycling (providing the similar condition to fish in an aquaponic system without use of plants). At the day of experimental