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Short Communication: Comparison of the water environment aspects and production of Nile tilapia (*Oreochromis niloticus*) between biofloc and conventional aquaculture systems in tropical dryland region

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Abstract. *Halla PTHB, Lalel, H, Santoso P. 2023. Short Communication: Comparison of the water environment aspects and production of Nile tilapia (*Oreochromis niloticus*) between biofloc and conventional aquaculture systems in tropical dryland region. Intl J Trop Drylands 7: 12-15.* The study aimed to compare the water quality of two aquaculture systems (i.e., conventional system and biofloc technology system) used to cultivate Nile tilapia (*Oreochromis niloticus* Linnaeus, 1758) in tropical dry land areas. This study used a survey method using seven samples for each aquaculture system. The results of the Kruskal-Wallis test showed that there was a significant difference ($P<0.05$) in the content of ammonia (NH_3) between the two aquaculture systems, while the content of nitrate (NO_3), phosphate (PO_4), dissolved oxygen (DO) and pH was not significantly different ($P>0.05$). Although the value of ammonia (NH_3) in the biofloc aquaculture system is higher than in the conventional aquaculture system, it is still below the quality standard of the aquatic environment. Conversely, the specific growth rate (SGR), relative growth rate (RGR), survival rate (SR), and production of fish between the two aquaculture systems showed significant differences ($P<0.05$). Where the value of SGR, RGR, and survival rate in conventional ponds is higher than that of biofloc ponds, on the contrary, the value of fish production in biofloc ponds is higher than in conventional ponds.

Keywords: Aquaculture, biofloc, environment, fish, freshwater, production

INTRODUCTION

The development of freshwater fish farming in tropical dryland areas is limited by freshwater availability, especially in the dry season. Therefore, appropriate technological innovations, especially to overcome the limitations of freshwater, are needed to increase freshwater fish production in this area. The biofloc system may be an alternative that can be applied in producing freshwater fish culture in tropical dryland areas.

The application of fish aquaculture systems, both intensive and semi-intensive, is faced with the problem of decreasing water quality caused by waste in the form of metabolite waste (feces and urine) and uneaten feed residue. The waste increases the content of inorganic nitrogen compounds, namely ammonia (NH_3), nitrite (NO_2), and nitrate (NO_3). However, feed with a high protein content is only used by fish by 20-30%, and the rest will be disposed of in aquaculture media in the form of urine and feces. The accumulation of these metabolites results in the formation of toxic compounds for fish, mineralization of nutrients that produce organic nitrogen, and high oxygen absorption, thereby accelerating the decline in water quality which impacts fish survival (Shin et al. 2016; Palupi et al. 2021).

Heterotrophic bacteria can convert nutrients from feed residues and waste metabolites into potential biomass for forming natural feed. If this process takes place effectively, the waste of metabolites in the aquaculture media will be resolved. As a result, heterotrophic bacterial communities will form floc that can be used as a source of natural fish food. Technology for activating heterotrophic bacteria under anaerobic conditions is known as the biofloc system (Ahadiftita et al. 2016; Kunindar et al. 2018).

The application of the biofloc system is based on the manipulation of the C: N ratio; if the ratio is 15-20 or there is a sufficient supply of additional carbon, such as glucose, sucrose, and starch in the pond, the inorganic nitrogen component will be converted into effective bacterial biomass. In principle, the biofloc system can change organic compounds in the nitrogen cycle in the aquaculture system through the enrichment of heterotrophic microbial growth that can reduce nitrogen waste (Kunindar et al. 2018).

The quality of the aquatic environment is one factor that affects fish's growth, survival, and production (Koniyo and Juliana 2018; Asriyana et al. 2021). On the other hand, biofloc technology has the opportunity to be an alternative solution to the problem of the quality of the aquatic environment in closed-system aquaculture. Based on these considerations, a comparative study has been carried out on aspects of the aquatic environment and production of tilapia (*Oreochromis niloticus* Linnaeus, 1758) in conventional and biofloc aquaculture systems in tropical dryland areas.

MATERIALS AND METHODS

Study area

The research was conducted in Oinlasi Village, South Mollo Sub-district, South Central Timor District, East Nusa Tenggara Province, Indonesia. Water quality analysis is carried out at the Fisheries Field Laboratory, UPT. *Laboratorium Lapangan Terpadu Lahan Kering Kepulauan* (Integrated Field Laboratory of Archipelagic Dryland), Universitas Nusa Cendana, Indonesia. In addition, water quality analysis is carried out at the Laboratory of Fisheries, Faculty of Marine Science and Fisheries, University of Nusa Cendana.

Procedures

The study used a survey method, with a variety of water, environmental parameters (ammonia, nitrate, phosphate, dissolved oxygen, and pH), and tilapia production in 2 (two) different groups of aquaculture ponds, namely ponds with biofloc systems and ponds with conventional systems respectively, each with a capacity of 10 m^3. Before the research, the ponds with the biofloc system had been treated with calcium hydroxide ($Ca(OH)_2$), cruciferous salt, granulated sugar, and aquaenzyme™ (containing bacteria *Bacillus subtilis*, *B. megaterium*, *B. polimyxa* each with a density of $5x10^9$ CFU). These materials are put into aquaculture water, then aerated.

The tilapia used weighs 10 grams. The density of tilapia in each conventional pond is 1,000 fish/pond, while in biofloc ponds, it is 2,000 fish/pond. Commercial feed was given at a dose of 5% by weight of biomass in the first month and 5% by weight of biomass in the following month, with a frequency of feeding three times a day. As a result, water changes in conventional pond systems are carried out every week as much as 30%, while in biofloc ponds, there are no water changes.

Water quality samples in NH_3, NO_3, and PO_4 were taken 7 times, and laboratory tests were carried out in the Field Laboratory of Fisheries, Universitas Nusa Cendana. In contrast, other water quality parameters were tested every week in the morning and evening.

Data analysis

Specific growth rate

$$SGR = \frac{(\ln W_t - \ln W_0)}{\mathrm{t}}\ X\ 100\%$$

Where:
SGR : specific growth rate (%/day);
W_t : average weight of fish on day t (g);
W_0 : average weight at the beginning of the study (g)

Relative growth rate

$$\mathrm{RGR} = \frac{W_t - W_0}{W_0 \times t} \times 100\%$$

Where:
RGR : relative growth rate;
W_t : fish biomass for the final test (%/day);
W_0 : fish biomass for the initial test;
t : length of the study.

Survival rate

$$SR = \frac{(N_0 - N_t)}{N_0}\ X\ 100\%$$

Where:
SR : survival rate (%);
N_0 : the number of fish at the beginning of the study;
N_t : the number of fish at the end of the study.

Biomass production

$$P = W \times N$$

Where:
P : biomass production,
W : individual weight at the end of the study,
N : number of live fish at the end of the study.

Statistical analysis

This study used the statistical analysis by the Kruskal Wallis test using the software SPSS VER 24 (Statistical Package for the Social Sciences version 24).

RESULTS AND DISCUSSION

Results

The mean values of environmental parameters in conventional ponds are ammonia 0.04 mg/L, nitrate 1.96 mg/L, phosphate 0.08 mg/L, dissolved oxygen 5.57 mg/L, and pH 7.9. Meanwhile, in the biofloc ponds, ammonia 0.04 mg/L, nitrate 1.33 mg/L, phosphate 0.12 mg/L, dissolved oxygen 5.31 mg/L, and pH 8.21 (Figure 1). The results of the Kruskal-Wallis Test showed that the ammonia value in conventional ponds was significantly different ($P<0.05$) compared to biofloc ponds. In contrast, nitrate, phosphate, dissolved oxygen, and pH values did not show significant differences ($P>0.05$), where the value of ammonia (NH_3) in biofloc ponds is higher than in conventional ponds.

The observations on tilapia in conventional ponds obtained the following results: specific growth rate (SGR) of 0.82 %/d, relative growth rate (RGR) of 3.59 %/d, a survival rate of 89.46%, and fish production of 95.67 kg. Meanwhile, tilapia in biofloc ponds obtained SGR of 0.78%/d, RGR of 3.15%/d, a survival rate of 85.86%, and fish production of 896.66 kg (Figure 2). The results of the Kruskal-Wallis Test showed that the values of SGR, RGR, survival rate, and fish production in conventional ponds were significantly different ($P<0.05$) compared to biofloc ponds. Where the value of SGR, RGR, and survival rate in conventional ponds is higher than that of biofloc ponds, on the contrary, the value of fish production in biofloc ponds is higher than in conventional ponds.

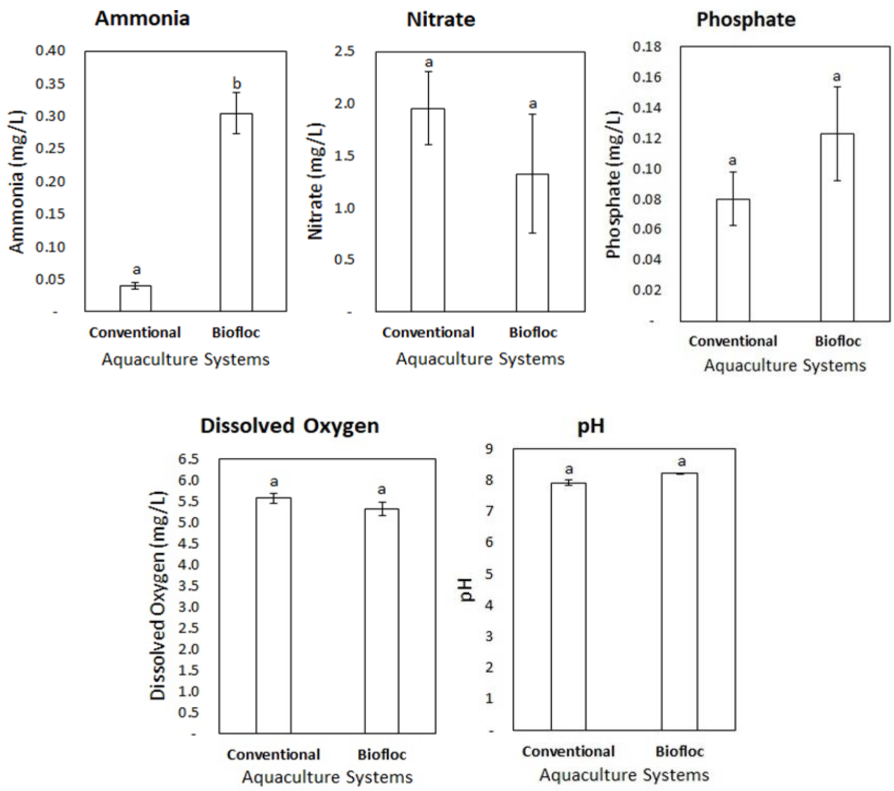

Figure 1. Graph of water environment parameters

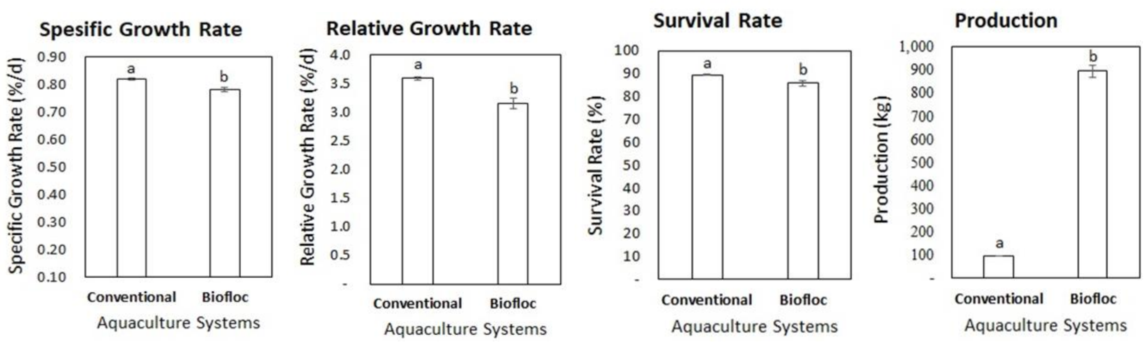

Figure 2. Graph of growth (SGR and RGR), survival rate, and fish production

Discussion

The high content of ammonia in the biofloc aquaculture system in this study was due to this system being run without water changes until the end of the study. That allows the accumulation of ammonia in the waters due to the ineffective reduction of ammonia in the biofloc formation process in this system. The results of previous studies also showed that soil ponds produced lower ammonia content (Mustapha and Akinshola 2016). In aquaculture systems, ammonia comes from the decomposition of organic matter from food residue or dead plankton and the excretion of metabolic products through the kidneys and gill channels (Ahadiftita et al. 2016).

Ammonia concentrations above 0.2 mg/L in fish ponds threaten fish life (Ogbonna and Chinomso 2010). The ammonia value for rearing tilapia in calm water is 0.02 mg/L level. If the ammonia concentration is more than 0.08 mg/L, it will reduce the appetite and growth of fish (Panggabean et al. 2016). Ammonia content will poison fish if it is 0.06-2 mg/L (Effendi 2016). Increased ammonia can increase fish leukocytes and reduce erythrocytes, hematocrit, and hemoglobin. Ammonia as a stressor can reduce the specific growth rate (SGR), reduction of feed intake, disturbance in metabolism, and harm the health of tilapia (Zeitoun et al. 2016). In addition, an increase in ammonia in fish ponds will trigger other reactions that can increase the concentration of other physicochemical parameters, namely TDS, Calcium, Electrical Conductivity, chloride, and nitrite (Ogbonna and Chinomso 2010).

Ammonia oxidation is carried out by aerobic chemoautotrophic bacteria (Nitrosomonas and Nitrobacter, primarily) to produce nitrite and nitrate (Camargo et al. 2005). Nitrite is toxic to fish because it disrupts several physiological functions, namely osmoregulation, respiratory, cardiovascular, endocrine, and excretory (Kroupova et al. 2015). Although nitrate is not toxic to fish, at too high concentrations, it can cause hypoxia in fish (Isaza et al. 2021). Nitrates in water are reduced by phytoplankton and aquatic plants for nitrogen assimilation (Ahadiftita et al. 2016).

Phosphate values in conventional aquaculture systems are not different from those in biofloc aquaculture systems. That is because both aquaculture systems are closed systems, so the source of phosphate in aquaculture media comes from the same source, namely fish feed. In addition, the presence of phosphate in the waters is related to stocking density, residual feces, and food residue that fish do not eat. Therefore, phosphate values in aquaculture systems occur in line with an increase in fish density, metabolic waste, and feed waste that fish do not eat (Kunindar et al. 2018; Piranti et al. 2018). However, both in conventional and biofloc aquaculture, the phosphate values in this study were still below the phosphate quality standard, which was <2 mg/L (Effendi 2016; Putri et al. 2019).

Dissolved oxygen values in conventional aquaculture and biofloc systems also did not show significant differences. Although the biofloc aquaculture system is equipped with an aeration system to supply oxygen to the air, the oxygen consumption in this system is also high because this system applies a high fish density. Therefore, the dissolved oxygen concentration in these two cultivation systems is in the range following the quality standard, which is >4 mg/L (Effendi 2016; Kunindar et al. 2018).

The pH values in this study did not differ between the biofloc system ponds and conventional ponds. However, the results of this study showed that the pH value in the second cultivation system showed a range that followed the quality standard for aquaculture, which was between 6-9. In water, the pH value is related to ammonia; if the ammonia is high, then the pH also increases (Effendi 2016; Putri et al. 2019).

Specific Growth Rate (SGR), relative growth rate (RGR), and Survival Rate (SR) in conventional aquaculture systems were higher than in biofloc aquaculture systems. Fish production in aquaculture systems is higher than in conventional aquaculture systems. Fish production in the biofloc aquaculture system is higher because the farmed fish receives the feed in the form of biofloc in addition to artificial feed. Biofloc is a microorganism that forms floc, a natural food for cultured fish (Kunindar et al. 2018). The Survival Rate (SR) in the biofloc aquaculture system is lower due to competition for oxygen. Although this system is equipped with an aeration system, the high concentration of floc causes competition for oxygen between the floc community and fish fry in the cultivation media of the biofloc system (Ahadiftita et al. 2016).

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