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Short Communication: Water quality improvement of Nile tilapia and catfish polyculture in aquaponics system

ZAHIDAH HASAN[1,♥], YAYAT DHAHIYAT[1], YULI ANDRIANI[1], IRFAN ZIDNI[2]
[1]Faculty of Fisheries and Marine Science, UniversitasPadjadjaran, Jl. Raya Bandung Km 21, Jatinangor, Sumedang 45363, West Java, Indonesia. Tel./Fax.: +62-22-87701519, ♥email: ibuzah@gmail.com
[2]Faculty of Agriculture, Universitas Padjadjaran. Jl Raya Bandung-Sumedang KM 21, Jatinangor, Sumedang 45363, West Java, Indonesia

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Abstract. *Hasan Z, Dhahiyat Y, Andriani Y, Zidni I. 2016. Water quality improvement of Nile tilapia and catfish polyculture in aquaponics system. Nusantara Bioscience 8: 83-85*. Research on the improvement of polyculture water quality in aquaponics system was conducted from July 2014 to August 2014. This study aims to improve the water quality in Nile tilapia and catfish polyculture by applying the aquaponics system. The results show that several water quality parameters increase, such as dissolved oxygen, ammonia, and nitrate. Meanwhile, Orthophosphate tends to be similar both in aquaponics system and control. The study is conducted experimentally by using completely randomized design. The cultured fish are catfish and Nile tilapia while the aquatic plants are water spinach and lettuce. At the end of the study the concentration of dissolved oxygen in the aquaponics system ranges from 5.3 to 7.6 mg/L, while in the media control ranges from 4.2 to 4.3 mg/L. Average concentrations of ammonia, nitrate and orthophosphate in the aquaponics system range from 0.003 to 0.25 mg/L, 10.0 to 50.7 mg/L and 3.0 mg/L-5.0 mg/L respectively. Meanwhile, in media control, concentration of those three parameters are 0.003 to 0.35 mg/L, 10.0 to 60.0 mg/L and 3.0 to 5.0 mg/L respectively. Based on this study, it is concluded that the polyculture water quality can be improved through the application of the aquaponics system.

Keywords: Aquaponics, catfish, polyculture, tilapia

INTRODUCTION

Aquaculture is an industrial activity that is undergoing 7% increase each year and is projected to replace conventional fish catching in meeting the need for fish (FAO 2009). According to the Ministry of Marine and Fishery (2010), the fishery production in Indonesia in 2010 amounted to 10.83 million tons, 50.55% of which derives from aquaculture. The availability of land and water for aquaculture is getting more limited due to population growth and physical development. Besides the communal activities that cause pollutions, the fish culturing activity also produces waste such as feed leftover, feces, and residue of fish metabolism, high in ammonia content that is toxic to the cultured organisms and decreases the concentration of dissolved oxygen. These will later ignite domino effects that are both economically and ecologically devastating.

Innovation and technological inputs are required to anticipate the decline in aquaculture production and productivity due to the decrease of land availability and water quality. One technological innovation is the integration of fish culturing with a plant growing called the aquaponics system (Diver 2010). Somerville et al.(2014) stated that the aquaponics system is a solution due to growing price of land, limited water source, and infertile land. It is further stated that aquaponics is suitable for sandy areas as well as urban farming. Most plants can be grown in the aquaponics system, among which are water spinach and lettuce. These plants are biofilter alternatives in absorbing nitrogen in form of ammonium ($NH4^+$) and nitrate (NO_3^-), in order to reduce the nitrogen content in water (Rakocy et al. 2006; Rakocy 2007).

Most plants can be grown in the aquaponics system. Based on Diver (2010) the selection of plant species adapted to hydroponic culture in aquaponic greenhouses is related to stocking density of fish tanks and subsequent nutrient concentration of aquacultural effluent. Lettuce, herbs, and specialty greens (spinach, chives, basil, and watercress) have low to medium nutritional requirements and are well adapted to aquaponic systems. Meanwhile Pantanella (2010) stated that plants performance is specific for each cultivar and the same aquaponics nutrient pool may not be totally applicable to others plant varieties for optimal growth due differences nutritional needs. to In this research water spinach and lettuce be chosen as plants tested. These plants are biofilter alternatives in absorbing nitrogen in form of ammonium (NH^{4+}) and nitrate (NO_{3-}), in order to reduce the nitrogen content in water (Rakocy et al. 2006; Rakocy 2007). A simplified nitrogen cycle in an aquaponic system that includes plants, fish and nitrifying bacteria has been stated by Tyson and Simmone (2015).

The initiation of the aquaponics system in the experiment pond the Faculty of Fisheries and Marine Sciences has begun since the study by Zidni et al. (2013). In the study the culturing of Sangkuriang catfish is integrated with growing water spinach. The results of the study show that Sangkuriang catfish can be cultured at the stocking density ratio of up to 100 fish/m^2 with excellent growth rate without deterioration in the quality of water in the culture media. These results show that there are opportunities in using the available spaces and water quality to increase productivity through polyculture. The polyculture has been studied in 2014 (Zidni et al. 2015) by polyculturing Nile tilapia and catfish. The aim of the study is to obtain the optimal water quality in Nile tilapia and catfish polyculture integrated with an aquatic plant growing in an aquaponics system.

MATERIALS AND METHODS

The study was conducted from July to August 2014 for seven weeks, taking place at the Ciparanje Laboratory of Fish Culture, Faculty of Fisheries and Marine Sciences, Universitas Padjajaran, Sumedang, West Java, Indonesia. The design of the study is completely randomized design with three treatments repeated three times as the following: (i) catfish and Nile tilapia with water spinach, (ii) catfish and Nile tilapia with lettuce, (iii) catfish and Nile tilapia without aquatic plant.

The cultured fish used in this study are 54-day-old Sangkuriang catfish fry 3.07 g in weight and Nile tilapia fry 4-5 g in weight. The stocking density ratio of both fish is 75 fry/m^2. The cultured fish were obtained from the Center of Fish Fry in Ciparay, Bandung Regency, West Java. Fishes were cultured in nine cubical fiberglass of 1 m x 1m x 0.5 m in dimension. The water spinach sprouts used are 7-10 cm high and were previously seeded at Ciparanje pond. The lettuce sprouts are 5-7 cm high and were seeded by PT. Momenta Agrikultura “Amazingfarm” Lembang, West Bandung, West Java, Indonesia. The receptacles for plant growing are six units made of styrofoam measuring 90 cm x 90 cm x 3 cm.

Analysis of variance was used for testing different parameters for statistical difference and test Duncan multiple range tests was applied to rank the treatment means tested for significance.

RESULTS AND DISCUSSION

The dissolved oxygen content in the water during study fluctuated between 4.3 mg/L and 6.5 mg/L. According to SNI (2009), the dissolved oxygen content for Nile tilapia fry is >3 mg/L, while also according to SNI (2000) the dissolved oxygen content for catfish fry is >4 mg/L. As such, the fluctuating dissolved oxygen in the study is still within the normal limits for the growth of both the Nile tilapia and catfish fry. The fluctuation of dissolved oxygen can be seen in Figure 1. The statistical analysis on the seventh week shows that the concentration of dissolved oxygen in the aquaponics treatment is significantly different from that in the control ones. However, different plant species do not give a significant difference in concentration. The treatments with aquatic plants increase the concentration of dissolved oxygen since, in the daytime, aquatic plants produce oxygen in the photosynthesis process. The increase in dissolved oxygen concentration in the treatments with aquatic plants improves the fish’s appetite, resulting in better growth rates.

Mallya (2007) stated that in fish, the metabolic rate is highly affected by the concentration of oxygen in the rearing environment. As the dissolved oxygen concentration decreases, respiration and feeding activities also decrease. As a result, the growth rate is reduced and the possibility of a disease attack is increased. Futhermore Mallya (2007) stated that decreased oxygen availability is also considered a major factor in determining food intake. Low dissolved oxygen is a type of stress frequently found in fish farms characterized by high fish densities and polluted fresh or marine waters. This is evident in both Nile tilapia and catfish. After seven weeks, the weight of the fish increases 5.70 g on average in the media with water spinach and 5.19 g on average in the media with lettuce, while in the control treatment, the average weight gain of the fish is only 4.30 g.

The results show that the nitrate concentration fluctuates. The treatments with aquatic plants utilize the nitrate very well, resulting in the lower concentration at the end of the study as opposed to the higher nitrate concentration in the media without aquatic plant (Figure 2). The statistical analysis of the seventh-week data shows a significant difference between the aquaponics treatments. The treatment with water spinach results in the lowest nitrate concentration while the concentration in the lettuce treatment is not significantly different with the control treatment.

In the treatments with aquatic plants, the nitrification process runs well since there is an interaction among fish, aquatic plants and nitrification bacteria. The protein from the feed is decomposed into the simple compound by converting bacteria such as *Nitrosomonas* hat converts ammonia into nitrite and *Nitrobacter* that converts nitrite into nitrate; this nitrate is further used by both water spinach and lettuce as a nutrient, resulting in the balance of nitrogen in the aquaponics system. At this condition, the good quality of water is maintained, supporting fish growth through the use of feed.

The results show that the ammonia concentration in the culture media fluctuates (Figure 3).The statistical analysis shows significant differences among treatments. While the water spinach treatment is not significantly different from lettuce treatment, these two treatments are significantly different from the control treatment. Even though both aquaponics treatments are not significantly different from each other, the water spinach treatment has a tendency to have a lower ammonia concentration. The root characteristic of water spinach can absorb ammonia in water much better than that of lettuce since water spinach has more branching roots.

Ammonia in the waters affects the survival rate of fish. The growing of water spinach that results in lower ammonia concentration demonstrates a higher survival rate (81.78%) than lettuce (80.00%), while in the control treatment, the survival rate is 76%. Another compound in the water that influences plant productivity is phosphate. Lack of phosphate may reduce the growth of aquatic plants (Bahri 2006). The fluctuation of phosphate concentration is showed in Figure 4. The analysis shows that there are no significant differences among treatments.

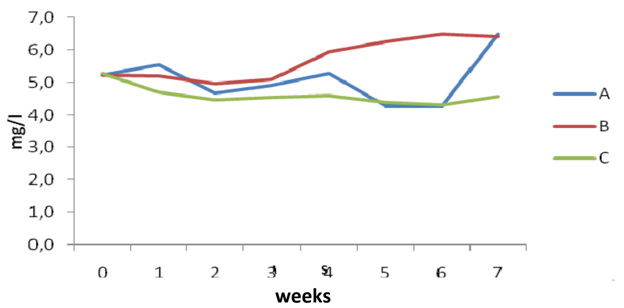

Figure 1. Dissolved Oxygen concentration. A. Catfish and Nile tilapia with water spinach, B. Catfish and Nile tilapia with lettuce, C. Catfish and Nile tilapia without aquatic plant

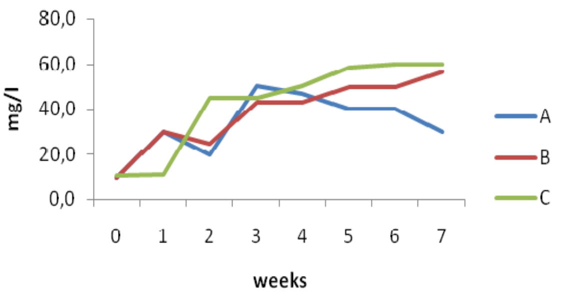

Figure 2. Nitrate concentration. A. Catfish and Nile tilapia with water spinach, B. Catfish and Nile tilapia with lettuce, C. Catfish and Nile tilapia without aquatic plant

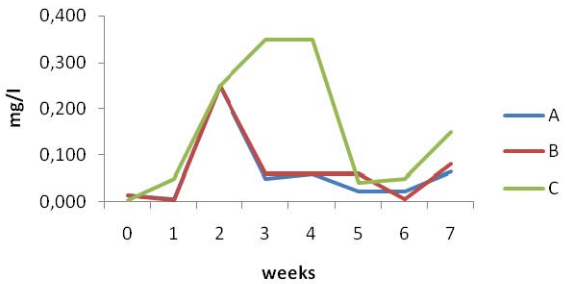

Figure 3. Ammonia concentration. A. Catfish and Nile tilapia with water spinach, B. Catfish and Nile tilapia with lettuce, C. Catfish and Nile tilapia without aquatic plant

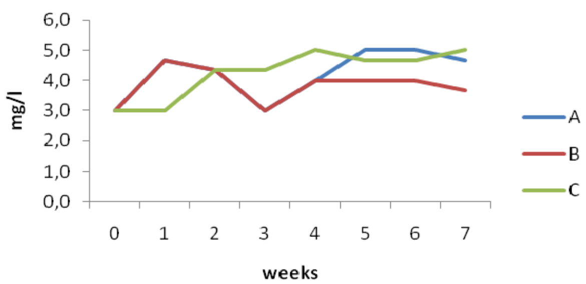

Figure 4. Orthophosphate concentration. A. Catfish and Nile tilapia with water spinach, B. Catfish and Nile tilapia with lettuce, C. Catfish and Nile tilapia without aquatic plant

The concentration of phosphate during the study is around 3.0 mg/L to 5.0 mg/L. The treatments with aquatic plants reduce the phosphate concentration at the end of the study, due to phosphate being used by the plants as a nutrient, while in the control treatment without water plants, the concentration of phosphate increases as it is not well-utilized. Based on Somerville et al. (2014), aquaponics system provide better water quality compare to conventional system.

Based on the results, it can be concluded that the aquaponics system increases the concentration of dissolved oxygen and reduces the concentration of nitrate, ammonia and orthophosphate in the polyculture of Nile tilapia and catfish. The growing of water spinach in the aquaponics system results in higher growth rate and survival rate for both the Nile tilapia and catfish, compared to the growing of lettuce in the same system.

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REFERENCES

Bahri FA. 2006. Analysis of Nitrate and Phosphate Content in Recovered Mangrove Sediments in Sub-District Mallusetasi, District of Barru. Asosiasi Konservator Lingkungan, Makassar, Indonesia [Indonesian].

Diver S. 2010. Aquaponics – Integration of Hydroponics with Aquaculture. National Sustainable Agriculture Information Service 1-800-346-9140 Australia.

FAO. 2009. The State of World Fisheries and Aquaculture 2008. FAO, Rome.

Mallya YJ. 2007. The Effect of Dissolved Oxygen on Fish Growth in Aquaculture. United Nation University Final Report. Reykjavik, Iceland

Ministry of Marine and Fishery. 2010. MMF Optimistic Increase Production of Aquaculture. http://www. kkp.go.id

Pantanella E. 2010. New Aquaponics Research In Italy. www.aquaponicsjournal.com. Issue No. 56, 1st qtr 2010

Rakocy JE. 2007. Ten guidelines for aquaponic systems. Aquaponics J 46: 14-17.

Rakocy JE, Masser MP, Losordo TM. 2006. Recirculating aquaculture tank production systems: aquaponics-integrating fish and plant culture. SRAC Publication No. 454 (revision November 2006). USA, Department of Agriculture.

SNI. 2000. Indonesian Nasional Standard (SNI): 01-6484.4 – 2000. Seed production of "Dumbo" Catfish (*Clarias gariepinus X Clarias fuscus*) stocked seed size. [Indonesian]

SNI. 2009. Indonesian Nasional Standard (SNI): 7559– 2009. Nile tilapia Production (*Oreochromis niloticus* Bleeker) rearing size. [Indonesian]

Somerville C, Cohen M, Pantanella E, Stankus A, Lovatelli A. 2014. Small-Scale Aquaponics Food Production; Integrated fish and plant farming. FAO Fisheries and Aquaculture Technical Paper No. 589. Food and Agriculture Organization of The United Nations, Rome.

Tyson R, Simmone E. 2015. A Practical Guide for Aquaponics as an Alternative Enterprise. University of Florida IFAS Extension Publication #HS1252

Zidni I. 2013. The effect of stocking density on "Sangkuriang" seed Catfish (*Clarias gariepinus*) in Aquaponics System [Hon. Thesis]. Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran. Bandung [Indonesian].

Zidni I. 2015. Effectiveness of Biofilter Water Plants in Polyculture of Fishes on Aquaponics System. [Thesis]. Faculty of Agriculture Universitas Padjadjaran. Bandung [Indonesian].