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Wastewater of gourami (*Osphronemus goramy*) cultivation treatment by romaine lettuce (*Lactuca sativa* L. var. *longifolia*)

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Introduction

Aquaculture releases organic compounds and nutrients (nitrogen, phosphorus, and other elements) that require treatment before disposal in the large amounts [1]. According to Ghaly et al. [2], organic matter, nitrogen, and phosphorus are utilized by fish as a main indicator of feed efficiency. Feed is the main source of ammonia in the aquaculture system because fish only absorb 20-30% of nutrients derived from feed while the rest is excreted into the environment in the form of ammonia and organic protein [3]. In general, most of the nitrogenous wastes (60-90%) is in dissolved form (mainly ammonia), while for phosphorus (25-85%), a greater proportion is excreted in the form of residual waste of fish metabolism [2].

Research on aquaponics systems is now being developed. Some studies that have successfully applied this method included Effendi et al. [4] using water spinach with crayfish; Delis et al. [5] using tilapia and vetiver; Effendi et al. [6] using tilapia and romaine lettuce. This study was aimed to investigate nitrogen characteristics (TAN, ammonia, ammonium, nitrite, and nitrate) of gouramy cultivation wastewater remediated by romaine lettuce.

Materials and methods

Recirculation system was applied using set of aquariums (Fig. 1). Gouramy (*Osphronemus goramy*) had total length of 11-13 cm and were maintained in aquarium at stocking density of 100-150 fish/m^3 (10 fish per aquarium). Fish were reared for 35 days and fed as much as 3% of body weight, three times a day. Two weeks old romaine lettuces (*Lactuca sativa* L. var. *longifolia*), height (4-5 cm) were planted in the pots. The seeds had a distance of ± 20 cm for 10 lettuces (P2) and ± 10 cm for 20 lettuces (P3) in the gutters. P1 was the control aquarium without lettuce. Lettuces were transferred into the gutters one week after the fishes were put into the aquarium.

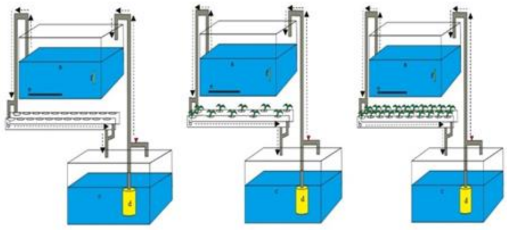

Fig. 1. (A) P1: Aquaponics control without lettuce (B) P2: Aquaponics with 10 romaine lettuces (C) P3: Aquaponics with 20 romaine lettuces. Note: a) Aquarium (80l x 40w x 40h), b) Hydroponics Gutters (81l x 14w x 11h), c) Water Reservoir (80l x 40w x 40h), d) Water Pump, and e) Water Heater, f. Water

During the 35 days of experiment, no additional nutrients were given to the lettuce. The nutrients were only derived from gouramy cultivation waste.

Feed conversion ratio (FCR) and survival rate (SR) of the fish were calculated. Daily growth rate (DGR) and relative growth (RGR) of romaine lettuce were measured. Water quality parameters [7] observed weekly included temperature, turbidity, pH, dissolved oxygen (DO), TAN, nitrate, nitrite and orthophosphate. NH_4^+ and NH_3 was calculated based on total ammonia nitrogen (TAN) [8]. Data were analyzed by ANOVA, followed by Duncan ($p<0.05$), Pearson's correlation and biplot.

Results and Discussion

Water quality characteristic

DO ranged 4.68-4.97 mg/L. DO above the critical threshold (>2 mg/L) is necessary to make the nitrification process goes well [9]. TAN ranged 1.74-2.24 mg/L. TAN in P2 was lower than that of P1 and P3. TAN was lower than TAN of Wahyuningsih et al. [3]. NH_3 ranged 0.02-0.04 mg/L. NH_3 decreased on day 28 until the end of treatment ($p<0.05$). NH_3 was still safe for fish life namely ≤1.0 mg/L. Nitrite ranged 0.38-0.67 mg/L. Nitrite was lower than nitrite by Ridha and Cruz [10]. In the recirculation system, nitrite should not exceed 10 mg/L and it should remain <1 mg/L [11]. Nitrate ranged 1.59-1.86 mg/L. Nitrate was lower than the research of Effendi et al. [6]. Orthophosphate in P1 (0.29±0.20 mg/L) was lower than in P2 (0.59±0.61 mg/L) and P3 (0.59±0.60 mg/L). Orthophosphate in P1 was significantly different from the P2 and P3 ($p<0.05$).

Romaine lettuce and gouramy growth

A detailed discussion linked to the growth of romaine lettuce and gouramy was elaborated by elsewhere [12].

During the experiment, the growth of romaine lettuce in P2 (aquaponics with 10 romaine lettuces) and P3 (aquaponics with 20 romaine lettuces) showed a favorable growth which was marked by the green and fresh leaves. The final weight in P2 and P3 exhibited not much different namely 89.4±7.4 g (P2) and 85±11.5 g (P3) [12]. The final weight of romaine lettuce was better when compared with the research of Sikawa and Yaakupitiyage [13]. Daily growth of romaine lettuce (plant height) was almost the same when compared to [4]. Relative growth (RGR) of romaine lettuce was 0.002-0.003 g/day [12]. The growth rate was relatively small when compared with Buzby and Lin [14], the relative growth of lettuce on aquaponics system at the end of the experiment reached 0.01 g/day [12].

The success of phytoremediation of fish farming waste on aquaponics system was also supported by the growth performance of fish. Final weight of gouramy reached 58.83±8.83 g (P1), 67.90±17.5 (P2), and 72.17±12.69 (P3). P3 had higher FCR (0.59±0.28) than P1 (0.69±0.25) and P2 (0.66±0.07) [12]. The highest SR of gouramy was in P1 and P2 of 100% and the lowest SR was in P3 of 66.67%. According to Budi et al. [15], gouramy is a fish that has been slow and difficult growth. Even oil-contaminated water could be processed by plant in floating wetland system [16].

Pearson correlation of water quality parameter

Relationship between TAN with ammonium (1.000) and nitrate (0.781) was positive. This is in line with the data of TAN, ammonium and nitrate in the three treatments (P1, P2, P3) which amounted to 2.24 mg/L, 1.74 mg/L, and 2.11 mg/L for TAN; 2.21 mg/L, 1.70 mg/L, and 2.10 mg/L ammonium; 1.75 mg/L, 1.59 mg/L and 1.86 mg/L for nitrate, respectively.

TAN with ammonium showed a strong correlation of 1.000. The relationship between TAN and ammonia (-0.833) and nitrite (-0.997) was negative. It is also supported by ammonia and nitrite in the three treatments (P1, P2, P3) amounting 0.02 mg/L, 0.04 mg/L, and 0.02 mg/L for ammonia; 0.38 mg/L, 0.67 mg/L, and 0.43 mg/L for nitrite, respectively.

Biplot Analysis

The dominant parameters in P1 were turbidity, ammonium, and TAN. Meanwhile the dominant parameter in P2 (aquaponics with 10 lettuce) were wet weight of lettuce, DO, nitrite, pH, and ammonia.

P3 had dominant parameter of nitrates, temperature, wet weight of fish, fish length, plant height, number of leaves, leaf width, and orthophosphate.

Overall, it indicates that fish parameters in P3 (wet weight, total length); plant parameters (plant height, leaf width, number of leaves); and water quality parameters (pH, turbidity, ammonia, nitrate, and nitrite), were better than those of in both other treatments. Although, the wet weight of lettuce in P2 was better than that of P3, yet P2 had the disadvantage of high nitrite and ammonia.

Conclusions

Organic waste from gouramy cultivation could be processed in phytoremediation using romaine lettuce. It can be seen from the lowest concentration of TAN, ammonium, nitrate, and orthophosphate on P2 (aquaponics system using 10 romaine lettuces) namely 1.74±0.76 mg/L, 1.70±0.74 mg/L, 1.59±0.81 mg/L and 0.59±0.61 m/L, respectively. However, the lowest concentration of ammonia (0.02±0.02 mg/L) and nitrite (0.02±0.02 mg/L) was obtained in treatment of P3 (aquaponics system using 20 romaine lettuces). The highest wet weight of lettuce was in P2, yet ammonia was still relatively high. Meanwhile, the highest fish weight and lower ammonia were found in P3.

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