

Impact of Red Water System (RWS) application on water quality of catfish culture using aquaponics

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Abstract. This study aim was to analyze the effect of Red Water System (RWS) probiotics application on water quality in aquaponic system. The research used experimental method using Completely Randomized Design (CRD) with five treatments and three replications. Treatment A: RWS 7.5 $\mu\text{L}\cdot\text{L}^{-1}$ /week without aquaponic probiotic, Treatment B: aquaponic without RWS probiotics, treatment C: RWS probiotic addition in aquaponic media at 7.5 $\mu\text{L}\cdot\text{L}^{-1}$ /week, treatment D: addition of RWS probiotics in aquaponic media at 10 $\mu\text{L}\cdot\text{L}^{-1}$ /week and treatment E: addition of RWS probiotics in in aquaponic media at 12.8 $\mu\text{L}\cdot\text{L}^{-1}$ /week. Parameters measured were pH, temperature, ammonia, nitrate and phosphate. The results showed that water temperature and pH relatively unchanged in all treatments. The addition of RWS probiotics did not improve the concentration of ammonia, nitrate and phosphate. In fact, the catfish culture with only aquaponic resulted lower concentration of ammonia, nitrate and phosphate than other treatment. The lowest value of ammonia, nitrate and phosphates was obtained in the experimental groups of aquaponic with RWS of 10 $\mu\text{L}\cdot\text{L}^{-1}$ /week (Treatment D). Treatment D has the lowest average ammonia of 0.50 ppm, reduced nitrate up to 60.78 % and temperature and pH relatively unchanged.

1. Introduction

Limited land size, limited water source, reduced water quality, and lack of technology inputs have become issues in increasing the production of fresh water fish, especially catfish. The increase in catfish production is only 47.21 %, which is far below the expected target [1]. Therefore, efforts are needed to improve the production of catfish by adding the technology inputs. The technology that can be adopted is the integration of fish culture with plant culture through the aquaponics system [2]. Aquaponics is one of the culture technologies that combine fish and plant culture [3]. The plants in the aquaponics system function as the biofilter that absorbs and uses nitrate (NO_3), ammonia (NH_3) and phosphate (PO_4) as the fertilizer that they reduce the concentration of N and P contaminants and improve water quality [4].

In addition to producing nitrate (NO_3) and phosphate (PO_4), catfish culture also produces ammonia (NH_3) as a result of metabolism and the primary protein element reshuffling that tends to cause physiological disturbance, trigger stress and is also toxic for fish [5]. To deal with the problem, a new innovation that collaborate aquaponics and Red Water System has appeared.

Red Water System (RWS) is a new technology in catfish culture activity that utilizes the result of *Lactobacillus casei* bacteria and *Saccharomyces cerevisiae* fungus fermentation during the culture. RWS is an extension of probiotic application in shrimp farming that is then applied in intensive catfish culture. Adding probiotics in the culture pond leads to decomposition of organic materials in the pond that will produce lower ammonia concentration compared to the control pond [6]. The application of



probiotics gives a positive effect on the water quality (dissolved oxygen, ammonia, nitrite and nitrate) compared to control and is able to support the sangkuriang catfish survival [7]. The probiotic microorganisms can also oxidize ammonia, reducing the amount of ammonia in the culture pond [8]. This will directly help the plant to reduce the excessive ammonia in the media that cannot be absorbed by the plants. Hence, this study aim was to analyze the effect of application of RWS probiotics on water quality in aquaponics system fish culture.

2. Materials and Methods

This study was conducted during the period of February to March 2016 at the Laboratory of Fish Culture, Ciparanje, Faculty of Fishery and Marine Science, Universitas Padjadjaran. The method used in this study was the experimental study using Complete Randomized design (CRD) that included five treatments and three replications. The treatments in this study were:

- Treatment A : $7.5 \mu\text{L} \cdot \text{L}^{-1}$ /week RWS solution in fiber without aquaponics (Control A)
- Treatment B : aquaponics without RWS solution (Control B)
- Treatment C : aquaponics with $7.5 \mu\text{L} \cdot \text{L}^{-1}$ /week RWS solution
- Treatment D : aquaponics with $10 \mu\text{L} \cdot \text{L}^{-1}$ /week RWS solution
- Treatment E : aquaponics with $12.5 \mu\text{L} \cdot \text{L}^{-1}$ /week RWS solution

In this study, the culture tanks were fibre glass of $70 \text{ cm} \times 70 \text{ cm} \times 70 \text{ cm}$ and water depth of 50 cm, with total density of 100 fry per tank. The tanks were equipped with rectangular PVC pipes and styrofoam for plants media holder. Lettuce plants were planted in the netpot with rockwool. The water from the tanks was pumped and distributed into plants media through PVC pipe (figure 1).



Figure 1. Aquaponics design used in this study.

Parameters measured were pH, temperature, ammonia, nitrate and phosphate (table 1). The measurement was performed three times: in the beginning of the study and was repeated every 10 days culture. The RWS solution was applied to the trial pond every 3 days. Data analysis on the physical and chemical parameters was performed descriptively by comparing the collected data to the Indonesian National Standard (*Standar Nasional Indonesia*, SNI) for water quality parameters.

RWS used in this study contained *Lactobacillus casei* and *Saccharomyces cerevisiae* in extract of bean sprouts.

Table 1. Measured parameters, units and its methods.

Parameters	Units	Methods/instrument
pH		Potensiometric/pH meter
Temperature	°C	Potensiometric/thermometer
Ammonia	ppm	Spectrophotometric/Spectrophotometer
Nitrate	ppm	Spectrophotometric/Spectrophotometer
Phosphate	ppm	Spectrophotometric/Spectrophotometer

3. Results and Discussion

The success of fish culture is very much influenced by the quality of water in the culture media. Poor water quality will reduce appetite, delay growth, trigger diseases and may cause deaths among the fish. In fish culture, waste in the form of feces, urine and feed residuals are unavoidable [9]. But not all feed provided is consumed by fish because 15–30 % of the feed goes to the water [10]. In addition, some of the consumed feed will be removed in the form of feces [11, 12]. The unconsumed feed and fish feces are sources of contaminants in fish culture. A new innovation has been made to minimize the waste in fish culture, which includes ammonia, nitrate and phosphate that is referred to as aquaponics system [4] using Red Water System (RWS) method [6, 7]. Water quality analyzed includes the analysis on ammonia, nitrate, phosphate, temperature and acidity (pH).

3.1. Ammonia (NH_3)

This study showed that the concentration of ammonia in catfish culture using aquaponics with RWS was reduced after the second sampling (figure 2).

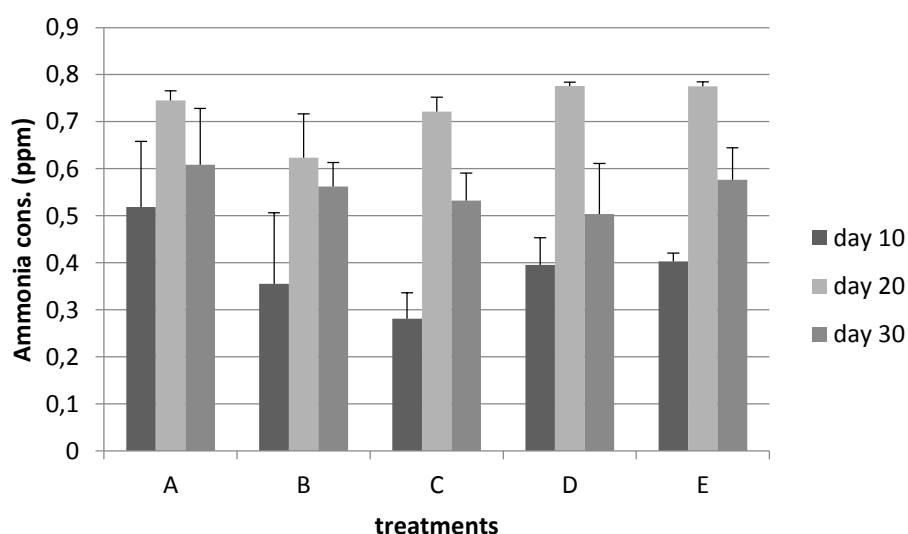


Figure 2. Ammonia concentration (ppm) in catfish tank water added with RWS at various concentrations. A: RWS without aquaponics, B: aquaponics without RWS, C: aquaponics with $7.5 \mu\text{L}\cdot\text{L}^{-1}/\text{week}$ RWS, D: aquaponics with $10 \mu\text{L}\cdot\text{L}^{-1}/\text{week}$ RWS and E: aquaponics with $12.5 \mu\text{L}\cdot\text{L}^{-1}/\text{week}$ RWS.

The measurement of ammonia concentration was performed when the fish was reared for 10 days. Based on (figure 2), ammonia concentration in all treatments increased in the middle of observation (Day 20). The increase of ammonia was caused by the accumulation of residual feed and metabolism waste of fish [9, 10, 12]. Meanwhile, at the end of the study (day 30), from three samplings, decrease in ammonia concentration was found in all treatments with a concentration reduction range of 0.04–

0.27 ppm). The decrease in the ammonia concentration might be caused by the ammonia absorption by the plants, which was getting higher. The reduction in ammonia concentration will reduce the toxicity [13]. The ammonia concentration reduction on the third observation (day 30) was also caused by the starting microbial activities (RWS bacteria) in converting ammonia into nitrate. Microorganisms in probiotics are able to degrade the organic residuals of the feed and feces rapidly that there is no excessive accumulation in fish culture [14]. Table 1 shows the ammonia fluctuations during the study. It was seen that ammonia increased at day 20. Ammonia increase in treatments C, D and E were higher than controls. Among RWS aquaponics, treatment D showed that the bacteria in RWS increased the decomposition of organic matter in fish culture medium. While on the 30th day, ammonia concentration decrease in RWS treatments were higher than controls. At the end period of culture, highest ammonia decrease was found in treatment D. These results suggested that the bacteria in the RWS solution converted ammonia into nitrate and also was utilized by plants. Inorganic nitrogen used for forming the structure formation of plants, chlorophyll formation, photosynthesis, cell growth and metabolic processes [15].

Table 2. Fluctuation of ammonia concentration (ppm) in catfish tank water added with RWS at various concentrations.

Treatment	D10	D20	D30	D20-D10	D30-D20
A	0.51 ± 0.139	0.73 ± 0.021	0.60 ± 0.119	0.22 ± 0.124	-0.13 ± 0.129
B	0.35 ± 0.151	0.61 ± 0.093	0.57 ± 0.051	0.26 ± 0.243	-0.04 ± 0.137
C	0.28 ± 0.055	0.72 ± 0.031	0.53 ± 0.059	0.44 ± 0.044	-0.19 ± 0.028
D	0.39 ± 0.058	0.77 ± 0.008	0.50 ± 0.108	0.38 ± 0.055	-0.27 ± 0.107
E	0.40 ± 0.018	0.77 ± 0.009	0.57 ± 0.007	0.37 ± 0.008	-0.20 ± 0.059

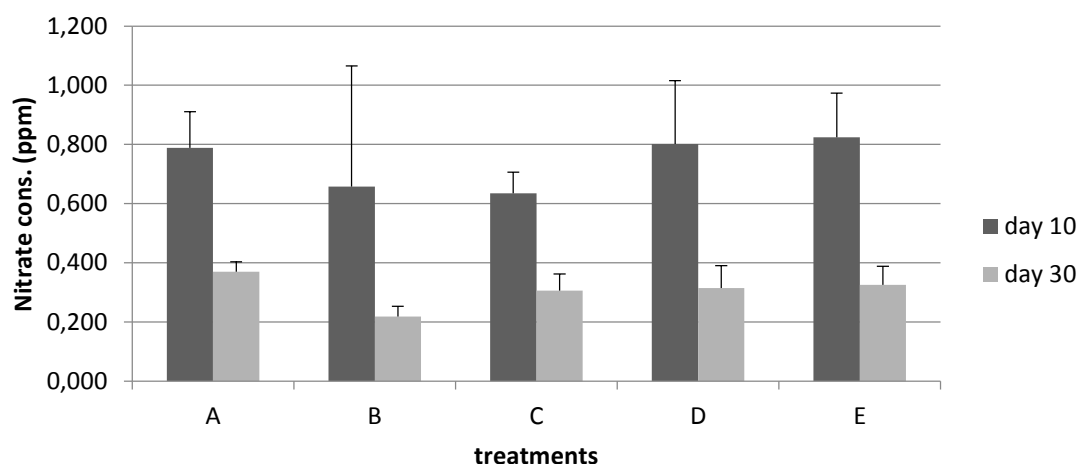
3.2. Nitrate (NO_3)

Nitrate (NO_3) is the primary nutrient for plant growth that is produced from the oxidation process of ammonia in the nitrogen cycle which happens in an aerobic condition. Plants cannot absorb nitrogen in the form of N^{2+} gas in the atmosphere. The Nitrogen has to be transformed into ammonium (NH_4) or nitrate (NO_3) first [16]. The results of observation showed that nitrate concentration decreased in the beginning to the 30th day in each treatment (figure 3).

The decrease in nitrate concentration in each treatment was suspected to be the effect of the utilization of compound by plants and microbes (RWS) applied in the culture media. Nevertheless, the nitrate concentration was still high due to the low number of plants in treatment B, C, D and E that they were unable to utilize the abundant concentrated nitrate in the culture media caused by feed residuals and feces. Unbalanced ratio between the pond size, media size and plants will lead to the failure of utilizing all concentrated nitrate in culture media by the plants which then accumulates in the fish culture pond [18]. Based on table 2, the nitrate reduction in the RWS treatment was higher than those of in two control treatments, except treatment C. In the later treatment showed better absorption of nitrate by the plant in aquaponics. In treatment B (aquaponic without RWS) nitrate concentration was lower at day 30 than those of in other treatments. In the treatment B there was no addition of bacteria that can accelerate the process of decomposition of organic materials into inorganic materials. The nitrate present in treatment B was derived from natural decomposition so the concentration was lower than that of in RWS treatment. Therefore treatment B gave highest decrease in nitrate concentration.

Table 3. Nitrate reduction (ppm) in catfish tank water added with RWS at various concentrations.

Treatment	D10	D30	D30-D10	% reduction
A	0.789 ± 0.122	0.370 ± 0.033	0.419 ± 0.008	53.147
B	0.658 ± 0.408	0.219 ± 0.035	0.439 ± 0.420	66.737
C	0.634 ± 0.072	0.306 ± 0.056	0.328 ± 0.045	51.739
D	0.802 ± 0.214	0.314 ± 0.076	0.487 ± 0.249	60.780
E	0.824 ± 0.150	0.325 ± 0.064	0.499 ± 0.193	60.547

**Figure 3.** Nitrate concentration (ppm) in catfish tank water added with RWS at various concentrations. A: RWS without aquaponics, B: aquaponics without RWS, C: aquaponics with $7.5 \mu\text{l}\cdot\text{L}^{-1}/\text{week}$ RWS, D: aquaponics with $10 \mu\text{l}\cdot\text{L}^{-1}/\text{week}$ RWS and E: aquaponics with $12.5 \mu\text{l}\cdot\text{L}^{-1}/\text{week}$ RWS.

3.3. Phosphate (PO_4)

Besides ammonia, phosphate is also produced through the decomposition of unconsumed feed [18, 19]. Phosphate concentration in fish feed is 0.96 % [20]. Around 10–15% of the feed provided is not consumed by the fish. The accumulation of phosphate in fish culture media produces a negative impact on the fish survival. On the other hand, phosphate is very beneficial for the life of plants because it is the basic ingredient to strengthen the cell wall, making the plants resistant to disease attacks [21]. The results of the study showed an increase and decrease in phosphate concentration during the study (figure 4).

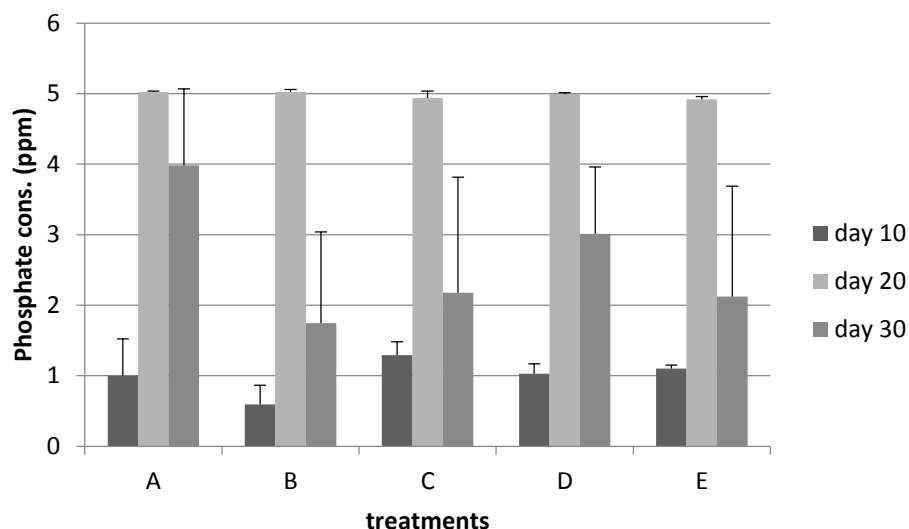


Figure 4. Phosphate concentration (ppm) in catfish tank water added with RWS at various concentrations. A: RWS without aquaponics, B: aquaponics without RWS, C: aquaponics with $7.5 \mu\text{l}\cdot\text{L}^{-1}$ /week RWS, D: aquaponics with $10 \mu\text{l}\cdot\text{L}^{-1}$ /week RWS and E: aquaponics with $12.5 \mu\text{l}\cdot\text{L}^{-1}$ /week RWS.

Phosphate concentration decreased in all treatments during the third sampling (day 30) suggested that aquaponics and RWS were able to reduce phosphate concentration in fish culture media. Good phosphate concentration for fish culture is 0.2–1 ppm [22]. The highest reduction of phosphate was seen in treatment E (3.71 ppm) and B (3.28 ppm), showing the effectiveness of phosphate absorption by the lettuce plants in the aquaponics system. This fact is supported by the result in treatment A with the lowest phosphate reduction because no RWS was applied in the aquaponics system.

3.4. Acidity (pH) and temperature

Acidity (pH) is one of the important parameters that determine the quality of water in the culture media. Most fish is able to adapt well to the environment with a pH of 5–9. Good water pH for catfish culture is between 6.5 and 8 [23]. This study showed that the pH value was still suitable for the life of fish in the culture media (figure 5).

In overall, the results of the 40 days observation revealed that the pH value for each treatment was still in the normal range. The pH value in all treatments with RWS tended to be lower because the microbes growing in the culture media produce acid compound to slow down the growth of pathogenic microbes in the media [14].

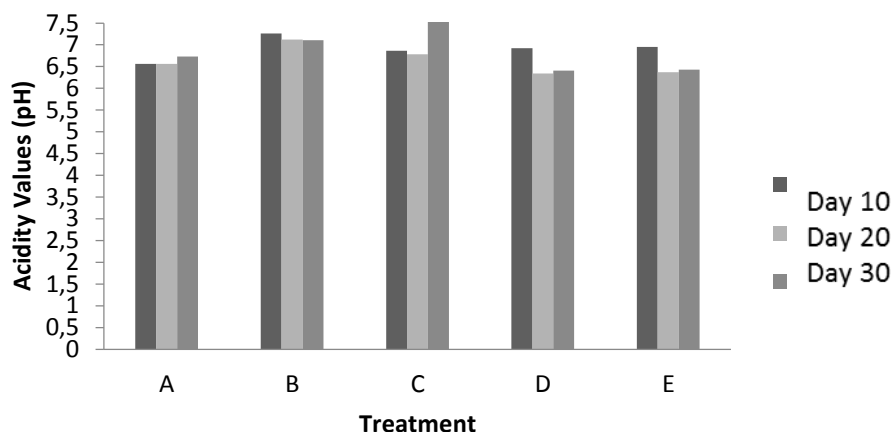


Figure 5. pH values catfish tank water added with RWS at various concentrations. A: RWS without aquaponics, B: aquaponics without RWS, C: aquaponics with 7.5 $\mu\text{L}\cdot\text{L}^{-1}/\text{week}$ RWS, D: aquaponics with 10 $\mu\text{L}\cdot\text{L}^{-1}/\text{week}$ RWS and E: aquaponics with 12.5 $\mu\text{L}\cdot\text{L}^{-1}/\text{week}$ RWS.

The temperature in this study ranged between 24–25°C for each treatment. This value was in the normal range for supporting the life of catfish. The Indonesian National Standard: 01-6484.4-2000, states that 25–30°C is appropriate temperature for growth of catfish.

4. Conclusion

The addition of RWS probiotics increased concentration of nutrient for plant such as ammonia, nitrate and phosphate, while the aquaponics system reduces the concentration of ammonia, nitrate and phosphate.

The addition of RWS probiotic increases the decomposition process and availability of nutrient for plant, while the aquaponics system reduces those nutrients. The addition of 10 $\mu\text{L}\cdot\text{L}^{-1}/\text{week}$ RWS solution gave best result.

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