Effect of different filter media use on aquaponics system on ammonium (NH$_4^+$), nitrite (NO$_2^-$) and nitrate (NO$_3^-$) concentrations of catfish (Clarias sp.) aquaculture

T A Lukmantoro$^1$, Prayogo$^{1,2}$, and B S Rahardja$^1$
Faculty of Fisheries and Marine, Universitas Airlangga, Surabaya 60115
Corresponding author: prayogo@fpk.unair.ac.id

Abstract. Catfish cultivation has been carried out in Indonesia. One such development is the maintenance of catfish using an aquaponic system. Aquaponics aims to improve the water quality of fish farming with the help of plants. But plants cannot directly utilize fish farming waste directly, it is necessary to have a nitrification process first. Nitrification is the reformation of inorganic compounds into organic compounds with the help of bacteria. Nitrifying bacteria are colonized and non-motile bacteria, so a substrate is needed as a place to attach to the bacteria. The substrate that can be used is bioball and bioring. This study aims to determine whether the effect and filter media are effective in catfish farming with an aquaponic system. This study using the RAL method consisting of 4 treatments and 5 replications, namely P0 = control, P1 = bioball, P2 = bioring and P3 = bioball and bioring combinations. The results obtained that P3 (bioball and bioring combination) is the most effective treatment in reducing the nitrogenous waste catfish aquaculture using an aquaponics system, the results is 0.000 mg / L ammonium, nitrite 0.001 mg / L and nitrate 13.0 mg / L at the end of the study.

1. Introduction

Catfish (Clarias sp.) is one of the most popular aquaculture commodities in the world, including in Indonesia. Catfish have the advantage of specific meat flavors, contain lots of protein but are low in fat, and catfish are able to live in environmental conditions with minimal oxygen so catfish have good cultivation prospects [1].

The prospect of developing catfish cultivation is estimated to have an opportunity because the production process is easy and many people have mastered the technology of catfish farming. One of the development of catfish cultivation is that it can be done using aquaponics system cultivation. Aquaponics is a cultivation activity that produces fish and vegetables simultaneously, both of which are interconnected namely fish waste to hydroponic cultivation of plants [2].

In an aquaponics system there is a filter tub, which contains filter media. Filter media that can be used in aquaponics systems are of many kinds, including bioball and bioring. The function of the filter media is to substrate the nitrification bacteria needed to reduce ammonia in water, becoming the end result in the form of nitrate. This research is important to do because of the importance of ammonia reduction which is a toxic substance for aquatic organisms to be non-toxic nitrate.

2. Materials and methods

2.1. Tools and materials
The tools used in this study, namely fish containers using 20 plastic buckets with a volume of 30 liters, 20 plastic buckets as filter containers, gutters with a length of 60 cm and a width of 12 cm, water pumps, hose pumps, bioball, bioring, basin, fishing net, thermometer, DO meter and pH pen.

The materials used in this study were cotton, rockwool, catfish with an average weight of 3 g/L of 700 fish, probiotics, kale seeds, MS pf-1000 fish feed, plant and fresh water fertilizer.

2.2. Work Procedures
a) Tools and Materials Preparation
Research preparations were carried out by preparing tools and materials to be used, including maintenance tanks, water quality measurement tools, and then starting to compile an aquaponics circuit to be used for fish maintenance.
b) Plant Preparation
This study uses water spinach plants as aquaponics plants. Water spinach plants used are in the form of kale seeds sown in rock wool for 14 days, then harvested to have strong roots to be included in the aquaponics system.
c) Making Aquaponics Systems
Aquaponics work system is recirculation. Waste water in fish ponds is flowed using a pump to the filter media tub. Water that has been filtered is flowed to the plant maintenance container, which is then flowed from the plant maintenance container to the fish rearing container.
d) Preparation of Catfish
Catfish seeds used in this study came from the Kabat Fish Seed Hall, Banyuwangi. Catfish seeds are bought as many as 700 tails with a weight of 3 g/L. Fish seeds are acclimatized before being put into a maintenance container.
e) Maintenance
Catfish seeds weighing 3 grams / liter are maintained in buckets with a total of 20 tails in each bucket. The bucket used has a water capacity of 30 liters, but the water filled is as much as 20 liters. Catfish are kept given commercial feed 3 times a day (morning, afternoon, evening). Feeding is 3% of the weight of biomass. The feed used contains 39-41% protein.
f) Sampling
Taking water samples is done once a week to determine the content of ammonium, nitrite and nitrate in catfish (Clarias sp.) Aquaculture water which is the main parameter of this study. For supporting parameters such as temperature, dissolved oxygen, and pH measurements are carried out every day while plant growth is measured once a week.

2.3. Data analysis
Data analysis used Analysis of Variance (ANOVA) then continued with further testing using Duncan’s Multiple Range Test (DMRT). The entire statistical analysis was carried out with the SPSS 21 program for Windows.

3. Results and discussion
3.1 Result

| Treatment | 1st Week | 2nd Week | 3rd Week | 4th Week |
|-----------|----------|----------|----------|----------|
| P0        | 0.011± 0.001 | 0.005± 0.001 | 0.028± 0.002 | 0.012± 0.001 |
| P1        | 0.012b± 0.002 | 0.011b± 0.002 | 0.018b± 0.001 | 0.001a± 0.001 |
| P2        | 0.013b± 0.001 | 0.009b± 0.001 | 0.018b± 0.001 | 0.001a± 0.001 |
| P3        | 0.011a± 0.001 | 0.010a± 0.001 | 0.012a± 0.000 | 0.000a± 0.001 |
### Table 2. Average nitrite concentration (mg/L) ± SD

| Treatment | 1st Week       | 2nd Week       | 3rd Week       | 4th Week       |
|-----------|----------------|----------------|----------------|----------------|
| P0        | 0.154 ± 0.003  | 0.002 ± 0.002  | 0.003 ± 0.001  | 0.001 ± 0.001  |
| P1        | 0.389 ± 0.005  | 0.002 ± 0.001  | 0.001 ± 0.000  | 0.003 ± 0.002  |
| P2        | 0.190 ± 0.002  | 0.169 ± 0.003  | 0.001 ± 0.000  | 0.002 ± 0.001  |
| P3        | 0.172 ± 0.002  | 0.010 ± 0.001  | 0.000 ± 0.000  | 0.001 ± 0.001  |

### Table 3. Average nitrate concentration (mg/L) ± SD

| Treatment | 1st Week       | 2nd Week       | 3rd Week       | 4th Week       |
|-----------|----------------|----------------|----------------|----------------|
| P0        | 11.4 ± 1.140   | 11.2 ± 1.095   | 10.6 ± 1.341   | 11.8 ± 1.483   |
| P1        | 17.0 ± 1.581   | 15.6 ± 1.140   | 10.6 ± 0.894   | 11.6 ± 1.673   |
| P2        | 11.6 ± 1.140   | 17.2 ± 1.483   | 11.4 ± 1.673   | 11.0 ± 1.414   |
| P3        | 11.6 ± 1.516   | 21.0 ± 1.581   | 12.0 ± 1.581   | 13.0 ± 2.000   |

Note: Different Notation Shows Different Effect

### Table 4. Average data of supporting parameters

| Parameters                      | Results |
|---------------------------------|---------|
|                                 | P0      | P1      | P2      | P3      |
| Dissolved Oxygen (mg/L)         | 3.9     | 4.3     | 5.0     | 5.4     |
| pH                              | 8.3     | 8.3     | 8.3     | 8.3     |
| Temperature (°C)                | 27.3    | 27.3    | 27.2    | 27.1    |
| Plants Length (cm)              | 71.1    | 77.2    | 75.6    | 84.0    |
| Number of Leaves                | 10      | 14      | 13      | 14      |

3.2 Discussion

Ammonium is one source of N for plants in water. If a plant absorbs only ammonium, without nitrate, the positive effect is that ammonium reduction is almost entirely assimilated in the roots, increasing the availability of protein and in leaf vegetables, ammonium is more efficient than nitrate in increasing greenness in the leaves. However, the negative impact can cause plants to gradually deteriorate and decrease sharp dry weight due to root system damage [3].

The results of the statistical test on the first Sunday showed results ranging from 0.011-0.013 mg / L. The results of Calculation of Analysis of Variants (ANOVA) showed that there were no significant differences (p> 0.05) on each treatment. Duncan's Multiple Distance Test (Duncan's Multiple Range Test) shows that P0 and P3 are significantly different from P2, whereas P1 is not significantly different from P0, P2 and P3.

The results of the statistical tests on the second week showed results that ranged from 0.005-0.011 mg/L. The results of the calculation of Analysis of Variants (ANOVA) showed a significantly different effect (p <0.05) on each treatment. Duncan's Multiple Distance Test (Duncan's Multiple Range Test) shows that P0 is significantly different from P1, P and P3. The results of the calculation of Analysis of Variants (ANOVA) showed a significantly different effect (p <0.05) on each treatment. Duncan's Multiple Distance Test (Duncan's Multiple Range Test) shows that P3 is significantly different from P1, P2 and P3.

The results of the statistical test on the fourth Sunday showed results ranging from 0.000-0.012 mg/L. The results of the calculation of Analysis of Variants (ANOVA) showed a significantly different effect (p <0.05) on each treatment. Duncan's Multiple Distance Test (Duncan’s Multiple Range Test) shows that P0 is significantly different from P1, P2 and P3.

Nitrate is a form of inorganic nitrogen in water [4]. Nitrite is the result of the nitrification process, which is the oxidation reaction of ammonia (NH₃). This process can occur biologically or chemically...
The biological nitrification process can take place with the help of nitrifying bacteria, namely *Nitrosomonas* sp.

The results of the statistical test on the first Sunday showed results ranging from 0.154 to 0.389 mg/L. The results of the calculation of Analysis of Variants (ANOVA) showed a significantly different effect (p < 0.05) on each treatment. Duncan's Multiple Distance Test (Duncan's Multiple Range Test) shows that there are significant differences between each treatment. The results of the statistical tests on the second week showed results ranging from 0.002-0.169 mg/L. The results of the calculation of Analysis of Variants (ANOVA) showed a significantly different effect (p < 0.05) on each treatment. Duncan's Multiple Distance Test (Duncan's Multiple Range Test) shows that P0 and P1 are significantly different from P2 and P3.

The results of the statistical test on the third Sunday showed results ranging from 11.4-17.0 mg/L. The results of the calculation of Analysis of Variants (ANOVA) showed a significantly different effect (p < 0.05) on each treatment. Duncan's Multiple Distance Test (Duncan’s Multiple Range Test) shows that P1 is significantly different from P0, P2 and P3. The results of the statistical tests in the second week showed results ranging from 11.2-21.0 mg/L. The results of the calculation of Analysis of Variants (ANOVA) showed a significantly different effect (p > 0.05) for each treatment. Duncan's Multiple Distance Test (Duncan’s Multiple Range Test) shows that P0 is significantly different from P1, P2 and P3.

The results of the statistical test in the third week showed results ranging from 10.6 to 12.0 mg/L. The results of the calculation of Analysis of Variants (ANOVA) showed an effect that was not significantly different (p > 0.05) for each treatment. Duncan's Multiple Distance Test (Duncan's Multiple Range Test) shows that there is no difference in each treatment. The results of the statistical test in the fourth week showed results ranging from 11.0-13.0 mg/L. The results of the calculation of Analysis of Variants (ANOVA) showed an effect that was not significantly different (p > 0.05) for each treatment. Duncan's Multiple Distance Test (Duncan's Multiple Range Test) shows that there is no difference in each treatment.

Ammonium, nitrite and nitrate concentrations in a waters can change. Changes in concentration can be influenced by the nitrification process and water quality. The nitrification process is a change in ammonia which has a toxic nature to be a non-toxic form of nitrate. The nitrification process can occur with the help of *Nitrosomonas* sp. and *Nitrobacter* sp., these two bacteria have non motile properties (they cannot move) so they tend to stick to the surface of objects around them [5]. Therefore, the use of bioball and bioring filter media is expected to be the attachment substrate for the *Nitrosomonas* sp. and *Nitrobacter* sp. The more bacteria that attach to the filter media, the nitrification process that occurs will also be more optimal.

Water quality is also an important factor in nitrification, such as temperature, dissolved oxygen and pH. Nitrifying bacteria can grow optimally between 20-30°C, if the temperature is lower than 20°C, the bacterial metabolic activity will decrease. The optimal pH value for nitrifying bacteria is between 7.5-8.5. Nitrifying bacteria require oxygen in their metabolic processes, if the dissolved oxygen
concentration is low, the denitrification process will occur, i.e. reduction of nitrate to nitrite followed by reduction of nitrite to ammonia, nitrate reduction can increase under dissolved oxygen conditions below 2 mg/L [6].

At P3, the best water quality measurement results from other treatments. With an average of one month's ammonium content of 0.008 mg/L, the average nitrite for one month was 0.045 mg/L and the average nitrate was 14.40 mg/L. This is supported by a good concentration of temperature, pH and dissolved oxygen and is in accordance with the range of optimal water quality for the nitrification process. Plant growth in P3 is also the most optimal growth than other treatments.

In the control treatment (P0) the results of nitrite and nitrate were low, with an average of one month of oil consumption of 0.040 mg/L and nitrate of 11.25 mg/L, but the ammonium concentration was higher than the other treatments, which was 0.014 mg/L, so that it is known that at P0, the nitrification process that occurs is less than optimal. Evidenced by the high concentration of ammonium contained in the treatment. The measurement values of temperature, pH and dissolved oxygen at P0 also showed poor results when compared with other treatments.

4. Conclusion

Bioring, bioball and the combination of the two filter media have an effect on the absorption of ammonium, nitrite and nitrate concentrations in catfish (Clarias sp.) in the aquaponics system. Filter media that are effective in absorbing ammonium, nitrite and nitrate in catfish (Clarias sp.) Cultivation in aquaponics systems is P3 (bioring and bioball combination).

5. References

[1] Prayogo, B S Rahardja, A N Asshanti, N N Dewi, M B Santanumurti 2018 Ind. Asean Fen. Intl. Fish. Symp.
[2] Kuswaha B, Kumar R, Agarwal S, Pandey M, Nagpure N S, Singh M, Srivastava S, Joshi C G, Das P, Sahoo L, Jayasankar P, Meher P K, Shah T M, Patel A B, Patel N, Koringa P, Das S P, Patnaik S, Bit A, Sarika, Iquebal M A, Kumar D, and Jena J K 2015 Meta Gene 5, 105-114.
[3] Love D C, Fry J P, Li X, Hill E S, Genello L, Semmens K, and Thompson R E 2015 Aquaculture. 435, 67–74
[4] Hasiholan B S, Suprihartini M S, and Muryas R I 2000 Effects of comparison of nitrate and ammonium on growth and yield of lettuce (Lactusa sativa L.) cultivated hydroponically (Salatiga: Universitas Kristen Satya Wacana).
[5] Effendi H 2003 Water quality study for water resource and environmental managers (Yogyakarta: Kanisius) p 50.
[6] Hastuti Y P 2011 J. Akua Indo. 10, 89-98
[7] Aswadi M 2006 Jur SMARTek. 4