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Analysis of Water Quality and Phagocytic Activity (Clarias Sp.) in Aquaponic and Non-Aquaponic Cultivation Systems

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Abstract: Catfish (Clarias sp.) is one of the many fishery biota that has animal protein which is much loved by Indonesian people. One way to develop environmentally friendly catfish cultivation is through the implementation of an aquaponic biofilter system. This research aims to analyze physical, chemical, and biological water quality parameters in catfish cultivation with and without aquaponics, to obtain a description of the non-specific immune system which is analyzed from the conditions of phagocytic activity of catfish cultivated with and without aquaponics. The method used is by taking samples ten times per week by taking water quality parameters as well as blood samples of catfish raised in ponds with and without aquaponics. The analysis used is the unpaired T-test. Based on the results obtained, it was concluded that all parameters showed that the aquaponic cultivation media was better compared to those without aquaponics.

Keywords: Cultivation; Blood; Catfish; Phagocytosis; Pool

Introduction

Catfish (Clarias sp.) is one of the many fishery biota that has animal protein which is much loved by Indonesian people. This is because catfish is easy to get, the price is relatively cheap, and has a high protein content and relatively lower fat. The need for animal protein sources, especially catfish, continues to increase, so innovation is needed to increase production (Kelana *et al.*, 2021). High market demand causes cultivators to increase production by means of intensive cultivation which applies stocking densities and feeding in high quantities. Fatimah *et al.* (2018) explained that growing cultivation activities can cause pollution to wastewater bodies.

According to Samsundari and Wirawan (2013), the aquaponic biofilter system is a fish cultivation system that has added value, namely being able to minimize fish cultivation waste in the form of leftover feed and feces in the media and also being able to increase by-products in the form of aquatic plants that can be harvested. Based on research from Muhammad et al. (2016), an aquaponics system with kale plants was able to reduce ammonia by 73.5% from levels of 2.1 ppm to 1.21 ppm. According to Masjudi et al. (2016), due to continuous stress, the fish's immune system becomes low so that diseases can easily attack. In fish infected with toxic compounds as a form of the body's immune response to foreign compounds, leukocytes will increase (Suprapto et al. 2019). Then the lymphocytes (part of the leukocyte cells) will divide (proliferate) and form antibodies to protect the body from disease (Suprayudi et al. 2006).

Therefore, it is necessary to observe fish health based on water quality dynamics and analysis of the non-specific immune system observed through phagocytosis activity as an indicator of the condition of catfish cultivation with and without aquaponics in Labruk Lor Village, Lumajang Regency, East Java. This

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research aims to analyze physical, chemical, and biological water quality parameters in catfish cultivation with and without aquaponics, to obtain a description of the non-specific immune system which is analyzed from the conditions of phagocytic activity of catfish cultivated with and without aquaponics.

Method

Time and Location of Study

This research was conducted in Labruk Lor Village, Lumajang Regency, East Java. The research will take place in March 2023-June 2023 (Figure 1.)

Figure 1. Map of research locations

Research Design

This study is a descriptive study using the survey method. The data used include primary data and secondary data. This research was carried out in 4 round pools with aquaponic media and 4 round pools with non-aquaponic media with each pool having a diameter of 3 meters and a water height of 90 cm with a density of 2 fish/liter.

Water Quality Parameter Measurement

Water quality measurements are carried out using physical parameters including temperature, total suspended solids (TSS), total dissolved solids (TDS), chemical including pH, dissolved oxygen, nitrate, orthophosphate, ammonia and biological including phagocytic activity). These measurements were carried out in situ and out situ. In situ measurements include temperature, pH, and DO. TSS, TDS, nitrate, orthophosphate and ammonia parameters were carried out ex situ.

Temperature, Dissolved oxygen, pH, Nitrate, Orthophosphate, Ammonia

The water quality parameters measured in this study were temperature, dissolved oxygen, pH and ammonia. Temperature and dissolved oxygen are measured using a DO meter, pH is measured using pH paper. Nitrate, orthophosphate, and ammonia were measured using a spectrophotometer.

Total Suspended Solid (TSS)

Total Suspended Solid (TSS) is the total suspended solid material in water. According to Fathiyah et al. (2017), TSS can be calculated using the following formula:

$$Mg\ TSS\ per\ liter = \frac{(A-B)x\ 1000}{Test\ sample\ volume\ (ml)} \quad (1)$$

Information:
A : Weight of filter paper and shellfish residue (mg)
B : Weight of filter paper (mg)
1000 : Convert Liters (L) to Millimeters (ml)

Total Dissolved Solid (TDS)

Total dissolved solids are one indicator of the level of water pollution that is often analyzed. According to Putra et al. (2019), TDS can be measured using the following formula:

$$TDS = \frac{residue\ weight\ x\ 1000}{ml\ sample} \quad (2)$$

Observation of Phagocytic Activity

According to Sudirman et al. (2021), observations and calculations of phagocytic activity are as follows:

$$\frac{Number\ of\ phagocyte\ cells\ carrying\ out\ predation}{Number\ of\ phagocyte\ cells\ observed} x\ 100\% \quad (3)$$

Data Analysis

The data obtained were collected and analyzed statistically using the unpaired T-test via the Microsoft Excel 2019 application. The results obtained were then explained descriptively

Results and Discussion

Water quality parameters are used as supporting data in pollution estimation. Water quality parameters will influence water quality conditions. Thus, if the water conditions are bad, the survival of the biota in those waters will be disrupted. The following are the results of measuring water quality parameters, which can be seen in Table 1 for physical parameters and Table 2 for chemical parameters.

Table 1. Physical Parameters

Week	Pool	Temperature (°C)	TSS (mg/l)	TDS (mg/l)
W1	Aquaponic	29.4	40.5	31
	Non-Aquaponic	29.6	52.8	45.5
W2	Aquaponic	28.6	63.5	53.25
	Non-Aquaponic	28.5	104.8	92
W3	Aquaponic	29.5	80.3	64
	Non-Aquaponic	29.4	116.3	95.5
W4	Aquaponic	28.2	78.3	57
	Non-Aquaponic	28.4	151.3	124.25
W5	Aquaponic	28.7	114.0	105.5
	Non-Aquaponic	28.9	238.8	257.25
W6	Aquaponic	29.0	215.3	108.5
	Non-Aquaponic	29.1	231.8	231
W7	Aquaponic	28.4	151.0	135.75
	Non-Aquaponic	28.5	237.5	237
W8	Aquaponic	29.0	144.0	42.25
	Non-Aquaponic	29.0	320.8	127.5
W9	Aquaponic	28.9	155.5	144.25
	Non-Aquaponic	28.9	310.5	277.75
W10	Aquaponic	29.2	200.0	169
	Non-Aquaponic	29.2	342.0	312.75

Table 2. Chemical Parameters

Week	Pool	DO (mg/l)	pH	Nitrate (mg/l)	Orthophosphate (mg/l)	Ammonia (mg/l)
W1	Aquaponic	8.0	7.3	0.35	0.08	0.06
	Non-Aquaponic	7.6	7.3	0.59	0.36	0.68
W2	Aquaponic	7.8	7.1	0.74	0.08	0.12
	Non-Aquaponic	7.8	7.1	1.08	0.66	0.97
W3	Aquaponic	8.1	7.1	0.43	0.09	0.15
	Non-Aquaponic	7.4	7.1	0.56	0.61	0.74
W4	Aquaponic	7.9	7.1	0.52	0.10	0.32
	Non-Aquaponic	7.7	7.1	1.24	0.62	0.96
W5	Aquaponic	7.6	7.1	0.80	0.12	0.40
	Non-Aquaponic	7.5	6.9	1.41	0.78	1.12
W6	Aquaponic	6.2	7.0	0.53	0.23	0.43
	Non-Aquaponic	6.2	7.2	1.13	0.97	1.23
W7	Aquaponic	5.7	7.1	0.52	0.07	0.29
	Non-Aquaponic	5.2	7.3	0.76	0.35	0.77
W8	Aquaponic	4.5	7.1	0.49	0.12	0.34
	Non-Aquaponic	4.4	7.1	1.25	0.81	1.07
W9	Aquaponic	3.6	7.2	0.60	0.22	0.41
	Non-Aquaponic	3.5	7.0	1.14	0.70	0.97
W10	Aquaponic	3.4	7.0	0.79	0.25	0.52
	Non-Aquaponic	3.2	6.9	1.99	0.90	1.22

Temperature

Based on the results obtained in Table 1, measuring temperature parameters in aquaponic and non-aquaponic cultivation ponds from week 1 to week 10 showed that the average yield for aquaponic ponds was 28.2-29.4°C. The lowest average temperature of the aquaponic pond was in the 4th week, namely 28.2°C, while the highest average temperature of the aquaponic pond was in the 1st week, namely 29.4°C. The average yield in non-aquaponic cultivation ponds ranges from 28.4-29.6°C. The lowest average temperature of non-aquaponic ponds was in week 4, namely 28.4°C, while the highest average temperature of non-aquaponic ponds was in week 1, namely 29.6°C. According to Wulansari et al. (2022), in general, the recommended temperature intensity for cultivating catfish is 26-32°C.

So it can be concluded that the results of the temperature parameters for both aquaponic and non-aquaponic ponds are still considered good for use as a medium for cultivating catfish.

Dissolved Oxygen (DO)

Based on the results obtained in the graph above, measuring dissolved oxygen (DO) parameters in aquaponic and non-aquaponic cultivation ponds from week 1 to week 10 showed that the average yield for aquaponic ponds was 3.4-8.1 mg/ L. The lowest average DO results for aquaponic ponds were in week 10, namely 3.4 mg/L, whereas the highest average DO for aquaponic ponds occurred in week 3, namely 8.1 mg/L. The average DO yield of non-aquaponic cultivation ponds ranges from 3.2-7.8 mg/L. The lowest average DO result for non-aquaponic pools was in week 10, namely 3.2 mg/L, whereas the highest average pH for non-aquaponic pools occurred in week 2, amounting to 7.8 mg/L. According to Pratama et al. (2016), good oxygen levels for catfish cultivation should not be less than 3 mg/l. So it can be concluded that the results of the pH parameters in both aquaponic and non-aquaponic ponds are still considered good for use as a medium for cultivating catfish.

Total Suspended Solid (TSS)

Based on the results obtained in Table 1, measuring TSS parameters in aquaponic and non-aquaponic cultivation ponds from week 1 to week 10, the results obtained were for aquaponic ponds of 40.5-215.3 mg/L. The lowest TSS for the aquaponic pond was in week 1, namely 40.5 mg/L, whereas the highest TSS for the aquaponic pond occurred in week 6, namely 215.3 mg/L. For non-aquaponic cultivation pond, TSS results ranged from 52.8-320.8 mg/L. The lowest TSS for non-aquaponic pools was in week 1, namely 52.8 mg/L, whereas the highest TSS for non-aquaponic pools occurred in week 8, namely 320.8. According to Nurchayati et al. (2021), a good TSS value for cultivating freshwater fish, especially catfish, is no more than 200 mg/L. So it can be concluded that the results of the TSS parameters for aquaponic ponds and non-aquaponic ponds are still categorized as good for cultivation media, especially catfish cultivation.

Total Dissolved Solid (TDS)

Based on the results obtained in Table 1, measuring TDS parameters in aquaponic and non-aquaponic cultivation ponds from week 1 to week 10, the results obtained were for aquaponic ponds of 31-169 mg/L. The lowest TDS for the aquaponic pool was in the 1st week, namely 31 mg/L, whereas the highest TDS for the aquaponic pool occurred in the 10th week, namely 169 mg/L. For non-aquaponic cultivation ponds, TDS results range from 45.5-312.75 mg/L. The lowest TDS for non-aquaponic pools was in week 1, namely 45.5 mg/L, whereas the highest TDS for non-aquaponic pools occurred in week 10, namely 312.75 mg/L. According to PP Number 82 of 2001, the maximum limit for TDS levels for class III waters is less than 1000 ppm. So it can be concluded that the results of the TDS parameters for aquaponic and non-aquaponic ponds are still good for use as a cultivation medium, especially for cultivating catfish.

Point of Hydrogen (pH)

Based on the results obtained in Table 2, measuring the pH parameters in aquaponic and non-aquaponic cultivation ponds from week 1 to week 10 showed that the average yield for aquaponic ponds was 7-7.3. The lowest average pH results for aquaponic ponds were in week 6, namely 7, whereas the highest average pH for aquaponic ponds occurred in week 1, namely 7.3. For results, the average pH of non-aquaponic cultivation ponds ranges from 6.9 to 7.3. The lowest average pH results for non-aquaponic ponds were in the 5th and 10th weeks, namely 6.9, whereas the highest average pH for non-aquaponic ponds occurred in the 1st and 7th weeks, namely 7.3. According to Hermansyah et al. (2017), the requirements for good quality water are clear, odorless, unpolluted, and pH between 5.5 and 7.5. So it can be concluded that the results of the pH parameters in both aquaponic and non-aquaponic ponds are still considered good for use as a medium for cultivating catfish.

Nitrate

Based on the results obtained in Table 2, measurements of Nitrate parameters in aquaponic and non-aquaponic cultivation ponds from week 1 to week 10 showed that the results for aquaponic ponds were 0.35-0.80 mg/L. The lowest nitrate in the aquaponic pool was in the 1st week, namely 0.35 mg/L, whereas the highest nitrate in the aquaponic pool occurred in the 5th week, namely 0.80 mg/L. For non-aquaponic cultivation pond nitrate results range from 0.56-1.99 mg/L. The lowest nitrate in non-aquaponic pools was in week 3, namely 0.56 mg/L, whereas the highest nitrate in non-aquaponic pools occurred in week 10, namely 1.99 mg/L. According to Ramadhan et al. (2020), the normal limit for nitrate levels in cultivation waters for catfish is <5 mg/L. So it can be concluded that the results of the nitrate parameters for aquaponic and non-aquaponic ponds are still good for use as a medium for cultivating catfish.

Orthophosphate

Based on the results obtained in Table 2, measurements of phosphate parameters in aquaponic and non-aquaponic cultivation ponds from week 1 to week 10 showed that the results for aquaponic ponds were 0.07-0.25 mg/L. The lowest phosphate in the aquaponic pool was in the 7th week, namely 0.07 mg/L, whereas the highest phosphate in the aquaponic pool occurred in the 10th week, namely 0.25 mg/L. For non-aquaponic cultivation pond phosphate results range from 0.35-0.90 mg/L. The lowest phosphate in non-aquaponic pools was in week 7, namely 0.35 mg/L, whereas the highest phosphate in non-aquaponic pools occurred in week 10, namely 0.90 mg/L. According to Afriansyah et al. (2016), a good level of orthophosphate for cultivating freshwater fish, especially catfish, is <1 mg/L. So it can be concluded that the results of the phosphate parameters for aquaponic and non-aquaponic ponds are still good for use as a medium for cultivating catfish.

Ammonia

Based on the results obtained in table 2, measurements of ammonia parameters in aquaponic and non-aquaponic cultivation ponds from week 1 to week 10 showed that the results for aquaponic ponds were 0.03-0.52 mg/L. The lowest ammonia in the aquaponic pool was in the 1st week, namely 0.03 mg/L, whereas the highest ammonia in the aquaponic pool occurred in the 10th week, namely 0.52 mg/L. For non-aquaponic cultivation ponds, ammonia results range from 0.18-1.07 mg/L. The lowest ammonia in non-aquaponic pools was in week 1, namely 0.18 mg/L, whereas the highest ammonia in non-aquaponic pools occurred in week 10, namely 1.07 mg/L. According to Muhammad et al. (2016), ammonia is toxic to fish cultivated in media that have a concentration above 1.5 mg/L. So it can be concluded that the results of the ammonia parameters for aquaponic and non-aquaponic ponds are still good for use as a medium for cultivating catfish.

Phagocytic Activity

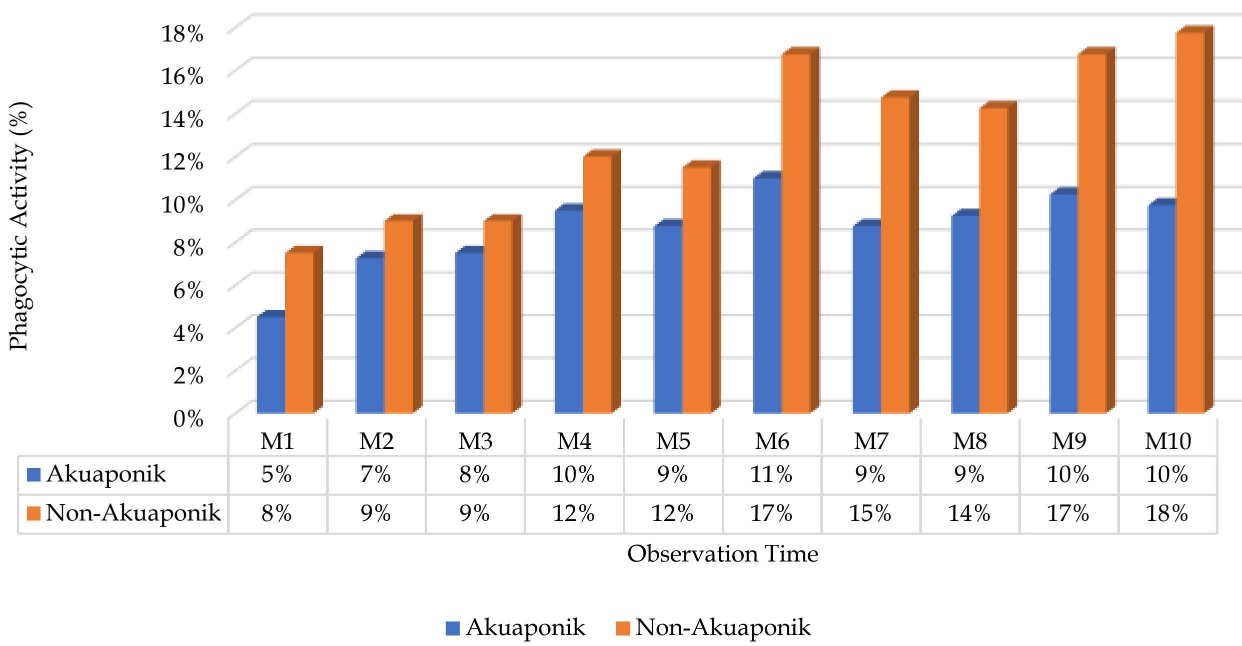

Figure 2. Phagocytic Activity Observation Graph

Based on the results obtained in the graph above, observing phagocytosis activity in aquaponic and non-aquaponic cultivation ponds from week 1 to week 10, the results obtained were 5-11% for aquaponic ponds. The lowest phagocytic activity of the aquaponic pool was in the 1st week, namely 5%, whereas the highest phagocytic activity of the aquaponic pool occurred in the 6th week, namely 11%. For non-aquaponic cultivation pond phagocytosis results range between 8-18%. The lowest phagocytosis in non-aquaponic pools was in week 1, namely 8%, whereas the highest phagocytosis activity in non-aquaponic pools occurred in week 10, namely 18%. According to Utami et al. (2023), the average phagocytosis index for normal fish is 4-10%. One way to see non-specific immune responses is by observing phagocytic activity. Phagocytic activity occurs if a foreign object is present. Based on the previous statement, it can be concluded that the results of phagocytosis activity from aquaponic cultivation ponds are still better than non-aquaponic ponds.

Conclusion

The use of catfish (*Clarias* sp.) cultivation media with aquaponics media has proven to be better than media without aquaponics. This can be seen from the water quality and phagocytosis activity between aquaponic ponds and those without aquaponics.

Author Contributions

Conceptualization, Punto Apri Sembodo and Asus Maizar Suryanto Hertika.; methodology, Yuni Kilawati; software, Punto Apri Sembodo; validation, Asus Maizar Suryanto Hertika, Yuni Kilawati.; formal analysis, Punto Apri Sembodo; investigation, Asus Maizar Suryanto Hertika; resources, Asus Maizar Suryanto Hertika; data curation, Punto Apri Sembodo; writing—original draft preparation, Punto Apri Sembodo ; writing—review and editing, Punto Apri Sembodo; visualization, Punto Apri Sembodo; supervision, Asus Maizar Suryanto Hertika; project administration, Yuni Kilawti; funding acquisition, Asus Maizar Suryanto Hertika.

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Conflicts of Interests

The authors declare no conflict of interest.

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