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Water Quality in Koi Fish (*Cyprinus carpio*) Concrete Ponds with Filtration in Nglegok District, Blitar Regency

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Abstract Water is the most precious natural resource and its quality must be checked before use. Water sources should be monitored regularly to determine whether they are in good condition or not. The poor water quality is not only an indicator of environmental degradation but also a threat to ecosystems, including aquaculture activities. The success of koi fish farming is generally determined by an understanding of the physical, chemical, and biological qualities of water. It is necessary to research water quality analysis to determine the environmental condition through a comparison of two different types of ponds (traditional and filter). The research method is descriptive. Water quality analysis in each pond includes parameters of temperature, pH, water brightness (cm), Dissolved Oxygen (DO), Total Organic Matter (TOM), Carbon dioxide (CO_2), Orthophosphate, Ammonia, Nitrate, Biological Oxygen Demand (BOD), Total Suspended Solid (TSS) and Chemical Oxygen Demand (COD). This research activity was carried out as a community service, related to monitoring the water quality of koi fish farming ponds in the Nglegok sub-district, Blitar Regency, East Java. The results of temperature in traditional ponds were lower than in filter ponds. Meanwhile, CO_2 and ammonia levels in traditional ponds and filter ponds exceed the optimal quality standard for the koi fish viability. However, other parameters are quite good for koi fish cultivation. In cultivation activities, three important components are interconnected and affect each other, the environment, the host, and the pathogen. Optimization of water quality management can be applied by using aeration or filtration, calculating feed conversion to reduce organic material residues, and regularly changing the water.

Keywords Cyprinus Carpio, Water Quality, Filter Pond, Ammonia, Chemical Oxygen Demand

1. Introduction

Indonesian fisheries management continues to improve both in national and international markets, especially for ornamental fish. The Ministry of Maritime Affairs and Fisheries (KKP) has issued a policy for the development of the marine and fisheries sector based on the Minapolitan concept to support increasing fisheries production. Minapolitan is the concept of a fishery economic development area based on the principles of integration, efficiency, quality, and acceleration [1]. The Minapolitan program has been running in Blitar Regency since 2011, centered in Nglegok District. Blitar Regency is one of the centers of koi fish in Indonesia [2,3]. Koi fish farming in Blitar has been started in 1983 and has progressed and become a very promising new business area for fish cultivators and investors [4].

The flagship commodity in this Minapolitan program is Koi Ornamental Fish. The availability of adequate facilities and infrastructure is Indonesia's potential to develop koi fish as an export commodity. The domestic koi fish market is also no less good, although not as much as foreign demand, it always increases every year. The koi fish (Cyprinus carpio) is one of the most popular ornamental fish that has the potential to be cultivated in Indonesia [5]. Koi fish have beautiful colors, ideal body shape, bright and patterned colors, which make koi fish have artistic value. Therefore, the demand for koi fish is increasing and it has the potential to become a business [6].

Water quality is essential in aquaculture for the life cycle of the biota that is kept in water. The results of the primary study found a relationship between fish growth and the quality of the water in cultivation [6]. The water must be clean and free of pollution. Water condition for cultivation consists of physical, chemical, and biological parameters. The essential factors of water for freshwater fish farming are temperature, dissolved oxygen, water exchange, water brightness, turbidity, water acidity, and organic matter compound [7]. Fish have a limited ability to adapt to changing aquatic environmental factors. Even sudden changes can be dangerous. The pH also significantly affects the toxic effects of many other substances (ammonia, hydrogen sulfide, cyanide, heavy metals, etc.) on fish. The water temperature is suitable for carp cultivation, for example, 24-30°C. The secchi depth is one of the simplest and most effective tools for estimating water productivity. The value of the secchi disk depth helps to assess the low concentrations of chlorophyll, algae, and TSS in water bodies [8]. Inhaling fish, bacteria, and phytoplankton in ponds can result in high concentrations of carbon dioxide (CO2) in the water [9].

Oxygen is also an important determinant of fish farming, and the needs of fish species determine dissolved oxygen levels. Carp (Cyprinus carpio) is known to be resistant to oxygen fluctuations of 0.5-20 mg/L in ponds [10]. TOM is an indicator of dissolved oxygen consumption to oxidize dissolved organic matter in water [11]. The combination of organic and inorganic elements determines the strength of wastewater, and its potential to pollute the receiving area. Wastewater intensity is usually measured by oxygen deprivation through biochemical (BOD) or chemical (COD) oxygen demand. BOD estimates oxygen consumption by microorganisms during aerobic oxidation of organic matter, and most of all BOD is consumed within 5 days [12,13].

Phosphorus is present in high concentrations in wastewater and is another nutrient required for the growth and metabolism of microalgae. The form of phosphorus that is most easily assimilated by microalgae is orthophosphate (monophosphate and dihydrogen phosphate), which are organic components (phospholipids, nucleic acids, and proteins) during biosynthesis during the phosphorylation process [14]. Meanwhile, ammonia-N is the main nitrogenous waste produced by fish and is also produced during the decomposition of inedible feed. Nitrates, on the other hand, are relatively non-toxic to fish and pose no health risks except at very high concentrations above 90 mg/L. Total Suspended Solid (TSS) grows in the system and can significantly limit the number of fish that affect gill work. Suspended solid is usually a term associated with plankton, fish manure, inedible fish feed, or clay particles in water that settles over time from water accumulation [9].

The high content of organic matter in the waters is still one of the crucial problems in koi fish cultivation. This condition is the main cause of pathogenic infection [2,15]. Especially attention to the importance of water quality in most farmer communities is still not enough. The traditional pond is still used by most of the Nglegok people because the land is quite large. Also, river water flows are used as the main source for irrigation to aquaculture ponds to reduce production costs [2,16]. Some others have used a filtration pond system with aeration. Therefore, this study aims to determine the environmental conditions of the waters through a comparison between traditional pond systems and different filter ponds in koi fish farming.

2. Materials and Methods

2.1. Study Area and Materials

This study was conducted in Nglegok District, Blitar Regency, East Java and Indonesia. Kemloko Village, Nglegok District has an area of 327.13 Ha. Geographically, this village is located at coordinates 80- 80 9' North Latitude and 1120 - 1120 21' East Longitude. This village has a type of clay and sandy soil, so it is very potential for fishing activities. The area for koi fish farming in Nglegok District is 381,440 m^2. The fish farming land used are soil ponds (traditional) and concrete ponds (filter) with shapes and sizes based on soil fields of around 1,000 m^2 per plot and concrete ponds with a size of 4 m x 7 m [17].

The parameters of water quality in this study are Physics parameters (Temperature, Water Brightness and TSS-*Total Suspended Solid*) and Chemical parameters (pH, DO-*Dissolved Oxygen*, TOM-*Total Organic Matter*, CO_2-Carbon dioxide, Orthophospate, Ammonia, Nitrate, BOD-*Biological Oxygen Demand* and COD-*Chemical Oxygen Demand*). The water sample was conducted from Traditional pond and Filter Pond in Koi Fish Aquaculture.

2.2. Pond Condition

The pond was used as an artificial habitat for fish to live and breed properly. The selection of ponds must be adjusted to the needs, but still with proper monitoring and maintenance. There are two aquaculture pond systems used by the community, traditional ponds, and filter ponds. Traditional ponds were characterized by a natural pond structure that comes from the ground. Soil and water are very important environmental factors in determining the success of freshwater fish farming. The type of soil that is good for freshwater fish farming is clay or loam [18]. The use of traditional ponds is still used today. The cost of making a soil pond is relatively cheap and simple. Generally, control is only carried out under certain conditions. The advantage of a soil pond is there is a lot of plants that grow around the pond, also the planktons so it is not difficult to get natural food for fish [19]. Weaknesses of traditional ponds, productivity can be disrupted if the soil contains hazardous materials or pathogens. The walls and bottom of the pond are susceptible to erosion. Furthermore, extreme weather, such as continuous rain, will make controlling pond water quality even more difficult. Meanwhile, the filter pond was characterized by a pond wall made of concrete. This pond has easier maintenance, is not easily damaged by erosion, and is easy to control. The irrigation system can be made well to maximize water circulation. Generally, making a pond is also accompanied by the addition of an aeration system to increase oxygen levels in the water. Aerators also play a role in controlling ammonia. Aeration can accelerate the diffusion of ammonia gas from pond water into the air [20]. Although maintenance is cheap, making a filter pond is relatively more expensive. The potential aquaculture production depends on how the water quality can be maintained until its optimum level. The provision of artificial aeration is very important for the maintenance of water quality. This is related to the availability of oxygen supplies in the water. Aquaculture systems that have low dissolved oxygen may not directly cause fish death but cause water quality to decrease. This condition can cause stress on the fish body, reduce feed consumption, and in turn cause death. The aeration process can increase DO concentrations in a cost-effective way to treat sewage, simultaneously removing dissolved gases such as CO_2, H_2S, and other dissolved metals. The stirring of water carried out by the aerator can increase the contact area between the water-air surface. Therefore, more oxygen from the air can mix in the water [20].

2.3. Research Methods

The research method is descriptive to report the comparison of koi fish soil ponds and filter ponds according to water quality values. Water sampling was conducted from koi fish (*Cyprinus Koi*, Linn) rearing ponds. There are two types of pond systems, Traditional pond and Filter Pond. Water quality measurement and analysis were carried out. Water quality analysis can be carried out using the in-situ method (directly at the research site) and the ex-situ method carried out in the laboratory (only for water parameters that can last a long time) [21]. The temperature, water brightness, pH, Dissolved Oxygen were determined directly in the field site. The concentration of TOM, CO_2, orthophosphate, ammonia nitrate, BOD, TSS, and COD were analyzed at the laboratory of Fisheries and Marine Science, Brawijaya University. Water sampling was carried out in the morning (07.00-08.00; UTC+7).

The temperature was determined by using a thermometer (National Standardization Agency, 2005; SNI 06-6989.23-2005)[22]. The water brightness of the pond was determined by using Secchi disk [23]. The transparency of the waters was determined with the aid of the Secchi disc. The disc was lowered into the water and the depth at which it disappeared was observed and recorded. It was there after gradually withdrawn from the water and the depth at which it became visible was noted and recorded [8]. Also, pH and DO were determined by using a DO meter (YK-22DO Lutron-Taiwan). Water samples for TOM, CO_2, Orthophospate, Ammonia, Nitrate, BOD and COD parameters were stored in an icebox container before being brought to the laboratory for analysis. The concentration of CO_2 was determined by using the titrimetric method and ammonia by using the spectrophotometric method, (National Standardization Agency, 2005; SNI 06-6989.30-2005) [24]. The concentration of Orthoposphate was determined according to (National Standardization Agency, 1991) [25] and Nitrate was using APHA, 1992:4005-NO_3 [26]. The concentration of TOM was determined according to SNI 06-6989.22-2004 (National Standardization Agency, 2004) [27]. COD analysis method by SNI 6989.2:2009 (National Standardization Agency, 2009) [28] with the calculation formula:

$$\text{COD (mg/l)} = C \times f \quad (1)$$

Where:
C: Test sample value (mg/l)
f: Dilution factor

The measurement of BOD concentration is calculated by taking water samples using a dark glass bottle. The mouth of the bottle is directed into the water at an air brightness of 10-15 cm below the water surface. DO for five days and the volume of sample added was then used to measure BOD5. Measurement of BOD 5 days using the APHA method (2005) [29]:

$$BOD_5 \text{ test} = \text{DO initial} - \text{DO final} \quad (2)$$

The analysis of Total Suspension Solid (TSS) uses the TSS method (APHA 2005) [29]. Water was filtered by whatman filter paper (0.45 µm pore size, 47 mm diameter). The filter paper was dried at 105°C in an oven for two hours and weighed.

$$\text{Total Suspended Solids (mg/L)} = \frac{(A-B) \times 1000}{Sample\ volume\ (L)} \quad (3)$$

where:
A: Weight of filter paper before filtration (mg)
B: Weight of filter paper after pulling (mg)

3. Results and Discussion

3.1. Water Quality

Water is the source of life for fish and has certain requirements. In the aquaculture business, water quality must be monitored properly. Each parameter is important to be managed and monitored because it can affect the growth rate and fish health. The results of the water quality analysis can be seen in Table 1.

3.1.1. Physical Parameters

The results showed the parameters value and the optimal value based on each quality standard. The temperature in traditional ponds was lower (23°C) than in filter ponds (27°C). However, this value is classified as optimal value. Temperature affects the metabolism of aquatic organisms including fish [36]. The high temperature will be accompanied as well as an increase in the metabolic rate. Water brightness for the traditional pond is below the optimal value (20 cm); meanwhile, the filter pond exceeds the optimal value (120 cm). These results show different characteristics between the two pond systems based on water brightness. The greater water brightness in the filter pool is due to the function of maintenance and construction of the filter tool. The brightness of the waters is very influential on the fish. Because the depth of explanation about brightness is the entry of sunlight, which causes photosynthesis to produce oxygen [37]. Secchi disc values can help estimate low concentrations of chlorophyll, algae and TSS present in pond water [8]. TSS concentration in the traditional pond was 0.0007 mg/l and in the filter pond was 0.0006 mg/l. TSS concentration is closely related to water brightness. High concentrations of TSS can reduce water quality due to light absorption [38].

(a)

(b)

Figure 1. Pond Condition, (a) Traditional ponds, (b) Filter ponds

Table 1. Water Quality Analysis Results

No.	Parameters	Unit	Ponds		Optimal Value*)	Reference
			Traditional	Filter		
1	Temperature	^{0}C	23	27	22-32	[30]
2	Water Brightness	cm	20	120	30-80	[31]
3	pH		7	7	6.5-8.0	[30]
4	DO (Dissolved Oxygen)	mg/l	5	7	>5	[32]
5	TOM (Total Organic Matter)	mg/l	34.13	26.54	20-40	[33]
6	CO_2 (Carbon Dioxide)	mg/l	23.9	10.4	<12	[32]
7	Orthophosphate	mg/l	0.156	0.53	<1	[32]
8	Ammonia	mg/l	0.244	0.145	<0.02	[32]
9	Nitrate	mg/l	0.247	1.266	0.09-3.5	[32]
10	BOD	mg/l	1.28	2.07	<3	[34]
11	TSS (Total Suspended Solid)	mg/l	0.0007	0.0006	<0.5	[35]
12	COD (Chemical Oxygen Demand)	mg/l	12.46	12.28	<25	[34]

*)Optimal value of water quality for koi fish : [30-35]

3.1.2. Chemical Parameters

Meanwhile, the pH value between the traditional pool and the filter pool is at the same value and is classified as neutral [38]. Parameters value of DO (5 mg/l), Orthophosphate (0.156 mg/l), Nitrate (0.247 mg/l), and BOD (1.28 mg/l) in traditional ponds is slightly lower than the value of DO (7 mg/l), Orthophosphate (0.156 mg/l), Nitrate (0.247 mg/l), BOD (1.28 mg/l) in the filter pond and is still classified as optimal according to each quality standard. On the other hand, the value of TOM (34.13 mg/l), and COD (12.46 mg/l) in traditional ponds is higher than the value of TOM (34.13 mg/l), and COD (12.46 mg/l) in the filter pond although it is-similar and is still classified as optimal according to each quality standard. This shows that the parameters related to organic matter, suspended solids, and chemical reactions are more common in traditional ponds due to natural pond conditions that many factors contribute. According to Haryono *et al.* [39], temperature and rainfall are several climatic factors in the accumulation of TOM in sediments. The density of organic matter is found to be higher in colder regions. The higher DO value in the filter pool may occur due to the help of the aeration system [40]. The need for oxygen is needed in the body's metabolism and binds nutrients in the bloodstream. Time, weather, air brightness, and currents are some of the factors of oxygen content in the air. In the morning, the oxygen content is slightly lower than in the afternoon. Then it decreases again in the afternoon. The oxygen content there is also activity with the photosynthetic activity of phytoplankton associated with sunlight [41]. If the oxygen value is very low, it can cause death [10]. BOD is a description of the number of biodegradable organics in the waters. Meanwhile, COD is the amount of oxygen to break down all organic matter contained in the water [42]. Furthermore, the role of nitrate and orthophosphate is in water fertility. These nutrients are utilized properly for the growth of phytoplankton [37].

The value of carbon dioxide in the traditional pond (23.9 mg/l) exceeds the optimal value, far compared to the filter pond (10.4 mg/l). High CO_2 values are possible due to high stocking densities and high fish metabolism. Furthermore, the accumulation of residual feed and feces are related to the ammonia concentration [41]. Carbon dioxide concentration in the water is not highly toxic to fish when sufficient dissolved oxygen is present. Furthermore, ammonia levels in both traditional ponds (0.244 mg/l) and filter ponds (0.145 mg/l) exceed the optimal value. Fish cannot extract energy from feed efficiently if ammonia accumulates into the fish production system and becomes toxic [9]. The carbon dioxide that reaches a concentration of more than 10 mg/l can be toxic to aquatic biota, especially fish because its presence in the blood can inhibit the binding of oxygen by hemoglobin. Likewise, un-ionized ammonia is toxic to fish. Ammonia is the result of the metabolic process of fish. It can also come from the rest of the feed that is not eaten and dissolves in water [43]. In good water body conditions, fish can grow optimally. On the other hand, in poor water conditions, some fish can tolerate and survive. However, poor water quality can lead to a decreased appetite for fish and can experience stress; then fish can be susceptible to disease. Water management can be carried out by using a flow-through system, adding aeration, cleaning filters, and picking up waste. Water quality is adjusted to quality standards.

4. Conclusions

There are two pond systems, traditional pond, and filter pond which show different results of water quality analysis. In this study, most parameters are quite good for koi fish cultivation in both traditional and filtration ponds. The critical problems of the ponds were carbon dioxide and ammonia values. However, filter ponds that show better water conditions with high oxygen levels, are easier to control and more stable than the traditional pond. Optimization of water quality management can be applied by using aeration or filtration. Feeding management is very important in brood fish rearing in fish hatchery by calculating feed conversion to reduce organic material residues, and regularly changing the water. Traditional ponds can apply regular water changes and limit the use of standardized fertilizers.

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