Jurnal Agrinika: Jurnal Agroteknologi dan Agribisnis
Volume 08, Issue 02 (2024)
E-ISSN: 2721-2807

Water Quality Study to Improve Technology and Sustainability of Farmer's Pond in Banjarpanji Village Sidoarjo

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Keywords:
Banjarpanji;
Milkfish;
Pond;
Water quality

Submited:
19-07-2024

Accepted:
17-09-2024

Published:
29-09-2024

ABSTRACT

The technology used in pond processing in Banjar Panji village is still traditional, with minimal labor involvement. This extensive or traditional pond does not utilize windmills, and the feed is natural. The purpose of the study was to study the physicochemical parameters of water quality in fish farming based on the Ministerial Regulation of the Ministry of Marine Affairs and Fisheries No. 75/Permen-KP/2016. The study was conducted in Banjarpanji Village, Tanggulangin District, Sidoarjo Regency, East Java. The study began from January to February 2024. Meanwhile, water sample analysis activities were conducted at the Land Resources Laboratory I and II, Faculty of Agriculture, National Development University "Veteran" East Java. Data collection used a survey method by conducting reviews and direct observations at the research location. The station sample points were determined by purposive sampling based on the distribution of grid divisions. The results showed that most water quality parameters, such as temperature, salinity, pH, dissolved oxygen, ammonia, nitrite, and nitrate, were outside the ideal limits for optimal cultivation. The salinity at all points of the pond was very low, for example, indicating a mismatch with the ideal needs for milkfish cultivation, which requires a specific salinity range for optimal growth. In addition, inadequate dissolved oxygen levels can inhibit the respiration of aquatic organisms and result in dangerous anoxic conditions.

1. Introduction

Sidoarjo Regency in East Java is known as the region's main pond cultivation center. One of the superior products from pond cultivation activities in this district is milkfish and shrimp. Tanggulangin District, precisely in Banjar Panji village, is one of the areas where the majority of the population is engaged in the profession of pond farmers. People in Banjar Panji village tend to focus on cultivating milkfish as the primary commodity. Milkfish was chosen because it has a more robust survival rate than other fish types. Besides that, milkfish also has a vast market share and promises a profitable selling price (Yunita *et al*. 2022).

The superior survival rate of milkfish makes it the right choice for pond farmers in this area. This provides economic benefits for them and supports the sustainability of pond cultivation businesses in Sidoarjo Regency as a whole. Thus, Tanggulangin, especially in Banjar Panji village, has become an integral part of the local economy, which relies on milkfish cultivation as one of the main sources of income. (Hardjowigeno & Widiatmaka, 2023). The technology used in pond processing in Banjar Panji village is still traditional, with minimal labor involvement and technology. It only takes about 3 people to harvest each hectare of pond. These extensive or traditional ponds do not use windmills, and the feed is natural (Indriawati *et al*. 2020).

Pond cultivation is a series of activities carried out with the main objective of increasing the reproduction, growth, and quality of aquatic biota placed in a pond. In this context, "aquatic biota" refers to living organisms in water, such as fish, shrimp, or other types of biota that are maintained in the pond environment. The importance of this maintenance activity lies not only in reproduction, but also in improving the quality or quality of aquatic biota that are the focus of cultivation. This process includes handling from the reproductive phase to growth, with the ultimate goal of obtaining optimal results. To achieve these optimal results, it is necessary to prepare special conditions that are in accordance with the needs of the commodities to be maintained. These conditions involve various aspects, such as water quality, temperature, sustainability of feed resources, and other environmental factors that can affect the welfare of aquatic biota (Indriawati *et al*. 2020).

Most people's livelihoods in Banjarpanji Village, Tanggulangin, and Sidoarjo involve various sectors such as agriculture, trade, and private business. The majority of residents of this village are involved as rice farmers, pond farmers, traders, and entrepreneurs. The main focus of this livelihood is the potential natural resources of the pond area, which are used to cultivate various types of fish. Besides their role as pond farmers, the people of Banjarpanji also use the results of the ponds to develop home businesses or industries. In the context of home industry, the results of observations show that the dominant activity developing in this village is the production of various processed products, such as presto milkfish, smoked milkfish, otak-otak, onion crackers, and fish crackers (Ahmadi., 2023 *et al*.). These products are distributed to nearby shops, even outside the city. From the observation results, it can also be summarized that processed products from the home industry in Banjarpanji Village have received significant recognition and interest from people outside the village. This shows that the potential for the home industry in the village is well-known and has a broad market (Zhang *et al.* 2020). The purpose of the study was to study the physicochemical parameters of water quality in fish farming based on the Ministerial Regulation of the Ministry of Marine Affairs and Fisheries No. 75/Permen-KP/2016. And Efforts to address changes in water quality for fish farming that do not comply with KKP standards.

2. Methodology

The research was conducted in Banjarpanji Village, Tanggulangin District, Sidoarjo Regency, East Java. The research began in January 2024 to February 2024. Field sampling and data collection activities were carried out in Banjarpanji Village, Tanggulangin District, Sidoarjo Regency, East Java, which, according to the Banjarpanji Village Central Bureau of Statistics, Tanggulangin District, is located at latitude -7.50534 and longitude 112.75098. The research location includes several station points in the form of a distribution of ponds in Banjarpanji Village. Meanwhile, water sample analysis activities were conducted at the Land Resources Laboratory I and II, Faculty of Agriculture, National Development University "Veteran" East Java.

2.1. Research Procedure

The research procedure used is a survey method with data collection methods to obtain information by conducting inspections and direct observations in the field, which is the research location. The station sample points were determined deliberately (purposive samplin) based on the distribution of grid divisions, with 1 sample representing 1 grid shown on the land use map. Land use maps include the distribution of land used in the area for various purposes, such as housing, agriculture, forests, industry, or conservation areas. The research to be carried out is presented in Figure 1. Sampling Point Map.

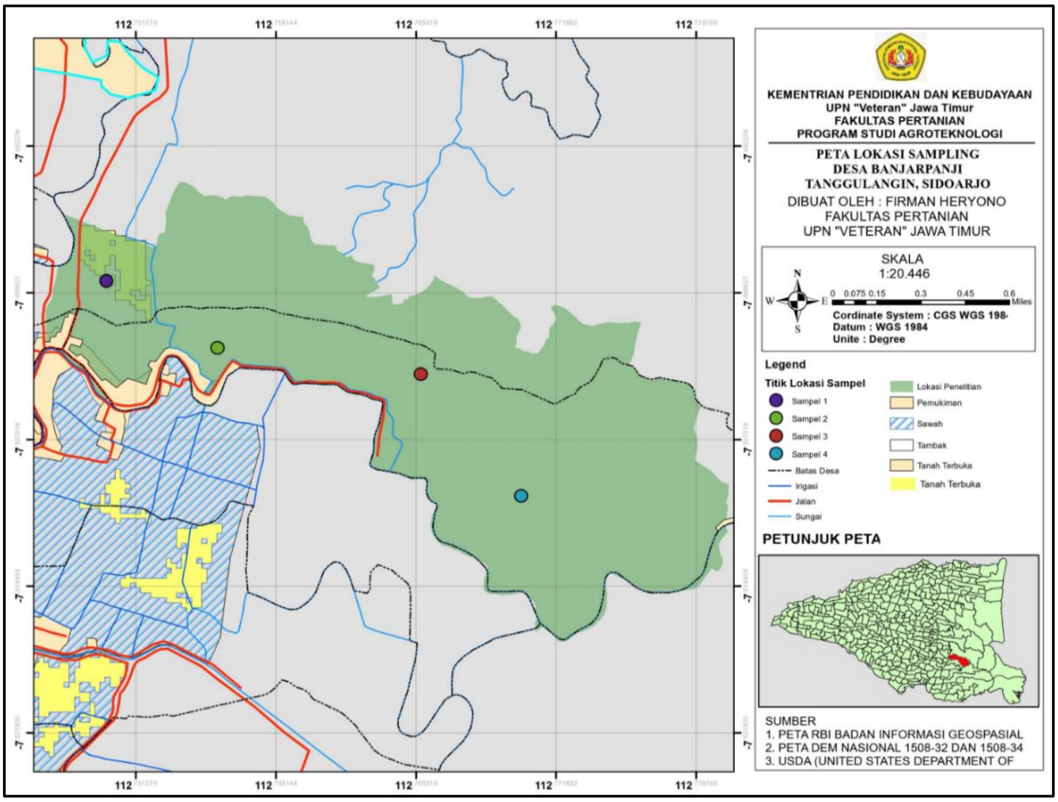

Figure 1. Sampling Location Map

2.2. Determination of Sampling Points

The research location covers almost the entire pond area in Banjarpanji Village, Tanggulangin District. Tanggulangin District is a location where ponds dominate the average land use, and this situation supports conducting a case study to determine the research location. The sampling points in this study were in several villages in Banjarpanji based on the grid distribution, 1 sample represents 1 grid shown on the sampling location map. Elevation at the research location starts from 0 to 1 meter above sea level. The selection of sampling points was adjusted to land use as pond land in each Banjarpanji village.

2.3. Water Sampling

Data regarding the value and concentration of each water quality parameter studied was obtained through water sampling activities from 4 sample point stations, including:

a) Station 1: Water intake door (Inlet)
b) Station 2: Map the pond
c) Station 3: Water outlet (outlet).
d) Station 4: Near residential areas

Water samples used to analyze water quality parameters are taken from the middle of the water column. For water samples that will be used to analyze water quality parameters in the laboratory, put them in a BOD TOMtle, then close them tightly and put them in an ice box.

2.4. Water Parameter Analysis

This study studied the water quality parameters of water temperature, salinity, water pH, dissolved oxygen, ammonia, nitrite, nitrate, phosphate, and TOM based on the physical and chemical parameters listed in the Minister of Fisheries and Maritime Affairs Regulation Number 75 of 2016.

Table 1. Analysis of Water Quality Parameters

Parameter	Unit	Analysis Tools/Methods	Location
Physics:			
Temperature	℃	Thermometer	In situ
Salinity	ppt	Refractometer	In situ
Chemistry:			
pH	SI Units	PH meter	In situ
DO	Mg/L	YSI Multiparameter	In situ
Ammonia	Mg/L	speaktrophotometer	Laboratory
Nitrite	Mg/L	speaktrophotometer	Laboratory
Nitrate	Mg/L	speaktrophotometer	Laboratory
Phosphate	Mg/L	speaktrophotometer	Laboratory
TOM	Mg/L	speaktrophotometer	Laboratory

Source: Minister of Maritime Affairs and Fisheries Regulation Number 75/PERMEN-KP/2016

3. Results and Discussion

3.1 Water Quality Parameters

This study's water quality parameters were water temperature, salinity, pH, dissolved oxygen, ammonia, nitrite, nitrate, phosphate, and TOM. Based on the results of observations of the physical and chemical parameters of pond water conditions at the 4 sampling locations are presented in Table 2 below:

Table 2. Results of Water Parameter Analysis

No.	Parameter	Sample			
		Pond 1	Pond 2	Pond 3	Pond 4
1	Temperature (˚C)	31-32	30-32	30-31	31-33
2	Salinity (ppt)	0.271-0.896	0.119-0.703	0.235-0.585	0.034-0.679
3	pH	6.72-7.88	7.09-7.67	6.96-7.70	6.75-7.88
4	DO (mg/l)	2.2-3.2	3.2-4.4	1.5-7.4	0.064-6.1
5	NH_3 (mg/l)	0.03-0.51	0.03-0.37	0.02-0.14	0.02-0.37
6	NO_2 (mg/l)	0.096-0.48	0.085-9.31	0.089-1.9	0.064-1.9
7	NO_3 (mg/l)	0.064-0.14	0.03-0.064	0.03-0.072	0.03-0.064
8	PO_4 (mg/l)	17-42.9	18.8-40.8	16.5-34.3	15-44.6
9	TOM (mg/l) %	11.35	10.39	9.59	10.37
10	Slope %	8	8	8	8
11	Distance from Beach (m)	7975-7983	7295-7311	6192-6207	5579-5596

3.2 Temperature

Water temperature parameters are very important in pond cultivation because they influence the environmental conditions pond biota requires. Based on the latest data, the water temperature in Ponds 1, 2, 3, and 4 ranges between 30-33°C, which is the optimal range for the growth of pond biota. Research by Suharto *et al*. (2023) shows that these temperatures support suitable conditions for various fish and shrimp species. Iskandar *et al*. (2023) underline the importance of regularly monitoring water temperature to ensure environmental balance in ponds (Wulansari *et al*. 2022).

3.3 Salinity

Salinity in the four ponds has a major impact on the pond's ability to cultivate. In Pond 1, salinity is in the range of 0.271-0.896 ppt, which is far from the ideal of 12-20 ppt, so it is included in the unsuitable category. Pond 2 has a salinity of between 0.119-0.703 ppt, also far below the ideal range, so it is not suitable for pond cultivation. Pond 3 shows a salinity lower than the appropriate one at all its stations, which is between 0.235-0.585 ppt. Likewise with Pond 4, which has a salinity below 5 ppt at all its stations. Low salinity like this can inhibit the growth of shrimp and other pond biota. Therefore, adjustments and improvements need to be made so that the salinity conditions in the pond can be more suitable for optimal cultivation (Akbar *et al*., 2023).

3.4 pH

The pH parameter in pond cultivation is a crucial factor influencing environmental balance and pond biota growth (Cholilulloh and Syauqy 2018; Wicaksana and Suprianto 2020). The four ponds show maximum pH conditions that are relatively stable and suitable for cultivation. However, the lower range is slightly lower at station 1. For example, Pond 1 has a pH range between 6.2 and 7.88, considered optimal; likewise, Pond 4, which is slightly lower with a pH of between 6.75 and 7.88, is still within acceptable limits.

3.5 Dissolved Oxygen

Dissolved oxygen is one of the main parameters of water quality that significantly influences the survival and growth of vaname shrimp. All organisms need dissolved oxygen to carry out respiration and metabolic processes, exchange materials, and provide energy for growth and reproduction (Wahyuni *et al*., 2022). Observation results showed that the DO content of Pond 1 ranged between 2.2-3.2, Pond 2 ranged from 3.2-4.4, Pond 3 between 1.5-7.4, and Pond 4 had a range of 2.3-6.1. The availability of dissolved oxygen in pond water is very important. Expected values are above 3.0 mg/l for simple and semi-intensive technologies and more than 4 mg/l for intensive and super-intensive technologies (Zhang *et al*. 2020).

3.6 Ammonia

Based on research by Susilo *et al*. (2023), observation results show that the ammonia level in Pond 1 ranges from 0.03 to 0.51 mg/L, still within safe limits according to water quality standards for cultivation, which is usually below 0.1 mg/L, so Pond 1 is considered quite suitable to support healthy pond biota without significant risk of ammonia toxicity. In Pond 2, ammonia levels varied between 0.03 to 0.37 mg/L. Although still within safe limits, values close to the upper limit indicate the need for regular monitoring to prevent dangerous increases. Pond 3 recorded ammonia levels between 0.02 and 0.14 mg/L, below the safe threshold. This condition is very good for cultivation, indicating that water quality management in Pond 3 effectively keeps ammonia levels low and is not harmful to pond biota.

However, Pond 4 showed ammonia levels between 0.02 to 0.37 mg/L. Some stations showed values slightly above the safe threshold, indicating a potential risk of toxicity to pond biota. Therefore, Pond 4 requires more effort in managing water quality, such as increasing water circulation and reducing nutrient input, which can increase ammonia levels (Wulansari *et al*. 2022).

3.7 Nitrite

In Pond 1, the nitrite concentration ranges from 0.096-0.048 mg/L, which is still within the safe tolerance limit according to water quality standards for fish and shrimp cultivation, below 0.1 mg/L. Pond 2 showed a slightly higher nitrite concentration between 0.085-9.31 mg/L. Although still within safe limits, this figure is close to the threshold that can cause stress to pond organisms. Therefore, better management is needed, including handling organic waste and increasing aeration to ensure that nitrite concentrations remain low. Pond 3 has a nitrite concentration range of 0.089-1.9 mg/L, also within safe limits. However, fluctuations in nitrite concentrations need to be monitored periodically to prevent potential increases that could be detrimental. Effective management strategies, such as controlled feeding and monitoring water quality, can help maintain nitrite concentrations at safe levels (Ndayisenga and Dusabe 2022).

Pond 4 showed nitrite concentrations between 0.064-1.9 mg/L. Handling waste, using probiotics, and improving water circulation are some of the steps that can be taken to maintain optimal water quality. Overall, although nitrite concentrations in all four ponds are still within safe limits, proper monitoring and management are essential to prevent increases in nitrite that could negatively impact the health of pond organisms. Using real-time water quality monitoring technology and implementing good pond management practices will significantly help maintain ideal conditions for aquatic cultivation

3.8 Nitrate

In Pond 1, High nitrate concentrations can indicate problems in waste management and nitrification processes in the pond, which can hurt the health of pond organisms. In Pond 1, nitrate concentrations ranged from 0.064-0.14 mg/L. According to water quality standards for cultivation, the ideal nitrate concentration is below 3 mg/L to maintain the health of fish and shrimp. Pond 2 showed a slightly higher nitrate concentration between 0.03-0.064 mg/L. Although at the upper limit of the safe range, special care must be taken to ensure that nitrate concentrations do not exceed 3 mg/L. Good management, such as reducing nitrogen input from excessive feed and improving water circulation systems, can help keep nitrate concentrations stable and safe for cultivation. Recent studies suggest regular monitoring and preventive measures can avoid excessive nitrate accumulation (Asbar *et al.*, 2015).

Pond 3 has a nitrate concentration between 0.03-0.072 mg/L. This value is also within safe limits but is close to the upper limit, indicating the need for stricter monitoring and management to prevent further increases. Implementing biofilter technology and efficient waste management practices can help control pond nitrate concentrations. Pond 4 showed nitrate concentrations ranging from 0.03-0.064mg/L. Although within the safe range, this value is close to the upper limit and requires attention to ensure that no increase could harm pond organisms. Recent literature shows that stable nitrate levels below 3 mg/L can support healthy and productive pond ecosystems (Rashmi *et al.*, 2008)

3.9 Phosphate

Phosphate parameters from the four ponds are an important indicator in assessing water quality for fish and shrimp cultivation. Phosphate is a nutrient necessary for the growth of algae and aquatic plants, but excessive concentrations can cause eutrophication, negatively impacting pond ecosystems. In Pond 1, phosphate concentrations ranged from 17-42.9 mg/L. This value is within unsafe limits and unsuitable for cultivation because excess phosphate can trigger excessive algae growth, disrupting the pond ecosystem's balance and reducing dissolved oxygen levels. Pond 2 showed a slightly higher phosphate concentration between 18.8-40.8 mg/L. Implementing good management practices, such as reducing phosphate input from feed and waste, can help keep phosphate concentrations low and stable (Asbar *et al*. 2015).

Pond 3 has a phosphate concentration between 16.5-34.3 mg/L. This value is also within unsafe limits, but regular monitoring is required to ensure phosphate concentrations do not increase. Pond 4 showed phosphate concentrations ranging from 15-44.6 mg/L. Recent literature shows that stable phosphate levels below 0.5 mg/L can support healthy and productive pond ecosystems (Susilo *et al.*, 2023). Overall, phosphate analysis from the four ponds shows that phosphate concentrations are still within safe limits for fish and shrimp cultivation. However, regular monitoring and effective management are still needed to ensure phosphate concentrations remain low and stable

3.10 Total Organic Matter (TOM)

The Total Organic Matter (TOM) parameter is an essential indicator in assessing pond water quality, especially in the context of fish and shrimp cultivation. Organic matter in pond water can come from leftover feed, waste from pond organisms, and organic matter entering the surrounding environment. In Pond 1, the TOM concentration was around 11.35 mg/L. This value is still within the acceptable range for fish and shrimp cultivation. A stable TOM concentration indicates that the organic material decomposition process is proceeding well and does not cause a significant decrease in water quality. Pond 2 showed a slightly higher TOM concentration, 10.39 mg/L. Even though it is still within safe limits, TOM concentrations close to the upper limit prevent an increase that could negatively impact. Good management practices, such as efficient feed management and regular organic waste removal, can help stabilize TOM concentrations (Asbar *et al*. 2015).

Pond 3 has a TOM concentration of 9.59 mg/L. This value is also within safe limits, but regular monitoring is still needed to ensure TOM concentrations do not increase. Water treatment technology, such as aeration and biofilters, can help control TOM concentrations in ponds. Recent literature shows that this technology effectively reduces the concentration of organic matter in cultivation systems (Bakosurtanal, 1996). Pond 4 shows a TOM concentration of around 10.37 mg/L. Even though it is within a safe range, regular monitoring is still needed to ensure no increase could harm the pond ecosystem. Recent literature shows that stable TOM levels below 10 mg/L can support healthy and productive pond ecosystems (Rissa *et al.*, 2024)

3.11 Suitability of Pond Cultivation

The condition of suitability of pond land in Banjar Panji Village, as reflected in the results of research referring to the latest literature, shows important variations in environmental factors that influence the productivity of pond aquaculture. In the evaluation carried out on four pond points where samples were taken, several key parameters such as salinity, temperature, pH, dissolved oxygen, ammonia, nitrite, nitrate, phosphate, and total organic matter (TOM) became the main focus in determining the level of land suitability. Water salinity, as one of the crucial parameters in pond cultivation, shows significant differences between the locations observed. Recent data shows that some locations have relatively low salinities, falling below the ideal range to support optimal pond biota growth and reproduction. In addition, variations in water temperature are also a concern, with some pond points showing temperatures that tend to be high, which can affect biological activity and the efficiency of metabolic processes in the pond.

Furthermore, chemical parameters such as pH are important in evaluating land suitability for successful pond cultivation. Although specific data regarding pH are not yet available for this analysis, recent studies highlight the importance of maintaining optimal pH balance in the pond environment. The influence of the Lapindo mudflow on pond water quality in Banjar Panji Village, Sidoarjo Regency, has become a significant concern in various environmental studies. The Lapindo mudflow, which occurred in 2006, has caused significant damage to the ecosystem, including water quality in surrounding ponds (Yulianti *et al*., 2023). Mud containing various chemicals and heavy metals can pollute pond water, disrupting aquatic biota's health and pond production.

One of the parameters affected is the salinity level. According to research by Fitria *et al*. (2023), the Lapindo mudflow can change the mineral composition in the water, impacting salinity fluctuations. Unstable or too low salinity can inhibit the growth of pond organisms such as shrimp and fish. In addition, changes in pH due to mud contamination can cause water conditions to become too acidic or too alkaline, which is also dangerous for aquatic life. The mudflow also decreased dissolved oxygen parameters. The high organic matter content in sludge can increase the activity of decomposing bacteria, which consume oxygen in the decomposition process. The Santoso *et al*. (2024) study showed that low dissolved oxygen levels can cause stress in pond organisms, reducing their survival and growth rates.

In addition, heavy metals such as mercury, cadmium, and lead in Lapindo mud can accumulate in pond water, as Fitria *et al*. (2023) reported. These heavy metals are toxic and can poison pond biota and impact the health of humans who consume pond products. Measurements of nitrite and nitrate parameters show increased concentrations, which indicate organic pollution and can cause eutrophication. Several pond water treatment technologies have been proposed to address these impacts. Some of the recommended solutions include biofilters to filter chemicals and heavy metals, aeration to increase dissolved oxygen levels, and probiotics to stabilize water quality (Juni *et al*. 2021). Research by Ahmadi *et al*. (2023) suggests that an integrated approach combining these technologies can help mitigate the impact of the Lapindo mudflow and restore pond water quality.

The influence of the Lapindo mudflow on pond water quality in Banjar Panji Village, Sidoarjo Regency, has become a significant concern in various environmental studies. The Lapindo mudflow, which occurred in 2006, has caused significant damage to the ecosystem, including water quality in surrounding ponds. Mud containing various chemicals and heavy metals can pollute pond water, disrupting aquatic biota's health and pond production (Wahyuni *et al*., 2020; Juni *et al*. 2021). One of the parameters affected is the salinity level. According to research by Susilo *et al*. (2023), the Lapindo mudflow can change the mineral composition in the water, impacting salinity fluctuations. Unstable or too low salinity can inhibit the growth of pond organisms such as shrimp and fish. In addition, changes in pH due to mud contamination can cause water conditions to become too acidic or too alkaline, which is also dangerous for aquatic life. Dissolved oxygen parameters also decreased due to the mudflow. The high organic matter content in sludge can increase the activity of decomposing bacteria, which consume oxygen in the decomposition process. The Santoso *et al*. (2024) study showed that low dissolved oxygen levels can cause stress in pond organisms, reducing their survival and growth rates (Yuliastuti *et al*., 2011; Zhang *et al*. 2020).

Table 3. Weighting and Scoring of Pond Cultivation Suitability Parameters

No.	Parameter	Pond 1	Pond 2	Pond 3	Pond 4
1	Slope (%)	S2	S2	S2	S3
2	Distance from Beach (m)	S1	S1	S1	S1
3	Distance from River (m)	S2	S2	S1	S1
4	Salinity (ppt)	N	N	N	N
5	Temperature (°C)	S1	S1	S1	S1
6	Dissolved Oxygen (mg/L)	S2	S2	S2	S2
7	pH	S2	S2	S2	S2
8	Phosphate (PO_4)	S3	S2	S2	S2
9	Ammonia (NH_3)	S2	S2	S2	S2
10	Nitrite (NO_2) (mg/L)	S2	S2	S2	S2

Source: Minister of Maritime Affairs and Fisheries Regulation Number 75/PERMEN-KP/2016

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4. Conclusion

The research results show that most water quality parameters, such as temperature, salinity, pH, dissolved oxygen, ammonia, nitrite, and nitrate, are upper or lower than the ideal limits for optimal cultivation. The water salinity at all points of the pond, for example, indicates a mismatch with the ideal requirements for milkfish cultivation, which requires a specific salinity range for optimal growth. Additionally, inadequate dissolved oxygen levels can inhibit the respiration of aquatic organisms and result in dangerous anoxic conditions. To increase water quality and sustainability, it was suggested that the technology of pond construction and workforce participation be improved.

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