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WATER QUALITY IN FLOATING NET CAGE AND NON-CAGE AREAS OF THE JATIGEDE RESERVOIR

Kualitas Air Daerah Kja Dan Non Kja Di Waduk Jatigede

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ABSTRACT

The rapid development of fish farming using the Floating Net Cage (KJA) system has raised concerns about the water quality of the reservoir. This study aims to evaluate the water quality in KJA and non-KJA areas of the Jatigede Reservoir based on the physical-chemical parameters of the water. Analysis was conducted at four stations with varying levels of KJA activity. The results showed that, based on Government Regulation No. 22 of 2021, the pH and BOD parameters have exceeded the established quality standards. However, Jatigede Reservoir is still considered suitable for fisheries activities as other water quality parameters remain within the standards for Class II and III water. This study is expected to serve as a basis for the sustainable management of Jatigede Reservoir, aiming to mitigate the negative impacts of KJA on water quality while supporting its utilization as an economic livelihood resource for the local community.

Key words: Floating Net Cages, Jatigede Reservoir, Water Quality

ABSTRAK

Aktivitas budidaya ikan dengan sistem Karamba Jaring Apung (KJA) yang berkembang pesat menimbulkan kekhawatiran terhadap kualitas air waduk. Penelitian ini bertujuan untuk mengevaluasi kualitas air daerah KJA dan non-KJA di Waduk Jatigede berdasarkan parameter fisik-kimiawi perairan. Analisis dilakukan pada empat stasiun dengan tingkat aktivitas KJA yang berbeda. Hasil penelitian menunjukkan bahwa Berdasarkan Peraturan Pemerintah No.22 Tahun 2021, parameter pH, dan BOD telah melampaui baku mutu yang telah ditetapkan. Namun, Waduk Jatigede masih tergolong layak untuk kegiatan perikanan dikarenakan parameter kualitas air yang lain masih termasuk kedalam baku mutu air kelas II dan III.Kajian ini diharapkan dapat menjadi landasan bagi pengelolaan berkelanjutan Waduk Jatigede, dengan tujuan mengurangi dampak negatif KJA terhadap kualitas air sekaligus mendukung pemanfaatannya sebagai sumber penghidupan ekonomi bagi masyarakat setempat.

Kata Kunci: Karamba Jaring Apung, Kualitas Air, Waduk Jatigede

INTRODUCTION

Jatigede Reservoir, as one of the largest reservoirs in Indonesia with a catchment area of 3,952 hectares and an average depth of 20.15 meters, has the main function of controlling flooding, irrigation, and providing raw water for the surrounding community (Marsela *et al*., 2023; Herawati *et al.*, 2018). This reservoir is designed to control flooding in an area of 14,000 hectares downstream of the Cimanuk River and provide irrigation for 90,000 hectares of agricultural land. In addition, this reservoir also supports a raw water supply of up to 3,500 liters per second for Cirebon Regency, Indramayu, and its surroundings (Purnama *et al.*, 2015). However, the utilization of Jatigede Reservoir by the local community extends to the fisheries sector, including fish farming with the Floating Net Cage system.

Cultivation with Floating Net Cages in Jatigede Reservoir is growing rapidly due to its potential economic benefits, ease of implementation, and availability of technology (Hardjamulia *et al.*, 1991). However, this activity is contrary to government policy which stipulates a ban on Floating Net Cages activities in Jatigede Reservoir, as regulated in Sumedang Regency Regional Regulation Number 4 of 2018. This prohibition is based on concerns about the decline in water quality due to cultivation waste.

Floating Net Cages cultivation waste such as leftover feed and fish metabolism, are the main sources of organic matter that increase the concentration of phosphate and nitrate in the waters (Neto & Ostrensky 2015). Previous research conducted by Zaniboni *et al.* (2018), that fish cultivation can reduce the quality of reservoir waters caused by sedimentation, turnover, and eutrophication. This is also reinforced by research conducted by (Kartamihardja, 1991) that excessive cultivation activities in Cirata Reservoir cause an increase in the concentration of nutrients and organic matter. This phenomenon has an impact on reducing dissolved oxygen, which if it reaches anoxic conditions can disrupt the life of aquatic organisms, including farmed fish.

In addition, the pollution of the Jatigede Reservoir waters is also exacerbated by domestic and agricultural waste from the Cimanuk River Basin. Domestic waste in the form of organic and inorganic waste and industrial waste from the leather and tofu sectors in the Upper Cimanuk area have polluted the waters (Sutriarti, 2011). This is proven by research by Marsela *et al.* (2023), that from the field conditions found in the Jatigede Reservoir, a lot of domestic waste is carried from the Cimanuk River Basin. Warsa (2016), has also conducted research on water quality in the Cimanuk River Basin in the Jatigede Reservoir inundation area. In his research, the concentration of total nitrogen and phosphorus tended to be high in all locations of the River Basin, this is because the location of the River Basin is surrounded by agricultural land.

The water quality of the Jatigede Reservoir is greatly influenced by a combination of internal and external pollution sources that have been described previously. Uncontrolled Floating Net Cage activities are a major concern because of their potential impact on water quality. Based on research in other reservoirs such as Cirata and Jatiluhur, the increase in the number of Floating Net Cages is often associated with problems of pollution, eutrophication, and mass fish deaths (Sutjinurani & Suharyanto 2016). Therefore, a deep understanding of the influence of Floating Net Cages activities on the water quality of Jatigede Reservoir is important to support sustainable management.

This study aims to evaluate the water quality in the Floating Net Cage and non-Floating Net Cage areas of Jatigede Reservoir based on physical and chemical parameters. By analyzing the relationship between Floating Net Cage activities and water quality, this study is expected to provide relevant information for policy making related to reservoir management. The results of this study are also expected to be a reference for efforts to improve water quality, so that Jatigede Reservoir can still be utilized optimally for various community needs.

RESAERCH METHODS

Time and Place of Research

Sampling was carried out in the waters of the Jatigede Reservoir, Sumedang, West Java on February 6, 2024 - February 27, 2024. Water quality measurements were carried out in situ at the Jatigede Reservoir and ex situ at the Aquatic Resources Management Laboratory, Faculty of Fisheries and Marine Sciences, Padjadjaran University.

Tools and Materials

The observed parameters include physical and chemical parameters. The tools, methods, and observation locations used are presented in Table 1.

Table 1. Physical and Chemical Parameters

Parameter	Unit	Tool	Method	Location
I. Physique				
Temperature	° C	Thermometer	Potentiometric	Insitu
Transparency	m	Secchi Disk	Visual	Insitu
II. Chemical				
DO	mg/L	Winkler Bottle	Titrimetric	Insitu
Nitrate	mg/L	Spectrophotometer	Spectrophotometric	Laboratory
Ammonia	mg/L	Spectrophotometer	Spectrophotometric	Laboratory
Phosphate	mg/L	Spectrophotometer	Spectrophotometric	Laboratory
CO2	mg/L	Erlenmeyer flask	Titrimetric	Insitu
pH	-	pH meter	Potentiometric	Insitu

Sampling Methods and Location Determination

This study used a survey method with purposive sampling station determination based on variations in the density of Floating Net Cages in the Jatigede Reservoir. Water quality analysis used a comparative descriptive method. There were four research stations, with sampling at three depths: surface, half compensation, and compensation for stations without Floating Net Cages, as well as surface, compensation, and bottom of Floating Net Cages for stations with Floating Net Cages activity. The selection of this depth is based on:

1. Depth of Water Surface

The surface depth was chosen because it has high sunlight intensity and can support phytoplankton photosynthesis, thus increasing the primary productivity of the waters. According to Effendi (2003), the euphotic layer is a zone with sufficient light for photosynthesis because in this layer the oxygen produced from the photosynthesis process is greater than the oxygen used for respiration. To avoid photoinhibition, the sampling depth was set at 0.5 m from the water surface, in accordance with Pulz (2001) who stated that excessive light intensity can damage chlorophyll and inhibit photosynthesis.

2. ½ Compensation Depth

Refers to the depth of the water surface where the light intensity received by phytoplankton decreases to half of the light intensity at the water surface. This depth is important because at the surface depth photoinhibition is still possible, while the depth below it allows photolimitation. This depth can be calculated using the formula:

$$\frac{1}{2} Compensation\ Depth = \frac{Compensation\ Depth}{2}$$

3. Compensation Depth

The compensation depth was chosen because at this depth, the intensity of sunlight has decreased so that the photosynthesis process is hampered. As a result, the organic materials produced (gross production) are reduced. Primary productivity can take place up to the compensation depth or the depth where the light intensity is only 1% of the surface light intensity (Nuzapril *et al.*, 2017). According to Hill *et al.* (2013) in Nuzapril *et al.* (2017), the compensation depth can be calculated using the formula:

$$Compensation\ Depth = \frac{4,6}{k}$$

*k is the attenuation coefficient from the reading of the depth of the secchi disk using the empirical equation relationship from Smith *et al.* (1999), as follows:

$$k = 0,191 + \frac{1,242}{Zsd}$$

Information :
k = Attenuation coefficient (m^{-1})
Zsd = Secchi disk depth (m)

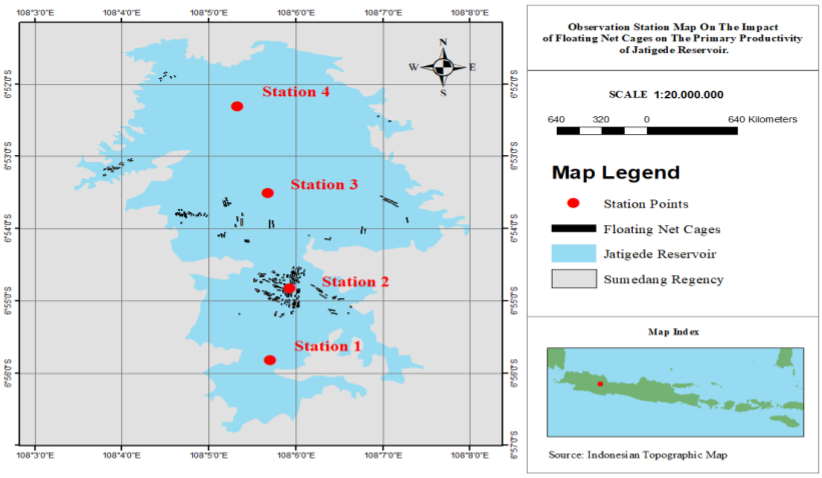

Figure 1. Location of Research Station

The sampling location was chosen considering representing dense areas of Floating Net Cages (KJA), clean areas of Floating Net Cages, and inlets and outlets of the reservoir. Sampling was carried out 4 times with a frequency of 30 days. The determination of the four stations can be seen in Table 2.

Table 2. Sampling Locations

Location	Coordinate	Information
Station 1	-6° 55' 50.26" S 108° 5' 38.12" E	This station is a location where there are no Floating Net Cage. This station is located in the Sukamenak area. This station is a *riverine zone* as well as the main *inlet* of the Jatigede Reservoir which comes from the Cimanuk River.
Station 2	-6° 54' 51.55" S 108° 5' 56.3" E	This station is the location with the highest total number of KJA units, which is ± 548 Floating Net Cage units. This station is located in the Leuwihideung area which is classified as a transition zone because its position is in the middle of the reservoir.

Station 3	-6° 53' 56.41" S 108° 5' 40.94" E	This station is the location with the lowest total number of Floating Net Cage units, which is ± 144 Floating Net Cage units. This station is located in the Pasir Calung area. This station is ± 900 m away from station 2 and its position located in the middle reservoir so that classified as a transition zone .
Station 4	-6° 52' 17.02" S 108° 5' 15.82" E	This station is a location where there are no Floating Net Cage. This station is located close to Mount Surian, close to the dam (*outlet of* Jatigede Reservoir) and is classified as a *lacustrine zone* .

RESULT

Physical-Chemical Parameters of Station 1 (Inlet)

The average graph of water quality measurements at Station 1 is presented in Figure 2. Measurements of physical and chemical parameters at Station 1 show that nitrate concentrations ranged from 0.027-0.057 mg/L. The average nitrate concentrations at the surface and at ½ compensation depth were 0.043±0.012 mg/L and 0.043±0.006 mg/L, which decreased at the compensation depth to 0.041±0.012 mg/L. Ammonia concentrations at Station 1 ranged from 0.001-0.027 mg/L, with the lowest average ammonia value at the surface of 0.004±0.005 mg/L. Phosphate concentrations at Station 1 ranged from 0.032-0.135 mg/L. The average phosphate concentration on the surface was 0.073±0.045 mg/L, at a depth of ½ compensation of 0.066±0.039 mg/L, and at a depth of compensation of 0.068±0.041 mg/L. BOD levels at Station 1 ranged from 1.9-13 mg/L with the highest average at a depth of ½ compensation of 7.99±4.15 mg/L. Dissolved oxygen (DO) levels ranged from 2.3-7.1 mg/L. CO_2 concentrations tended to decrease at a depth of ½ compensation. Vertically, the distribution of BOD values showed fluctuations with an increase in the depth layer of ½ compensation.

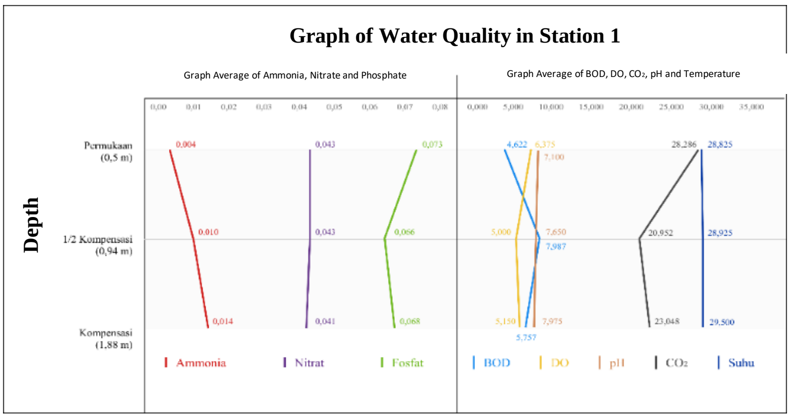

Figure 2. Average Water Quality Graph at Station 1

Physical-Chemical Parameters of Station 2 (High Floating Net Cage Density)

The average graph of water quality measurements at station 2 is presented in Figure 4. The water quality measured at Station 2 shows that the nitrate concentration ranges from 0.030-0.067 mg/L. The ammonia concentration measured at Station 2 ranges from 0.001-0.054 mg/L, with the highest average value at all depths of 0.025±0.022 mg/L. Phosphate concentration ranges from 0.020-0.118 mg/L. Dissolved oxygen (DO) at Station 2 was recorded to have a range of 1.9-6.8 mg/L, while the BOD value was in the range of 1.9-10.2 mg/L. The carbon dioxide (CO_2) concentration at Station 2 ranged from 21-83.8 mg/L and was recorded as the highest average value compared to other stations. The physical condition of the waters at Station 2 was also influenced by the presence of Floating Net Cages. Waste in the form of leftover feed and fish feces from the Floating Net Cages contributes to the increase in organic matter in these waters. Based on the measurement results, water quality parameters show fluctuations due to organic load from the Floating Net Cages activity.

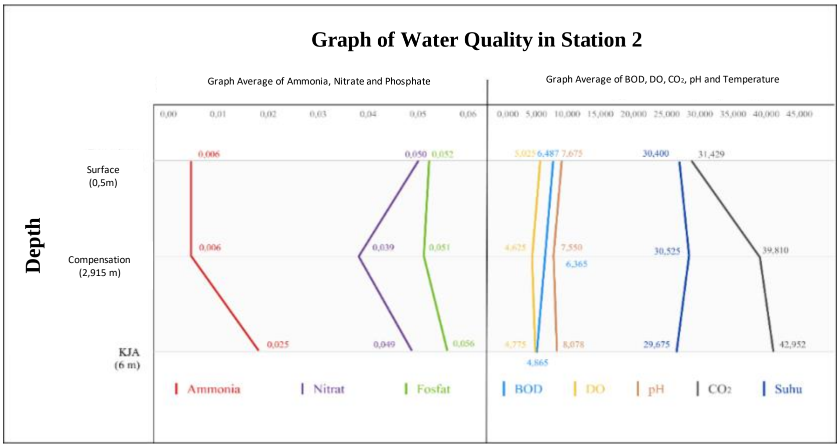

Figure 3. Average Water Quality Graph at Station 2

Physical-Chemical Parameters of Station 3 (Low Floating Net Cage Density)

The average graph of water quality measurements at station 3 is presented in Figure 5. The results of water quality measurements at Station 3 show that the nitrate concentration ranges from 0.027-0.082 mg/L. The measured ammonia concentration is in the range of 0.002-0.039 mg/L, while phosphate has a concentration of between 0.022-0.123 mg/L. Compared to Station 2, the levels of nitrate and phosphate nutrients did not show significant differences, but the ammonia concentration at Station 3 was higher. The pH value measured at Station 3 was also higher than the other stations. The dissolved oxygen (DO) concentration at Station 3 ranged from 1.8-7 mg/L, with the lowest value recorded in the first repetition. The BOD value at Station 3 ranged from 0.5-21.1 mg/L, with the highest value found at the compensation depth of the fourth repetition.

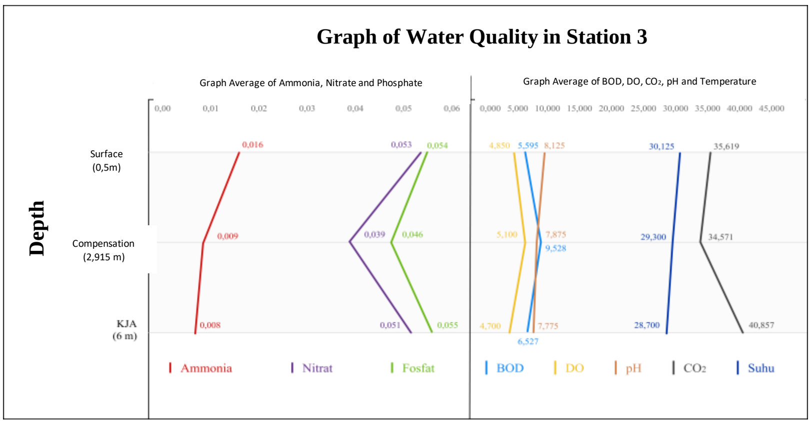

Figure 4. Average Water Quality Graph at Station 3

Physical-Chemical Parameters of Station 4 (Water Outlet)

The average graph of water quality measurements at station 4 is presented in Figure 6. The measurement results at Station 4 showed nitrate concentrations ranging from 0.027-0.082 mg/L, with ammonia concentrations reaching 0.002-0.039 mg/L. Both of these concentrations are higher than other stations, which is caused by the location of Station 4 as a reservoir outlet so that a lot of waste is retained and accumulated at the bottom of the waters (Larasati *et al.*, 2024). The phosphate levels measured at Station 4 were in the range of 0.022-0.102 mg/L, which is considered optimum to support the growth of aquatic organisms (Asriyana & Yuliana 2021).

The pH level at Station 4 ranged from 7.5-9, which exceeds the ideal range for phytoplankton life, which is 6.0-8.5 (Nuzapril et al. 2019). The measured carbon dioxide (CO_2) levels ranged from 12.6-29.3 mg/L, also exceeding the optimal range for phytoplankton growth as stated by Zonneveld (1991) in Prasetyaningtyas *et al.*, (2012). The dissolved oxygen (DO) levels at Station 4 showed the highest values compared to other stations, with a range of 5.4-7.2 mg/L. The average DO value at the surface was 6.30 ± 0.90 mg/L, at a depth of ½ compensation of 6.60 ± 0.26 mg/L, and at a depth of compensation of 6.40 ± 0.35 mg/L.

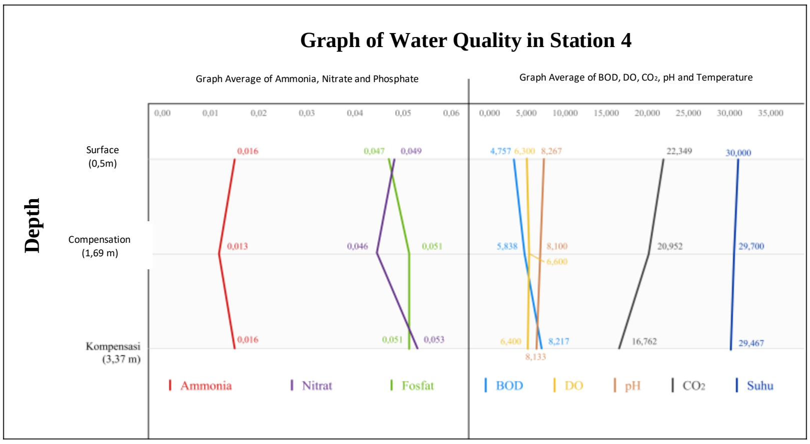

Figure 5. Average Water Quality Graph at Station 4

RESULT

Physical-Chemical Parameter Conditions of Station 1 (Inlet)

Low primary productivity at the inlet (station 1) is influenced by suboptimal nutrient concentrations, especially nitrate and ammonia. According to Putri *et al.* (2019), nitrate is an important macronutrient to support primary productivity, especially in the euphotic zone. However, nitrate levels at Station 1 are relatively low compared to the optimal phytoplankton requirements, which are 0.9–3.5 mg/L (Asriyana & Yuliana 2021). Low ammonia levels at Station 1 also indicate that the nitrification process and nitrogen uptake by autotrophic organisms are taking place rapidly (Wetzel 2001).

High phosphate concentrations at Station 1 can increase phytoplankton abundance. Phosphate from domestic and agricultural waste around the reservoir is the main source of nutrients (Putri *et al.*, 2019) This is reinforced by research by Marsela *et al.* (2023), which states that the use of NPK fertilizers in agricultural land around the reservoir contributes to high phosphate in the waters through runoff. However, increased phytoplankton biomass from high phosphate concentrations can also lead to decreased light penetration and ultimately reduced photosynthesis rates.

The average vertical distribution of BOD measurements in Figure 3 fluctuates with increasing depth, with the highest average BOD occurring at ½ compensation depth with a value of 7.99 ± 4.15 mg/L. According to Wardhani & Sugiarti (2022), this condition is related to relatively homogeneous temperatures indicating holomictic mixing due to shallow water depths accompanied by high current velocities. Meanwhile, the dissolved oxygen measured at station 1 ranged from 2.3 - 7.1 mg/L and was classified as optimum for phytoplankton growth. This is based on Garibaldi's statement (2012), that a good oxygen concentration for phytoplankton is more than 2 mg/L. Optimal DO levels indicate that oxygen is still being produced through photosynthesis or that there is good circulation, but this condition indicates the onset of eutrophication or limitations of essential nutrients (Wetzel 2001).

Physical-Chemical Parameter Conditions of Station 2 (High Floating Net Cage Density)

The nitrate concentration at Station 2 is relatively low compared to the optimum value required to support life in the waters (Purba *et al.*, 2015; Asriyana & Yuliana, 2021). This low nitrate concentration can be caused by the uptake of nitrogen by autotrophic organisms and the rapid nitrification process (Wetzel 2001).

Ammonia detected at Station 2 had the highest value at all depths, which is thought to originate from organic waste from Floating Net Cages, such as fish feces and uneaten feed. Boyd (2003) in Andria & Rahmaningsih (2018), explained that ammonia accumulation tends to occur in the lower layers due to low light and oxygen. However, the ammonia value measured at Station 2 is still relatively safe for aquatic organisms based on the safe limits (Boyd, 1983 in Haris & Yusanti, 2018). The low phosphate concentration at Station 2 can be caused by the limited phosphate sources in these waters. This is in accordance with the opinion of Asriyana & Yuliana (2021), who stated that the optimal range of phosphate to support aquatic ecosystems is 0.09-1.80 mg/L.

The DO value at Station 2 tends to be lower than other stations, influenced by the high organic matter originating from Floating Net Cages. Wardhani et al. (2018) stated that Floating Net Cages waste can reduce light intensity in waters, so that the photosynthesis process does not run optimally and reduces oxygen levels. The BOD value at Station 2 is included in the low to moderate pollution category (Salmin, 2005).

The high concentration of CO_2 at Station 2 is most likely related to the rainy season when the study was conducted (Harlina, 2021). The accumulated carbon dioxide comes from atmospheric diffusion, rainwater, decomposition of organic matter, and organism respiration. Despite the high concentration of CO_2, fish in these waters can still survive because the dissolved oxygen levels are quite adequate (Harlina, 2021; Garibaldi, 2012).

Floating Net Cages at Station 2 have a significant impact on water quality fluctuations, especially through increased BOD and CO_2. However, environmental conditions at Station 2 still allow for the life of aquatic organisms, including farmed fish such as carp and tilapia, which have a tolerance to dissolved oxygen levels within a certain range (Saputra et al. 2023).

Physical-Chemical Parameter Conditions of Station 3 (Low Floating Net Cage Density)

The nitrate concentration at Station 3 is relatively low and less than optimal to support aquatic life, as stated by Purba *et al.* (2015), that the optimum nitrate value is 1.12 mg/L. The ammonia concentration at Station 3 is relatively good because it is still below the maximum safe limit for aquatic organisms, which is 0.1 mg/L (Bhatnagar 2013). Phosphate at Station 3 is within the optimum range that supports aquatic ecosystems, which is 0.09-1.80 mg/L (Sidaningrat *et al.*, 2018).

The high ammonia concentration at Station 3 can be associated with a higher pH level compared to other stations. This is in line with the opinion of Rump and Krist (1992) in Effendi (2003) which explains that an increase in pH increases the percentage of free ammonia (NH_3), while a decrease in pH increases the percentage of ammonium (NH_4^+).

The high BOD value at Station 3, especially in the fourth repetition, reflects the high oxygen requirement by microorganisms to decompose organic matter. This condition is likely influenced by the higher temperature in the fourth repetition. Wirosarjono (1974) in Salmin (2005), classified the range of BOD values at Station 3 as low to high pollution levels. The low DO levels at Station 3 were also influenced by the activity of microorganisms that decompose waste carried by the current, especially after rain (Saputra *et al.*, 2013).

The water quality conditions at Station 3 showed a significant influence of KJA activity on increasing organic loads and fluctuations in water quality parameters, especially BOD and ammonia values.

Physical-Chemical Parameter Conditions of Station 4 (Water Outlet)

Higher concentrations of nitrate and ammonia at Station 4 indicate the accumulation of waste from the previous station. Larasati *et al.* (2024), stated that the location of the reservoir outlet causes the accumulation of organic compounds at the bottom of the waters, where the decomposition process produces ammonia and nitrate. In sediments, nitrate is formed through the oxidation of ammonia produced from the decomposition of organic compounds (Seitzinger, 1988 in Larasati *et al.,* 2024). The higher pH levels at Station 4 are influenced by the high concentration of basic chemical compounds. This pH level is correlated with low dissolved CO_2 because H^+ ions produced from respiration tend to decrease (Haris & Yusanti 2018). Although the pH and CO_2 levels exceed the ideal limits, the high levels of dissolved oxygen help maintain water quality at Station 4.

The high levels of dissolved oxygen at Station 4 are caused by several factors, including the presence of internal waves in the thermocline layer which increase oxygen circulation (Wardhani & Sugiarti 2022). In addition, the high wind intensity in this area supports the process of oxygen diffusion from the atmosphere into the waters (Paputungan *et al.,* 2022). The absence of barriers such as garbage in the lacustrine region also allows optimal light penetration, supporting photosynthesis by autotrophic organisms.

CONCLUSION

Based on Government Regulation No. 22 of 2021, the pH and BOD parameters have exceeded the established quality standards. However, the Jatigede Reservoir is still considered suitable for fisheries activities because other water quality parameters are still included in class II and III water quality standards. The results of the study indicate that the Floating Net Cage activity contributes to the decline in water quality in the Jatigede Reservoir, especially in parameters such as BOD, ammonia, and nitrate. Continuous monitoring is needed to maintain the sustainability of the reservoir's aquatic ecosystem.

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