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WATER QUALITY AND TROPHIC STATUS IN JATIBARANG RESERVOIR, SEMARANG

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ABSTRACT

Jatibarang Reservoir is one of the reservoirs in Central Java. This reservoir has functions for fisheries and tourism activities. The reservoir needs to be managed properly with water quality and water fertility for the function of the reservoir. The characteristics of a reservoir that is lentic cause nutrient mixing, so it is possible that there are differences in characteristics in certain columns. The purpose of this research is to analyze the water quality and trophic status in Jatibarang Reservoir. The sampling technique used purposive sampling technique at 7 stations with 3 depth points (surface, middle, and bottom). Water quality variables measured included nitrate, phosphate, and total bacteria. The results of the variable concentrations were then calculated and compared with the literature. The results showed nitrate concentrations of 0,5 – 3,5 mg/l. Phosphate results ranged from 0,29 – 2,63 mg/l. Total bacteria ranged from 2 x 10^2 to 1,4 x 10^4 CFU/ml. Based on the nitrate concentration, Jatibarang Reservoir waters are classified as oligotrophic-mesotrophic.

Keywords: ***:*** *Phosphate; Nitrate; Total Bacteria; Trophic Status; Jatibarang Reservoir.*

INTRODUCTION

Reservoir waters are lentic or submerged waters, which causes vertical stratification zones. Vertical stratification in reservoirs is influenced by the intensity of light in the waters which it also affects the temperature in the waters (Shi *et al.*, 2022). Depth stratification in reservoir waters based on temperature can be divided into 3 layers, which are:

1. Epilimnion layer, this layer is the top layer of surface waters.
2. Metalimnion layer, this layer is the layer below the epilimnion and above the hypolimnion layer. This layer is often referred to as the thermocline layer.
3. Hypolimnion Layer, this layer is the bottom layer of water or the bottom of the water, where the temperature is colder and the density of water is higher (Wei *et al.*, 2022).

Jatibarang Reservoir is one of the reservoirs built by the Semarang City Government which is used as a tourist spot, for fishery activities, and for flood control with an inundation area of 189 Ha, a catchment area of 54 km^2 and a storage capacity of 20,4x10^6 (Kusuma and Arifien, 2020). Jatibarang Reservoir management needs to be monitored to keep the function of the reservoir running well. Measurement of water quality in Jatibarang Reservoir can be used to determine water quality and fertility status in Jatibarang Reservoir. The fertility of water is affected by the nutrients related to nitrate and phosphate, the total bacteria in it. The amount of nutrients will affect water quality and biota populations in waters, especially bacteria that have a role as decomposers in water (Zhang *et al*., 2021). A high abundance of bacteria in the waters can be dangerous because Jatibarang Reservoir is used as a source of domestic water supply.

Human activities both around the inlet and the Jatibarang reservoir waters can affect water quality, one of monitoring changes in water quality through a fertility analysis approach. Water quality is influenced by the amount of nutrients present in the water. Nutrients in water consist of nitrates, phosphates, and total organic matter (Li *et al.*, 2020). The fertility status of water can be determined from nutrients, brightness, and other biological parameters (Halac *et al.*, 2020). Trophic status in waters is divided into oligotrophic, mesotrophic, and eutrophic (Sruthy *et al.*, 2021). The purpose of this study was to determine the water quality and fertility status of Jatibarang Reservoir.

RESEARCH METHODS

The research was conducted in Jatibarang Reservoir, Semarang, Central Java in October-December 2020. Sampling was carried out at 7 stations with 3 depths (surface, middle, and bottom) and then analyzed in the laboratory based on Indonesia Standart's sampling of waters number, 2008 (SNI: Standar Nasional Indonesia Nomer 6989.57 Tahun 2008). The sampling locations in Jatibarang Reservoir 6989.57 are presented in Figure 1 and Table 1. The method used in this research is a descriptive method with a case study approach, and detailed research regarding an object, especially the fertility of a reservoir over a certain period. The research was conducted by analyzing the results of nitrate, phosphate, and total bacteria at different depths.

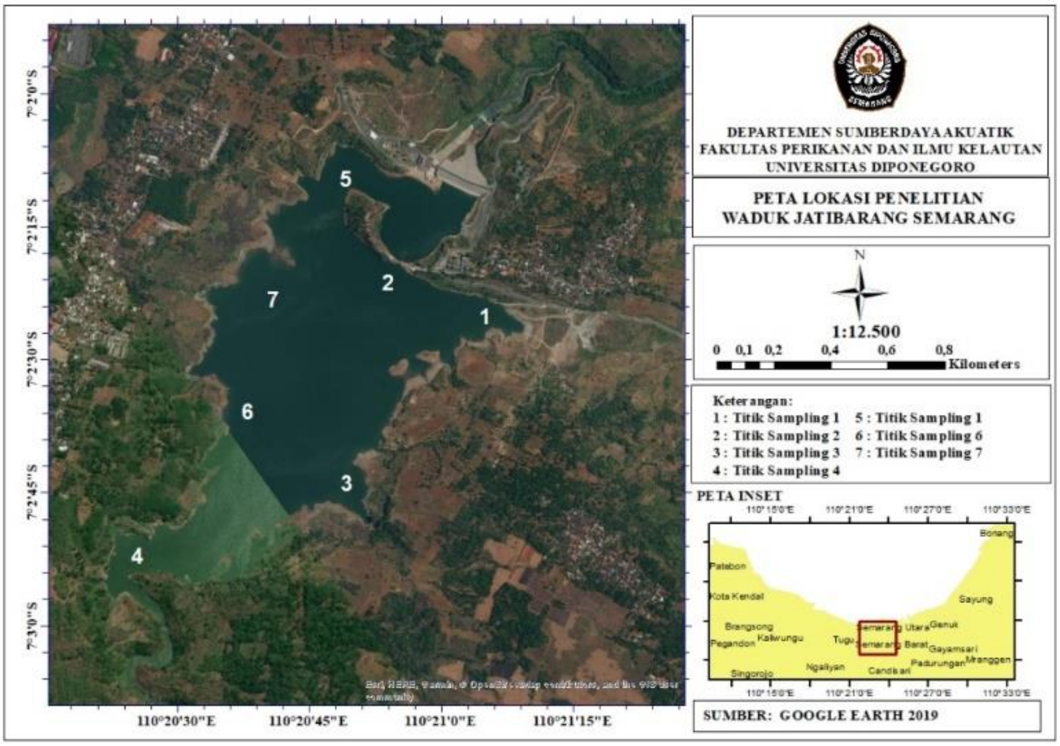

Figure 1. Water Sampling Location in Jatibarang Reservoir

Table 1. Description of Water Sampling in Jatibarang Reservoir

No.	Description	Station
1.	Inlet	IV
2.	Outlet	V
3.	Center	II, III, VI, VII
4.	Dock	I

Measurement of nitrate and phosphate using a Hach spectrophotometer, a 10 ml water sample was put into a nitrate and phosphate test tube. Nitraver 5 Nitrate Reagent was added to the nitrate tube and PhosVer 3 Phosphate was added to the phosphate tube and then shaken and let stand. After that, it was transferred to the cuvet and inserted into the spectrophotometer.

Calculation of total bacteria based on SNI Number 2332.3.2015 on Microbiological Test-section 3: Determination of Total Plate Numbers (TPN). Water fertility classification using comparison of parameter concentration results with literature PerMen LH No. 28 of 2009 for total-P, Vollenweider (1969) for nitrate concentration, and Badjoeri (2013) for total bacteria in Table 2.

The calculation of total-P conversion was calculated using the results of the measured phosphate concentration and then converted to the formula by the Water Research Center. The total-P conversion based on Oram (2019) in Kochary et al. (2017) is shown in the following:

Total P =PO4 x 0.3262..(1)

The value of 0.3262 is the same as 1 mg/l of phosphate-based on the weight of the molecules in the phosphate (PO4) content divided by the weight of the phosphorus (P) molecules.

Bacterial colonies were counted using a total plate counter. The Petri dish that was counted was the one with the number of bacterial colonies 25 - 250. Then calculate the abundance of bacteria with the formula::

$$N = \text{Number of colonies x } \frac{1}{\text{Dilution factor}} \quad ....(2)$$

Description : Dilution factor = Dilution x Number of Grown; N = Number of colonies (CFU/ml)

The classification of water fertility using the comparison of variable concentration results with the literature PerMen LH No. 28 of 2009 for total-P, Vollenweider (1969) for nitrate concentration, and Badjoeri (2013) for total bacteria presented in Table 2.

Table2. Trophic Status Based on Literature

Variable	Range	Trophic Status
Nitrate (mg/l)*	0-1	Oligotrophic
	1-5	Mesotrophic
	5-50	Eutrophic
	>50	Hypereutrophic
Total-P (mg/l)**	≤ 0.01	Oligotrophic
	≤ 0.,03	Mesotrophic
	≤ 0.1	Eutrophic
	> 0.1	Hypereutrophic
Total Bacteria (CFU/ml)***	$(0.5 – 3.4) \times 10^5$	Oligotrophic
	$(0.4 – 1.4) \times 10^6$	Mesotrophic
	$2.2 \times 10^5 – 1.2 \times 10^7$	Eutrophic
	$>1.2 \times 10^7$	Hypereutrophic

Source : Vollenweider 1969*, PerMen LH No. 28 Tahun 2009** dan Badjoeri 2013***

The hypotheses of this research are: H_o= There are no different variables in the difference of water's depth; H_1 = There are different variables in the difference of water's depth

RESULT AND DISCUSSION

Water Quality

Nitrate

The results of nitrate variables are presented in Table 3 and Figure 2. The results of nitrate concentration in Jatibarang Reservoir ranged from 0.5-3.5 mg/l. Nitrate concentrations at the surface ranged from 0.5-0.9 mg/l, nitrate concentrations in the middle range from 0.6-0.8 mg/l, and nitrate concentrations at the bottom ranged from 0.7-3.5 mg/l. Based on the results of nitrate measurements in Jatibarang Reservoir, there are differences in results at the surface, middle, and bottom of the reservoir.

Table 3. The Result of Nitrate Contrentation in Jatibarang Reservoir

Station	Depth (m)	Nitrate (mg/l)
I	0	0.5
	1.05	0.7
	1.68	3.5
II	0	0.6
	3.5	0.6
	5.6	0.8
III	0	0.5
	2.25	0.7
	3.6	0.7
IV	0	0.5
	1.83	0.8
	2.92	1
V	0	0.9
	8.5	0.8
	13.6	0.7
VI	0	0.5
	2	0.7
	3.2	0.7
VII	0	0.5
	7	0.6
	11.2	0.7

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Nitrate concentrations will be greater in areas close to land and at the bottom of the water. This can also encourage the nitrification process intensively with the presence of nutrient reserves in the form of organic matter and high DO content (Rakhman et al., 2022). Nitrate in waters is highly reactive and easily soluble in water so that aquatic biota can utilize it directly for biological needs (Indriani et al., 2016). Nitrate is not toxic to aquatic organisms. The high content of nitrate in waters can be influenced by the input of organic matter through river flow, high DO which can trigger bacteria to oxidize nitrogen into nitrate and anthropogenic activities (Kolbe et al., 2019). Nitrate in nature can be produced naturally or from human activities. Natural sources of nitrate are from the nitrogen cycle while sources from human activities come from the use of nitrogen fertilizers, industrial waste, and human organic waste (Kayame et al., 2021).

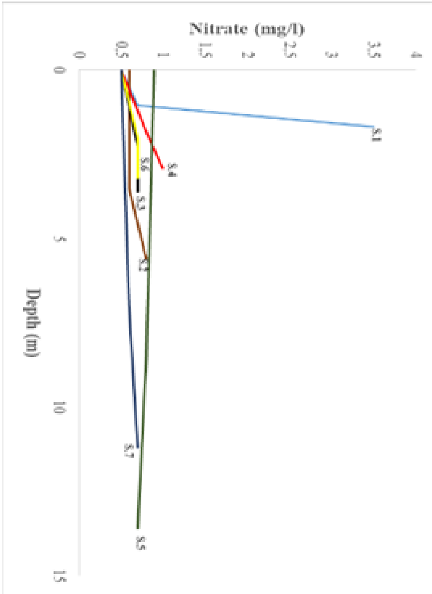

Figure 2. Graphic of Nitrate based on Depth in Jatibarang Reservoir

Phosphate

Based on the results of the measurement of phosphate concentration in Jatibarang Reservoir presented in Table 4. and Figure 3. the results of phosphate measurements ranged from 0.29-2.63 mg/l. The highest phosphate concentration was found in the bottom of the water at station IV at 2.63 mg/l and the lowest phosphate concentration was in the middle of station II at 0.29 mg/l. The phosphate concentration at the surface ranged from 0.41-0.72 mg/l, at the middle of the water ranged from 0.29-0.92 mg/l, and at the bottom of the water ranged from 0.34-2.63 mg/l.

The results of phosphate concentration in Jatibarang Reservoir at different depths appear to increase with increasing depth. The high concentration of phosphate at the bottom of the water occurs because phosphate is an element that has reactive properties and easily settles on sediments so phosphate elements accumulate at the bottom of the water (Siregar, 2013). Organic matter suspended in the bottom of the water can affect the availability of phosphorus in it (Zhang et al., 2023).

Excessive phosphate concentration in waters can cause an increase in water fertility or eutrophication. Eutrophication is a condition of excessive nutrient enrichment in waters that can cause a decrease in water quality due to increased algae growth or algae bloom followed by oxygen depletion and the decomposition of organic matter in waters (Yang et al., 2015). Abundant algae bloom in waters can cause the surface layer of water to become covered, this can inhibit light penetration reduce the photosynthesis rate of aquatic organisms that need it, and have an impact on the availability of dissolved oxygen in the waters decreases so that aquatic organisms experience oxygen deficiency in the respiration process and inhibit the mineralization process (Hatta et al., 2019).

The condition of the environment also affects the concentration of phosphate in the waters can be seen from the results of phosphate measurements obtained at station IV where station IV is the inlet area of Jatibarang Reservoir. The inlet at station IV is from the Kreo River flow. The inlet is an area that has a high orthophosphate and total phosphorus content due to the input of nutrients from anthropogenic activities into the reservoir so that phosphate in the waters accumulates and settles at the bottom of the waters (Shaleh et al., 2014).

The high concentration of phosphate in the water can also be caused by the release of phosphorus into the water and then deposited in the sediment (Aryani et al., 2021). Phosphorus is one of the chemicals that is important for living things because it can be used for growth and development. Phosphorus is related to organic matter and sediment minerals at the bottom of the water that can be mobilized by bacteria and released into the water column (Astuti and Tjahjo, 2020).

Table 4. The Result of Phosphate Contrentation in Jatibarang Reservoir

Station	Depth (m)	Phosphate (mg/l)	Total-P (mg/l)
I	0	0.64	0.21
	1.05	0.9	0.29
	1.68	0.67	0.22
II	0	0.53	0.17
	3.5	0.29	0.09
	5.6	0.34	0.11
III	0	0.55	0.18
	2.25	0.48	0.16
	3.6	0.58	0.19
IV	0	0.55	0.18
	1.83	0.66	0.22
	2.92	2.63	0.86
V	0	0.72	0.23
	8,5	0.92	0.30
	13.6	0.5	0.16
VI	0	0.71	0.23
	2	0.46	0.15
	3.2	0.1	0.33
VII	0	0.41	0.13
	7	0.77	0.25
	11.2	0.48	0.16

Total Bacteria

Based on the results of the study presented in Table 5. An Figure 4. obtained the total bacterial results ranged from (2.0× 102 - 1.4× 104) CFU/ml. The highest number was obtained from station V at the bottom of 1.4 × 104 CFU/ml and the lowest number at station VI in the middle of 2.0 × 102 CFU/ml

The presence of bacteria in the waters is related to the presence of organic matter in the waters. Waters that are impacted by river flow that enters through the reservoir inlet will carry organic material and will trigger the growth of heterotrophic bacteria where these bacteria utilize organic matter as a source of nutrition (Susanti et al., 2017). Organic matter is a nutrient that comes from the decomposition process of dead organisms in water (Riniatsih, 2016).

Bacteria are decomposer organisms that require substrates with high organic matter content as a place for bacterial growth. Environmental parameters such as temperature also play a role in the growth process of aquatic organisms such as bacteria. The water temperature used to encourage the activity of microorganisms in the decomposition of organic matter ranges from 26-30°C (Yuningsih et al., 2014). The results of temperature measurements in Jatibarang Reservoir ranged from 28.5 - 32.6°C where this temperature is considered optimal for the growth of organisms in tropical waters. According to Souhoka and Patty (2013), the temperature variation of tropical waters ranges from 25.6 - 32.3°C. In addition to temperature, other variables such as dissolved oxygen, nitrate, and total nitrogen can affect the presence of bacteria in waters because bacteria in waters have an important role ini environment like as decomposer and denitrifying bacteria in the nitrogen cycle in water (Yu et al., 2014). Some examples of denitrifying bacteria are Thiobacillus denitrificans, Micrococcus denitrificans, and some species of Serratia, Pseudomonas, and Achromobacter.

Data Analysis

The data obtained from the measurement of the variables were then analyzed using the normality test to see the normality of the data and then the T-test using the SPSS 20 application. Then data analysis was carried out using the PCA (Principal Component Analysis) method this method is a method for extracting the structure of a data set with quite a lot of dimensions. The PCA method can be used if the goal is to summarize the data with a smaller number of variables (Santosa, 2007). Data processing in this study used XLSTAT 2023 software. The results of statistical analysis using the t-test are presented in Table 6.

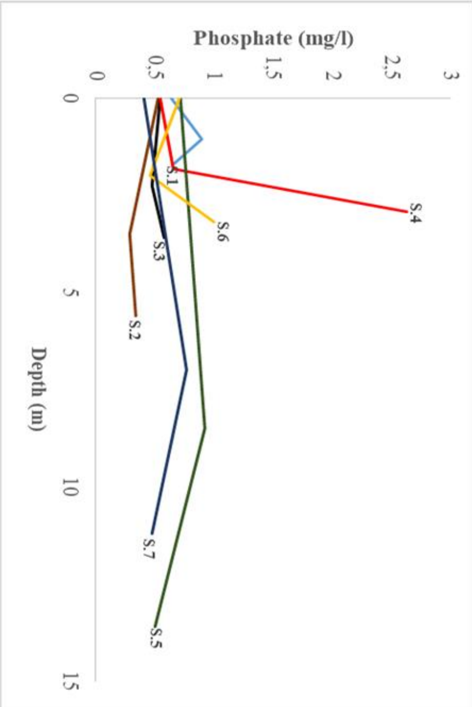

Figure 3. Graphic of Phosphate Based on Depth in Jatibarang Reservoir

Table 5. The result of Total Bacteria Contrentation in Jatibarang Reservoir

Station	Depth (m)	Total Bacteria (CFU/ml)
I	0	1.3 x 10^3
	1.05	3.4 x 10^3
	1.68	1.1 x 10^3
II	0	5.0 x 10^2
	3.5	1.7 x 10^3
	5.6	5.9 x 10^3
III	0	4.0 x 10^2
	2.25	3.0 x 10^2
	3.6	6.0 x 10^2
IV	0	8.0 x 10^2
	1.825	1.0 x 10^4
	2,.92	1.2 x 10^4
V	0	4.0 x 10^2
	8.5	2.2 x 10^3
	13.6	1.4 x 10^4
VI	0	6,0 x 10^2
	2	2.0 x 10^2
	3.2	8.4 x 10^3
VII	0	9.0 x 10^2
	7	6.0 x 10^2
	11.2	2.2 x 10^3

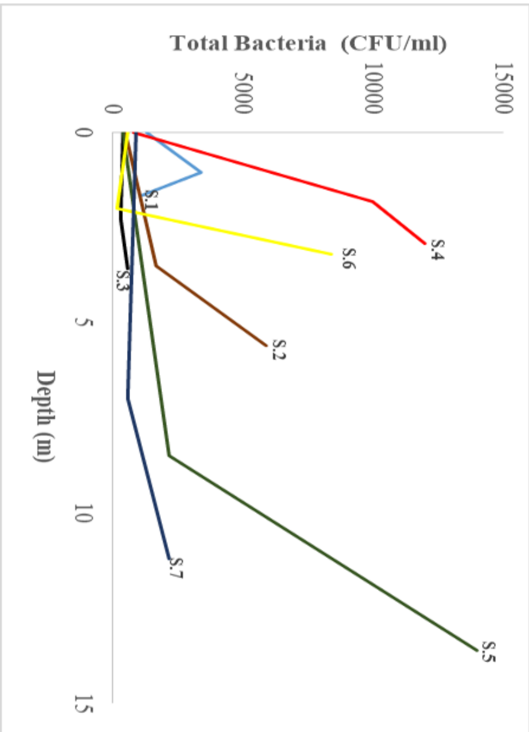

Figure 4. Graphic of Total Bacteria Based on Depth in Jatibarang Reservoir

Table 6. Result of *t-test*

Variable	*P-Value*	Sig.	Result
Nitrate	0.473	0.05	Accept H_0 (There is no difference)
Phosphate	0.391	0.05	Accept H_0 (There is no difference)
Total Bacteria	0,070	0.05	Accept H_0 (There is no difference)
TOM	0.246	0.05	Accept t H_0 (There is no difference)

The data were then analyzed using the t-test using the depth criteria according to SNI 6989.57 of 2008 where the depth data were classified into depth <10 m and depth >10 m. Based on the results of statistical analysis using the t-test, the significance value (p-value> 0.05) shows that there is no difference between variables with depth (<10 m and >10 m).

The results of analysis using the principal component analysis (PCA) showed that the variables and depth had an effect with a relationship value of 61.83% where the temperature and pH variables influenced at 7 points, namely at the surface and bottom (points 7,8,10,13,15,16 and 19). BOT, depth, DO and total bacteria variables are also influenced by points 2,3,6,14,17,20, and 21 where these points cover the surface, middle, and bottom. Points 1,4,5 and 18 had little effect on the variables. Nitrate and phosphate variables are influenced by points 9, 11, and 12 where this point covers the middle and bottom of the water. Based on the results of PCA analysis data, nitrate and phosphate are influenced by points that cover the bottom of the water. This is reinforced by Rahman et al. (2016), that the increasing depth the higher the nitrate content. Generally, the surface waters have phytoplankton that utilize nutrients for growth rates. The higher the depth, the less the presence of phytoplankton and the less light penetration in the water. The results of analysis using the principal component analysis (PCA) are presented in Figure 5.

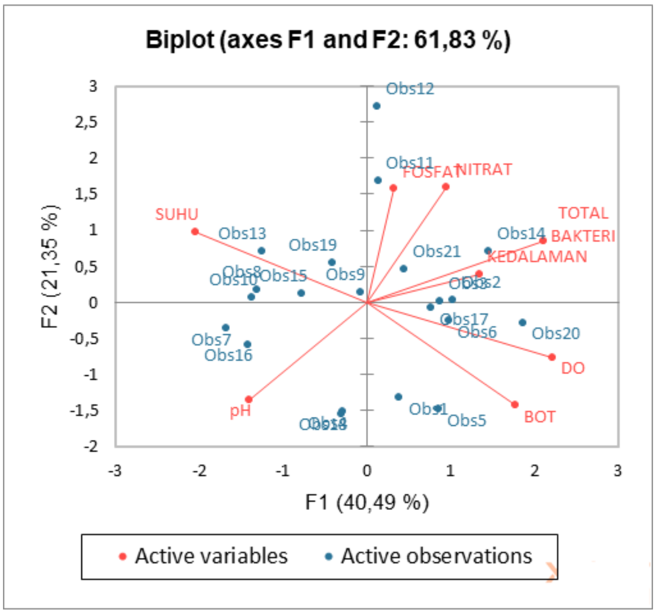

Figure 5. Principal Component Analysis (PCA)

Trophic Status

Based on the results of variable nitrate concentration levels in Jatibarang Reservoir and reviewed with literature from Vollenweider (1969) in Effendi (2003) contained in Table 2. for Jatibarang Reservoir waters, the fertility status is classified as oligotrophic-mesotrophic waters. According to Mustofa (2015), which states that nitrate can be used to classify the level of water fertility. A decrease in the quality and high fertility of water can adversely affect the productivity of water and the biota that live in it (Isnaeni et al., 2015).

Fertility status in water is strongly influenced by nutrient content (nitrate and phosphate). High fertility status in waters can be caused by environmental influences such as anthropogenic activities that cause household, fisheries, and agricultural waste to enter through inlets in waters so that they can pollute and reduce the quality of their waters (Syawal et al., 2022).

CONCLUSION

The results of research on Jatibarang Reservoir based on the variables of nitrate, phosphate, and total bacterial water quality are waters that can still support the life of aquatic organisms in it.

Jatibarang Reservoir's trophic status is classified as oligotrophic-hypertrophic waters adjusted to the measurement results of nitrate.

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