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Preliminary study of surface water quality based on DO and BOD_5 parameters in pangandaran reservoir

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ABSTRACT

Pangandaran Reservoir, located in Pangandaran Regency, West Java, serves as a water conservation facility and supports aquaculture activities. Its water quality, particularly in terms of dissolved oxygen (DO) and biochemical oxygen demand (BOD_5), is a key indicator for maintaining the reservoir's ecological and socio-economic functions. This study aims to analyze DO and BOD_5 parameters in Pangandaran Reservoir and evaluate their compliance with applicable water quality standards. Sampling was conducted in May 2025 at four stations representing both the inflow area and the inner reservoir waters. DO levels were measured using the Winkler titration method, while BOD_5 was determined based on the difference in DO concentrations before and after a five-day incubation period. The results showed that water temperatures ranged from 32 to 32.5°C, slightly exceeding the water quality threshold, likely due to high solar radiation and limited vegetation cover. The pH ranged from 7 to 9, which is still within the safe range, with higher pH values observed in the inflow area, influenced by the dominance of limestone (karst) formations in the surrounding Pangandaran region. The highest DO concentration was recorded at Station 4 (4.32 $mg. L^{-1}$), while the lowest was at Station 2 (3.40 $mg. L^{-1}$). Conversely, the highest BOD_5 values were found at Station 2 (8.3 $mg. L^{-1}$) and Station 1 (8 $mg. L^{-1}$). The spatial distribution pattern indicates a negative relationship between DO and BOD_5, where high organic pollutant loads in the inflow area reduce dissolved oxygen levels. Overall, the water quality of Pangandaran Reservoir falls within Class 2 to Class 4 based on Government Regulation No. 82 of 2001, with signs of declining quality in the inflow area. Therefore, pollution source control and routine monitoring are essential to preserve the aquatic ecosystem of the reservoir.

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INTRODUCTION

Reservoirs serve as one of the alternative water conservation infrastructures designed to store rainwater for supporting fisheries, irrigation, and environmental conservation activities (Azwarman, 2018; Saputra et al. 2022). In addition to functioning as water reserves, reservoirs also have the potential to develop into artificial aquatic ecosystems that support aquatic life. Therefore, water quality becomes a key factor in ensuring the ecological and socio-economic sustainability of these reservoirs (Dewi et al. 2020; Hanggara & Irvani, 2019). However, water quality in reservoirs can be threatened by the accumulation of organic matter originating from aquaculture activities, agricultural runoff, or natural materials, which can reduce the carrying capacity of aquatic ecosystems (Lutfiana, 2022; Sudarsono et al. 2024).

Pangandaran Reservoir, located in Pangandaran Regency, West Java, is one of the reservoirs built within the last decade with the primary functions of supporting aquaculture and water conservation. This reservoir plays a strategic role in improving the local economy and maintaining hydrological balance in the southern coastal area of West Java. Nevertheless, scientific data regarding the water quality status of this reservoir, particularly in terms of dissolved oxygen (DO) and biochemical oxygen demand (BOD), remain unavailable. These two parameters are recognized as essential indicators of aquatic ecosystem health.

DO reflects the availability of oxygen in the water, which is necessary to support aquatic life, while BOD indicates the organic matter load that must be decomposed by microorganisms (Salmin, 2005; Susilowati et al. 2018). Both parameters can be measured using iodometric titration or DO meters (Daroini & Arisandi, 2020; Habiba et al. 2021; Ilham et al. 2023; Salmin, 2005). DO and BOD concentrations are influenced by various factors, including population density, agricultural and livestock activities, and rainfall intensity (Susilowati et al. 2018). A BOD concentration below 3 mg. L^{-1} generally indicates unpolluted water conditions (Ilham et al. 2023). The application of wastewater treatment plants has been proven effective in reducing BOD concentrations in water bodies, as demonstrated by scenario analysis in the Ciliwung River (Budiman, 2010).

Another important parameter for monitoring the impact of organic pollution is five-day biochemical oxygen demand (BOD_5) (Habiba et al. 2021; Latif & Dickert, 2015). BOD_5 measures the amount of oxygen required by microorganisms to decompose biodegradable organic matter in water over a five-day incubation period at 20°C (Atima, 2015; Habiba et al. 2021). High BOD_5 values indicate a significant organic pollution load, which can reduce DO concentrations and negatively affect the survival of aquatic organisms. For example, in the Citarum River, elevated BOD levels have resulted in decreased DO concentrations, exceeding the river's carrying capacity and harming fish populations (Sugianti & Astuti, 2018).

Numerous studies have demonstrated that water bodies with BOD_5 values exceeding 3 mg. L^{-1} are generally under ecological stress due to organic pollution from various sources. For instance, in the Silugonggo River, residential and industrial activities have increased BOD_5 levels to 8.07–24.66 mg. L^{-1} and COD to 26.04–79.21 mg. L^{-1} (Hasibuan et al. 2021). Similarly, in the estuary of the Jajar River, high organic matter content has been recorded, with BOD_5 levels ranging from 1.33 to 5.89 mg. L^{-1} and COD from 85.97 to 177.00 mg. L^{-1} (Jubaedah et al. 2021). In the Cituis waters, excessive organic matter has triggered eutrophication processes, indicated by elevated nitrate and phosphate concentrations exceeding quality standards, even though BOD_5 and DO levels remain within acceptable limits (Simbolon, 2016). These findings highlight the importance of effective waste management and pollution control to maintain the balance of aquatic ecosystems.

To date, scientific information regarding the water quality conditions of Pangandaran Reservoir, particularly in terms of DO and BOD parameters, remains very limited. Therefore, this study was initiated to fill the knowledge gap concerning the aquatic ecosystem conditions of Pangandaran Reservoir. The objectives of this study are to analyze DO and BOD concentrations in Pangandaran Reservoir as indicators of water quality and to evaluate their compliance with applicable water quality standards. The results of this study are expected to provide baseline data to support the sustainable management and utilization of the reservoir.

MATERIAL AND METHODS

Study site. This study was conducted at Pangandaran Reservoir, located in Pangandaran Regency, West Java, which functions as a surface water storage facility for irrigation and conservation purposes. The research employed a descriptive-exploratory approach, focusing on the parameters of dissolved oxygen (DO), five-day biochemical oxygen demand (BOD_5), temperature, and pH. Sampling was conducted in May 2025 at four stations representing variations in aquatic characteristics both outside and inside the reservoir. The sampling locations are shown in Figure 1.

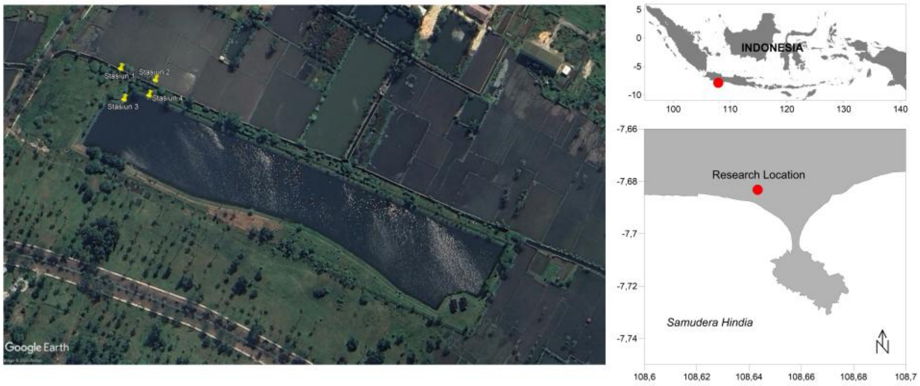

Figure 1. Study site and sampling locations at Pangandaran Reservoir

Stations 1 and 2 are located outside the reservoir, representing the inflow area with the potential to carry pollutants into the reservoir. Meanwhile, Stations 3 and 4 are located inside the reservoir, representing water conditions after the processes of retention, sedimentation, and biological activity. The combination of sampling points inside and outside the reservoir aims to evaluate the influence of inflowing water on water quality within the reservoir, as well as to observe changes in DO and BOD parameters.

Tools and Materials. This study utilized 100 mL Winkler/BOD bottles, measuring pipettes, drop pipettes, Erlenmeyer flasks, measuring cylinders, and a DO meter for field measurements. The chemical reagents used included manganese sulfate ($MnSO_4$) solution, alkaline azide iodide solution, concentrated sulfuric acid (H_2SO_4), 0.01 N sodium thiosulfate ($Na_2S_2O_3$) solution, and 1% starch indicator solution. Additionally, an incubator maintained at 20 ± 1°C was used for the 5-day incubation of water samples.

Sampling and Sample Preparation. The sampling was conducted using the grab sampling method with three replicates at each station to minimize data variability caused by natural fluctuations in water conditions (Virginia et al. 2020). Water samples were collected using Winkler/BOD bottles carefully to avoid air bubbles that could affect the accuracy of DO and BOD measurements. Samples were preserved by cooling and the addition of concentrated H_2SO_4 as a temporary preservative before laboratory analysis. The preparation followed the procedures outlined in SNI 6989.72:2009 (Pitalokasari et al. 2021; Rahman & Fajriati, 2021) to maintain the chemical stability of the water samples.

Dissolved Oxygen (DO) Measurement. DO was measured using the Winkler titration (iodometric) method, which is based on a redox reaction where dissolved oxygen oxidizes Mn^{2+} ions to form MnO_2 precipitate. The precipitate is then reacted with potassium iodide (KI) under acidic conditions to release iodine (I_2), which is subsequently titrated with sodium thiosulfate ($Na_2S_2O_3$) using starch as an indicator. The amount of iodine produced is equivalent to the concentration of dissolved oxygen in the water (Daroini & Arisandi, 2020; Hamzah et al. 2022; Ilham et al. 2023).

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Biochemical Oxygen Demand (BOD_5) Measurement. BOD_5 was measured to determine the biological oxygen demand over a 5-day incubation period. A high BOD_5 value indicates a significant organic matter load, which may suggest organic pollution in the water body.

Data analysis. The data on DO, BOD_5, temperature, and pH were analyzed descriptively using Microsoft Excel. The results were interpreted by referring to the Indonesian surface water quality standards (PP No. 82 of 2001). The DO and BOD_5 values were calculated using standard formulas based on SNI 6989.72:2009 2009 (Pitalokasari et al. 2021; Rahman & Fajriati, 2021) as follows:

$$\text{DO (mg. L}^{-1}) = \frac{\text{V thio x N thio x 1000 x 8}}{\text{V botol} - 2}$$

Explanation:

- Vthio = Volume of sodium thiosulfate titration solution used (mL)
- Nthio = Normality of sodium thiosulfate solution (N)
- 8 = Equivalent weight of oxygen (O_2)
- Vsampel = Volume of water sample used (mL), minus 2 mL for reagent correction

The BOD_5 value was calculated based on the difference in dissolved oxygen concentration before and after the 5-day incubation period using the following formula:

$$BOD_5 = DO_0 - DO_5$$

Explanation:

- BOD_5 = Biochemical oxygen demand over 5 days (mg. L^{-1})
- DO_0 = Dissolved oxygen concentration before incubation (mg. L^{-1})
- DO_5 = Dissolved oxygen concentration after 5 days of incubation (mg. L^{-1})

RESULTS AND DISCUSSION

Water quality measurements at Pangandaran Reservoir were conducted based on four key parameters: temperature, pH, dissolved oxygen (DO), and biochemical oxygen demand (BOD). Sampling was carried out at four stations representing the aquatic characteristics surrounding the reservoir (Table 1), namely: the left river inflow (Station 1), the right river inflow connected to the reservoir gate (Station 2), the water body inside the reservoir (Station 3), and the inlet stream area of the reservoir (Station 4).

Table 1. Average water quality measurement results at Pangandaran Reservoir compared to water quality standards based on Government Regulation No. 82 of 2001

Parameter	**Unit**	**Water Standard***		**Quality**	**Average Measurement Results**			
					St.1	**St.2**	**St.3**	**St.4**
Temperature	C		28 - 32		32	32.5	32.5	32.5
pH	-		6 - 9		9	8.5	8.5	8.75
Dissolved Oxygen (DO)	mg. L^{-1}	Class 4 3	Class 3 4	Class 2 6	4.05	3,40	4.21	4.32
Biochemical Oxygen Demand (BOD 5)	mg. L^{-1}	Class 4 12	Class 3 6	Class 2 3	8	8.3	5.4	6.2

(*): Water Quality Standard based on Government Regulation No. 82 of 2001.

The results of water quality measurements revealed that water temperature at all stations ranged from 32 to 32.5°C, slightly exceeding the quality standard threshold for surface water temperature, which is 28 to 32°C (Water Quality Standard based on Government Regulation No. 82 of 2001). This condition may be influenced by high solar radiation intensity, limited vegetation cover around the reservoir, and the geographic location of Pangandaran Reservoir, which is situated in a lowland coastal area. These factors align with previous studies, which

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state that temperature distribution in coastal waters is significantly affected by water depth and solar radiation intensity, where shallow areas tend to have higher temperatures, especially during midday when solar radiation reaches its peak (Deqita & Sudarti, 2022; Sidabutara et al. 2019). This temperature increase requires serious attention, as temperature is one of the key parameters influencing water quality and the balance of aquatic ecosystems, including dissolved oxygen (DO) availability. Elevated temperatures can reduce oxygen solubility in water, potentially disrupting the physiological processes of aquatic organisms, including fish and plankton, and ultimately lowering fisheries productivity (Deqita & Sudarti, 2022; Sidabutara et al. 2019). This is consistent with findings from marine ecosystems, which demonstrate that temperature, along with salinity, pH, and DO, are crucial parameters that should be regularly monitored to maintain water quality and support the survival of aquatic biota (Corvianawatie & Abrar, 2018; Patty & Akbar, 2018). Therefore, although the temperature in Pangandaran Reservoir is still relatively close to the standard threshold, the tendency of temperature increase due to local environmental factors indicates the need for regular monitoring and mitigation efforts, such as planting vegetation cover to maintain water quality stability and prevent ecological disturbances in the aquatic ecosystem.

The pH parameter at all observation stations remained within the standard water quality range (6–9); however, pH values at Station 1, which represents the left river inflow, were slightly higher. This can be associated with the geological characteristics and surrounding environmental conditions. Although the values remain within the neutral to alkaline range, the tendency of higher pH approaching the upper limit may be influenced by the geological characteristics of the Pangandaran area, where limestone or karst formations are dominant (Musyaffa et al. 2005; Nazir et al. 2017). The dissolution of carbonate minerals such as calcium carbonate ($CaCO_3$) from limestone carried by river flows can increase water alkalinity and pH (Metboki & Lake, 2018).

DO measurements showed variations among stations. The highest DO concentration was recorded at Station 4 (4.32 mg. L^{-1}), while the lowest was at Station 2 (3.40 mg. L^{-1}). According to water quality standards, DO levels at Stations 1, 3, and 4 fall within Class 3 to Class 4, while Station 2 is precisely at the Class 3 threshold (≥3 mg. L^{-1}). The relatively low DO concentration at Station 2 is suspected to be due to high organic pollutant loads entering the reservoir through external inflow. This location likely receives organic waste inflows or experiences organic matter decomposition from surrounding areas, contributing to reduced DO levels (Harianja et al. 2018). Conversely, the increased DO levels at Stations 3 and 4 indicate water quality improvement within the reservoir, supported by photosynthesis by autotrophic organisms and organic matter sedimentation processes.

The BOD_5 parameter at all observation points still meets the standard for Class 4, but most fail to meet the stricter standards for Class 3 and Class 2. The highest BOD value was observed at Station 2 (reservoir inlet), reaching 8.3 mg. L^{-1}, indicating the possibility of organic matter accumulation before the water enters the reservoir. This condition may be influenced by the relatively stagnant characteristics of the reservoir's water, allowing organic matter to settle. Additionally, a relatively high BOD concentration was also detected at Station 1, the left river inflow to the reservoir, reaching 8.0 mg. L^{-1}, indicating potential organic matter inputs from upstream, possibly originating from domestic activities, agriculture, or other pollutant sources. The high BOD levels at both stations are consistent with the natural dynamics of river and reservoir ecosystems, where organic matter tends to accumulate in slow-flowing or stagnant areas. Sedimentation processes in water bodies such as rivers and reservoirs not only function to settle suspended particles but also contribute to BOD reduction through organic matter decomposition at the bottom sediments (Niemistö et al. 2016; Roider et al. 2004; Toprak, 1994). However, if the organic matter input exceeds the water body's capacity to decompose or settle it, BOD levels remain high, as observed in this study. Such conditions can lead to decreased DO levels and negatively impact the quality of the aquatic ecosystem.

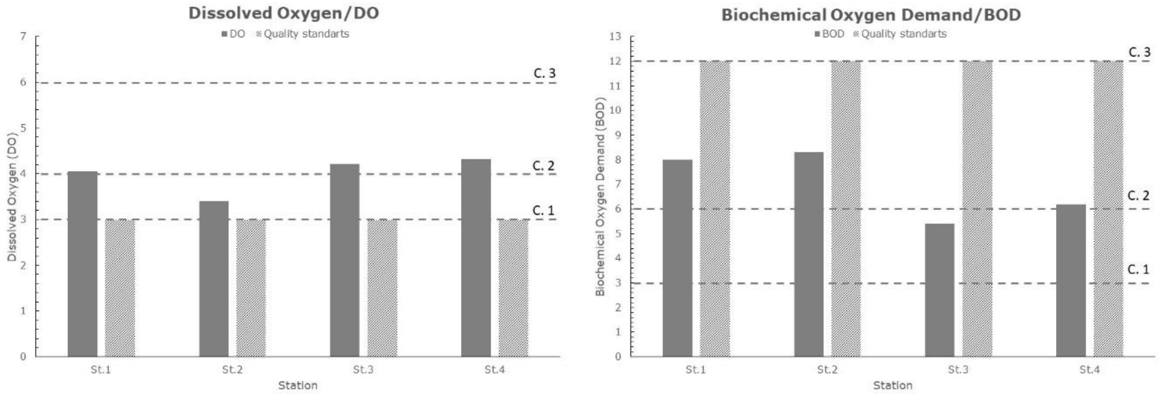

Figure 2. Concentrations of DO and BOD_5 at Pangandaran Reservoir compared to water quality standards based on Government Regulation No. 82 of 2001.

The data visualization in Figure 2 clearly illustrates the distribution patterns of DO and BOD_5 across stations. It is evident that the tendency for lower DO levels corresponds with higher BOD_5 values, indicating a negative relationship between these two parameters (Adis & AR, 2021; Budiman, 2010). High BOD_5 values reflect increased oxygen demand by microorganisms to decompose organic matter in the water, which consequently reduces dissolved oxygen concentrations (Daroini & Arisandi, 2020; Muslim et al. 2020).

In general, the results of this study show that the water quality at Pangandaran Reservoir falls within Class 2 to Class 4, based on DO and BOD_5 parameters. This condition indicates that the reservoir is still suitable for fish farming, recreational activities, and irrigation. However, there is a potential decline in water quality due to organic pollutant loads, particularly in the inflow area and certain sections within the reservoir. Therefore, appropriate management measures are necessary, such as controlling pollutant sources from incoming flows and conducting regular water quality monitoring to maintain the ecological and socio-economic functions of the reservoir.

CONCLUSION

This study indicates that the water quality in Pangandaran Reservoir generally falls within Class 2 to Class 4 based on dissolved oxygen (DO) and biochemical oxygen demand (BOD_5) parameters. The temperature and pH levels of the water remain relatively within acceptable standards, although there is a tendency for increased temperature and pH in certain areas due to environmental factors and the geological characteristics of the region. The lowest DO concentration and highest BOD_5 values were found in the inflow area (Stations 2 and 1), indicating a significant organic pollutant load from outside the reservoir. The negative correlation between DO and BOD_5 emphasizes the importance of controlling pollutant sources, particularly from river inflows, to prevent further deterioration of water quality. Integrated management efforts, including pollution control, vegetation planting to provide shade, and regular water quality monitoring, are essential to maintain the ecological and socio-economic sustainability of Pangandaran Reservoir.

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