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## The psychological impact of river water quality on communities: An analysis of lead (Pb), BOD, and COD levels

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### Abstract

**Background:** River water quality is influenced by various pollutants, particularly organic and chemical contaminants resulting from anthropogenic activities. In rural and peri-urban areas, domestic waste is a major contributor to the decline in water quality, which may pose risks to environmental and public health.

**Purpose:** To analyze river water quality based on lead (Pb), Biological Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) parameters, and to identify the psychological impacts on communities living along the river.

**Method:** A quantitative descriptive study with an observational approach was conducted using the grab sampling method. Water samples were collected from three points representing upstream, midstream, and downstream sections. Laboratory analyses were performed, and the results were compared with the water quality standards established by Government Regulation of the Republic of Indonesia No. 22 of 2021. The study was carried out from November to December 2025.

**Results:** BOD values at all sampling points (7 mg/L upstream, 12 mg/L midstream, and 6 mg/L downstream) exceeded the permissible limits, indicating non-compliance with water quality standards. In contrast, COD values ranged from 7 to 8 mg/L across all points and remained within acceptable limits. Pb concentrations ranged from 0.001 to 0.006 mg/L, which were also below the regulatory threshold.

**Conclusion:** The findings indicate that the deterioration of water quality in the Sawangan River is primarily driven by organic pollution rather than chemical or heavy metal contamination. These results highlight the need for improved domestic waste management and continuous monitoring to maintain river water quality.

**Keywords:** Biochemical Oxygen Demand (BOD); Chemical Oxygen Demand (COD); Lead (Pb); Organic Pollution; River Water Quality.

### INTRODUCTION

River water quality is strongly influenced by various physical, chemical, and biological parameters that serve as indicators of pollution levels. The Government of Indonesia has established water quality standards through Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Environmental Protection and Management. This regulation stipulates that each water body is classified according to its designated use, which is assessed based on chemical parameters such as heavy metal concentrations,

including lead (Pb), as well as organic parameters such as Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). According to Appendix VI of Government Regulation No. 22 of 2021, the water quality standards for Class II waters designated for water recreation, freshwater aquaculture, livestock, agriculture, and raw water sources for drinking water after treatment are a maximum lead (Pb) concentration of 0.03 mg/L, BOD of 3 mg/L, and COD of 25 mg/L.

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Rivers represent a form of open aquatic ecosystems that are highly vulnerable to pollution (Karubuy, Manan, Manangkalangi, Sembel, & Saleky, 2023). Contamination in river systems is generally influenced by environmental conditions and anthropogenic activities occurring in surrounding areas. Aquatic environments consist of biotic components (living factors influencing the environment) and abiotic components (non-living factors influencing the environment), which interact through energy flow and nutrient cycling, such as from soil to plants, from plants to animals, and back to the soil (Palar, 2022). These processes are essential for maintaining ecosystem balance and supporting the survival of organisms. Disruptions in these interactions may lead to ecological imbalance and degradation of aquatic ecosystems (Aprilia & Zunggaval, 2019; Rafi'i & Maulana, 2018). Lead (Pb) is a toxic heavy metal commonly originating from industrial waste, battery manufacturing, paint residues, and urban runoff carrying vehicular metal particles. Additionally, domestic waste disposal involving lead-based materials, such as pipes and paints, may contribute to further contamination. Once introduced into water bodies, lead can cause ecosystem degradation and pose significant health risks to humans, including neurological disorders, kidney dysfunction, and impaired brain development in children (Soukotta, Ozsaer, & Latuamury, 2019).

High Biological Oxygen Demand (BOD) values indicate elevated levels of organic matter in water. The higher the BOD value, the greater the concentration of biodegradable organic substances, which are typically derived from domestic waste such as wastewater from washing, detergents, food residues, and human or animal waste. Agricultural and livestock activities also contribute to increased organic loads, particularly through organic fertilizers and animal manure that are transported into rivers by surface runoff (Kurniati, 2023). Community activities such as bathing, washing, and direct disposal of waste into rivers further accelerate the accumulation of organic matter (Effendi, 2021). Similarly, high Chemical Oxygen Demand (COD) values reflect the presence of chemical pollutants that are resistant to biological degradation, including detergents, pesticides, oils, and industrial chemicals. Agricultural and plantation activities that utilize chemical fertilizers

and pesticides may also elevate COD levels due to chemical residues being carried into rivers through rainfall runoff (Kusuma, Supriyanti, & Munasik, 2022). Domestic activities significantly contribute to increased biological oxygen demand and overall water pollution. The physical quality of water can be assessed through indicators such as taste, odor, color, turbidity, and total dissolved solids (TDS) (Tumanduk, Naharia, Sumampouw, Ogi, Gedoan, & Mokosuli, 2024). Dissolved solids typically consist of organic substances, inorganic salts, and dissolved gases. An increase in total dissolved solids may lead to higher water hardness, primarily due to elevated concentrations of calcium and magnesium ions, which can have adverse health effects. Water turbidity is caused by suspended solids, both organic and inorganic. Inorganic substances may originate from soil particles, plant debris, or industrial waste, while organic substances can serve as nutrients for bacterial growth, thereby promoting microbial proliferation and increasing turbidity. Turbid water is more difficult to disinfect because microorganisms may be protected by suspended particles, potentially increasing the risk of pathogenic contamination and adverse health impacts (Putra, Adyatma, & Normlenai, 2016).

Based on preliminary observations, Sawangan Village in Tombulu District is one of the areas located near a river, characterized by dense settlements and intensive community activities in close proximity to the water body (Puspitasari, 2019). These activities include washing clothes, disposing of domestic waste, and agricultural practices, all of which serve as potential indicators of pollution that may directly affect public health. The local community relies on river water for daily activities such as bathing and washing. However, the actual quality of the river water in this area has not yet been clearly determined (Olivianti, Abidjulu, & Koleangan, 2016).

## RESEARCH METHOD

A quantitative descriptive design with an observational approach to assess river water quality in Sawangan Village, Tombulu District, Minahasa Regency, North Sulawesi, Indonesia. Water samples were collected using the grab sampling method and analyzed in the laboratory to determine lead (Pb), Biochemical Oxygen Demand (BOD), and Chemical

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Oxygen Demand (COD). The study was conducted from November to December 2025, with laboratory analysis performed at the Public Health Laboratory Center in Manado. The study population comprised the entire stretch of the Sawangan River from upstream to downstream. Samples were collected at three,

Data were analyzed using descriptive and comparative statistical approaches. The measured concentrations of Pb, BOD, and COD were summarized as mean, minimum, and maximum values for each sampling point (upstream, midstream,

and downstream). The results were then compared with the water quality standards established by Government Regulation of the Republic of Indonesia No. 22 of 2021 to determine compliance status. To examine spatial variations in water quality parameters among sampling points, the data were analyzed using one-way analysis of variance (ANOVA). When the data did not meet normality assumptions, a non-parametric alternative (Kruskal–Wallis test) was applied. Statistical significance was determined at a 95% confidence level ( $p < 0.05$ ). All analyses were performed using appropriate statistical software.

## RESEARCH RESULTS

**Table 1. Water Sampling in River Water**

| Sampling Point                         | Unit | Measured Value | Standard Limit | Status        |
|----------------------------------------|------|----------------|----------------|---------------|
| <b>Lead (Pb) Concentration</b>         |      |                |                |               |
| Upstream                               | mg/L | 0.001          | 0.03           | Compliant     |
| Midstream                              | mg/L | 0.001          | 0.03           | Compliant     |
| Downstream                             | mg/L | 0.003          | 0.03           | Compliant     |
| <b>Biochemical Oxygen Demand (BOD)</b> |      |                |                |               |
| Upstream                               | mg/L | 7              | 3              | Non-compliant |
| Midstream                              | mg/L | 12             | 3              | Non-compliant |
| Downstream                             | mg/L | 6              | 3              | Non-compliant |
| <b>Chemical Oxygen Demand (COD)</b>    |      |                |                |               |
| Upstream                               | mg/L | 7              | 25             | Compliant     |
| Midstream                              | mg/L | 8              | 25             | Compliant     |
| Downstream                             | mg/L | 8              | 25             | Compliant     |

\*Note: Compliant = meets water quality standard; Non-compliant = exceeds water quality standards; Compliant = meets water quality standards.

The results indicate that Pb concentrations at all sampling points were well below the permissible limit of 0.03 mg/L. The measured values were 0.001 mg/L at both upstream and midstream locations, and 0.003 mg/L at the downstream location. All samples met the established water quality standards, suggesting that the Sawangan River was not significantly contaminated by lead during the study period. The BOD values at all sampling points exceeded the permissible limit of 3 mg/L, with recorded concentrations of 7 mg/L at the upstream, 12 mg/L at the midstream, and 6 mg/L at the downstream. These findings indicate that the river water does not meet the established water quality standards for BOD. The

elevated BOD levels suggest a high concentration of biodegradable organic matter, likely originating from domestic waste and surrounding anthropogenic activities. The COD values at all sampling points were below the permissible limit of 25 mg/L, with concentrations of 7 mg/L at the upstream, 8 mg/L at the midstream, and 8 mg/L at the downstream. These results indicate that the river water meets the established water quality standards for COD, suggesting relatively low levels of chemically oxidizable pollutants.

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## DISCUSSION

Water sampling was conducted at three representative points (upstream, midstream, and downstream) to capture spatial variations in water quality along the river continuum (Wasir, 2023). This approach allows for the identification of potential pollution sources and the influence of anthropogenic activities on river water quality. The analyzed parameters included Pb, BOD, and COD, which were evaluated against the standards set by Government Regulation of the Republic of Indonesia No. 22 of 2021.

The upstream section, which is relatively less influenced by intensive human activity, already exhibited elevated BOD levels (7 mg/L), exceeding the permissible limit (Amelia, Effendi, Kurniawan, Andrianto, & Ahmady, 2025). This finding suggests that organic inputs are present even in the upper stream, likely originating from agricultural runoff, livestock activities, and natural organic matter transported via surface flow. In contrast, COD (7 mg/L) and Pb (0.001 mg/L) remained within acceptable limits, indicating that pollution in this section is primarily organic rather than chemical or heavy metal-based (Habiba, Sari, Budiono, & Kusuma, 2021).

The midstream section, characterized by dense residential activity, showed the highest BOD value (12 mg/L), reflecting substantial organic pollution (Budiastuti, Rahadjo, & Dewanti, 2016). This condition strongly indicates that domestic wastewater is the main contributor to the organic load in the river. Despite this, COD (8 mg/L) and Pb (0.001 mg/L) values remained within regulatory limits, suggesting that the pollutants are predominantly biodegradable organic substances rather than persistent chemical contaminants (Munfarida, Navratilova, & Oktorina, 2025).

At the downstream section, BOD levels decreased to 6 mg/L but still exceeded the standard, indicating partial natural attenuation through dilution and biodegradation processes along the river flow. COD remained stable at 8 mg/L, while Pb concentration increased slightly compared to upstream and midstream levels. This pattern suggests a tendency for cumulative input of heavy metals along the river, likely due to runoff from residential areas and surrounding land use. However, Pb levels remained

below the regulatory threshold, indicating no significant heavy metal contamination at the time of the study (Rahmawati, Yuliana, Ricih, Rusmiyati, & Susanti, 2022).

The consistently low Pb concentrations across all sampling points indicate minimal influence from industrial or mining activities. However, the slight increase downstream highlights the potential for gradual accumulation of heavy metals, which warrants continuous monitoring due to their toxic and bioaccumulative nature (Atima, 2018).

In contrast, the elevated BOD values across all sampling points clearly indicate significant organic pollution. High BOD reflects increased microbial activity requiring oxygen to decompose organic matter, which may reduce dissolved oxygen levels and adversely affect aquatic organisms (American Public Health Association, 2017). This condition is commonly associated with domestic waste inputs such as food residues, detergents, and untreated wastewater. Similar findings have been reported in other river systems in North Sulawesi, where domestic activities significantly contribute to increased BOD levels (Tilaar, 2024).

Interestingly, COD values remained within acceptable limits despite high BOD levels (Imelda, Saadah, Maidianti, Aritama, & Nofianti, 2023). This suggests that the organic pollutants present are largely biodegradable and not dominated by chemically resistant compounds. Such a pattern is typical in rivers impacted primarily by domestic waste rather than industrial effluents, where COD values are usually elevated (Ramadhani, Anna, & Cholil, 2016).

Overall, the findings indicate more affected by organic pollution than by chemical or heavy metal contamination. While Pb and COD parameters meet water quality standards, the consistently high BOD values highlight significant environmental pressure from domestic activities. Therefore, improving domestic waste management, increasing community awareness, and implementing regular water quality monitoring are essential to maintain the ecological sustainability of the river (Ilham, Masri, & Rosmah, 2023).

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## CONCLUSION

Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and lead (Pb) parameters, it can be concluded that Pb concentrations at all sampling points (0.001 mg/L upstream, 0.001 mg/L midstream, and 0.006 mg/L downstream) remained below the regulatory threshold, indicating no significant heavy metal contamination. In contrast, BOD values at all locations (7 mg/L, 12 mg/L, and 6 mg/L, respectively) exceeded the established water quality standards, reflecting considerable organic pollution along the river. Meanwhile, COD values (7–8 mg/L) were within acceptable limits, suggesting low levels of chemically resistant pollutants. Overall, the decline in water quality is primarily driven by organic pollution rather than chemical or heavy metal contamination.

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