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Research Paper

Analysis of Water Pollution Levels in Batang Masumai River, Merangin Regency, Jambi Province

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Abstract
Water pollution is a pressing environmental issue that adversely affects aquatic ecosystems and the usability of water resources. The Batang Masumai River, located in Merangin Regency, Jambi Province, is an essential water source for local communities but faces escalating pollution challenges due to industrial, agricultural, and residential activities. This study analyzes the pollution levels of the Batang Masumai River by assessing seven key parameters: temperature, pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD). A quantitative observational approach was employed, utilizing secondary data collected from 2021 to 2024. The results were evaluated against Class II water quality standards as stipulated in Government Regulation Number 22 of 2021. The findings indicate that while parameters such as temperature and pH generally adhered to acceptable standards, others, notably TSS, BOD, and COD, frequently exceeded the regulatory limits, particularly in 2021. This suggests substantial pollution stemming from untreated wastewater and soil erosion. Although improvements were observed in subsequent years, several parameters remained problematic, posing ongoing risks to aquatic ecosystems and water resource sustainability. These findings underscore the urgent need for enhanced wastewater treatment systems, stricter enforcement of environmental regulations, and the adoption of sustainable watershed management practices to restore and safeguard the ecological health of the river.

Keywords
Water Pollution, Water Quality, Environmental Management, Aquatic Ecosystems

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1. INTRODUCTION

Water pollution has become one of the most pressing environmental issues globally. Water, as a vital natural resource essential for the survival of humans, animals, and plants, is increasingly endangered by various human activities lacking environmental awareness (Rahmawati and Puspitaningrum, 2022). Rivers, as a key component of the water cycle, play a crucial role in maintaining ecological balance while offering significant social and economic benefits. However, anthropogenic activities such as improper waste disposal and industrial discharges have profoundly degraded river ecosystems, jeopardizing their sustainability. Kamalia and Sudarti (2022) argue that safeguarding rivers is essential not only to preserve their ecological integrity but also to ensure their long-term functionality as sustainable water sources.

Addressing the escalating problem of river pollution requires coordinated efforts to harmonize environmental conservation with human development. Effective waste management systems, increased public awareness of the importance of water conservation, and strict enforcement of environmental regulations are critical steps in preventing pollution and mitigating harm to river ecosystems. Kamalia and Sudarti (2022) emphasize that sustaining water resources demands consistent efforts to use them responsibly and protect them from contamination. By adopting sustainable practices, it is possible to preserve the ecological, social, and economic functions of rivers, ensuring their benefits remain accessible for current and future generations without compromising their natural ecosystems (Jha et al., 2020).

In Indonesia, water pollution is a pressing environmental concern. Many rivers, which serve as the primary water sources for the population, have been heavily contaminated by household, industrial, and agricultural waste. According to data from the Ministry of Environment and Forestry

(KLHK), over 70% of rivers in Indonesia are polluted. These rivers can no longer sustain healthy ecosystems and have directly impacted communities that depend on river water for their daily needs (Rakhmawati, 2024). A significant contributor to this pollution is industrial activity, as many industries discharge untreated liquid waste into water bodies without adhering to environmental standards. This waste often contains hazardous substances, such as heavy metals, which damage aquatic ecosystems and pose severe risks to human health (Pradani et al., 2024).

River water pollution stems from various waste types, including organic waste, household garbage, and hazardous industrial waste. Furthermore, groundwater in many areas is unsafe for consumption, as it is contaminated by seepage from septic tanks or polluted surface water (Kumar et al., 2020). Water pollution not only harms the environment but also poses significant risks to public health (Chabuk et al., 2020). Communities living near polluted rivers and relying on river water for daily activities such as bathing, washing, or cooking often suffer from various health problems. Among the most prevalent illnesses linked to water pollution is diarrhea, which remains a leading cause of mortality among children under the age of five in developing countries (Elvania, 2022). One of the rivers experiencing severe pollution in Indonesia is the Batang Masumai River, located in Merangin Regency, Jambi Province. This river serves as a vital water source for thousands of residents along its banks, supporting domestic and agricultural needs. Despite its importance, the water quality of the Batang Masumai River has significantly declined in recent decades due to increasing levels of pollution. Domestic and industrial waste are the main contributors to this deterioration, directly affecting public health in the region (Aydin et al., 2021).

Water pollution is a pressing global concern, particularly in developing countries where industrial, agricultural, and residential activities often lack proper environmental management (Anwar et al., 2021). Rivers play a critical role in maintaining ecological balance, providing water for domestic use, agriculture, and industry, yet they are increasingly threatened by pollution (Kiran et al., 2023). Recent studies emphasize the importance of sustainable water resource management to mitigate the effects of pollution on both the environment and public health (Siddique, 2024). This research focuses on the Batang Masumai River in Jambi Province, Indonesia, a vital water source for local communities, which faces escalating pollution levels. The novelty of this study lies in its integration of long-term water quality analysis (2021–2024) and its use of a pollution index method to provide a comprehensive assessment of the river's ecological health and pollution control efforts. Additionally, this study compares local water quality standards with international benchmarks, offering insights into policy alignment and intervention priorities.

The Batang Masumai River originates upstream in Kelumpang Hamlet, located in Sungai Manau Subdistrict, flows

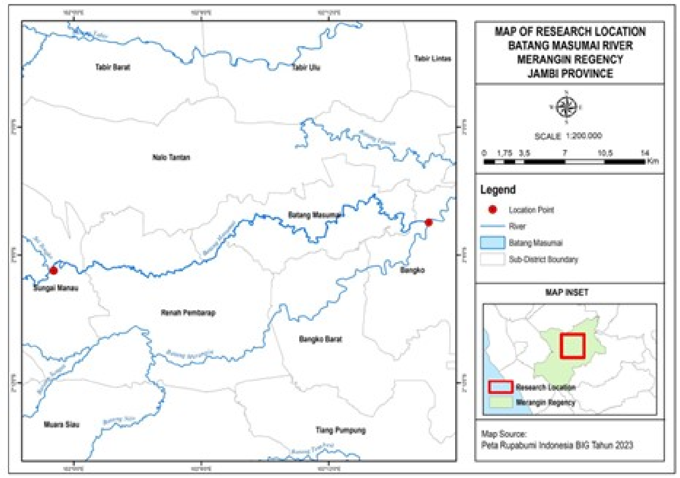

Figure 1. Sampling Location in the Batang Masumai River

through the midstream area in Salam Buku Village, Batang Masumai Subdistrict, and ends downstream in Pasar Atas Urban Village, Bangko Subdistrict (Figure 1). This approximately 100-kilometer-long river, a tributary of the larger Merangin River, is crucial for the livelihoods of local communities and the regional water network. However, increasing pollution has raised concerns about its ecological sustainability.

This study evaluates river water quality and investigates efforts to control water pollution by analyzing seven key parameters: temperature, pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), and Biochemical Oxygen Demand (BOD) (Wu et al., 2021). The results are compared against Class II water quality standards as outlined in Government Regulation Number 22 of 2021 on Water Quality Management and Water Pollution Control (Ewaid et al., 2020), and international standards from the EPA and WHO. This study focuses on assessing water quality and reviewing pollution control measures in the Batang Masumai River, located in Merangin Regency, Jambi Province with the determination of sampling points presented in Table 1. The research aims to assess water quality trends, identify key pollution sources, and provide actionable recommendations to enhance water management in the Batang Masumai River.

2. EXPERIMENTAL SECTION

2.1 Research Design

This study adopts an observational research design using a quantitative analytical approach. The data utilized in this research covers the period from 2021 to 2024 and comprises secondary data on the water quality of the Batang Masumai River, located in Merangin Regency, Jambi Province. Sampling locations were strategically selected along the ±100-kilometer stretch of the river, focusing on areas influ-

Table 1. Determination of Sampling Points in the Batang Masumai River, Merangin Regency, Jambi Province

Year	Location	Coordinates	Description
2021	Perentak Village, Pangkalan Jambu District	101°55'45.22" E - 02°08'09.75" S	Upstream
2022	Lower Bangko Market, Batang Masumai Bridge	102°04'25.66" E - 02°16'27.11" S	Downstream
2023	Lower Bangko Market, Batang Masumai Bridge	102°04'25.66" E - 02°16'27.11" S	Downstream
2024	Kelupang Village, Manau River District	101°59'45.086" E - 02°06'443" S	Upstream

enced by pollution sources entering the Batang Masumai River. This process identified seven specific sampling points to provide a comprehensive analysis of the river's water quality across its length (Creswell, 2016).

The study evaluates primary data on the Batang Masumai River's water quality by measuring seven key parameters: temperature, pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD). These parameters were monitored over a four-year period (2021–2024) and compared against Class II water quality standards specified in Government Regulation Number 22 of 2021 on Water Quality Management and Water Pollution Control. The comparison aims to assess the river's compliance with regulatory benchmarks and to identify significant deviations (Mubarok, 2025).

To provide a comprehensive understanding of pollution trends, the water pollution quality index for the Batang Masumai River was calculated over the four-year period using the methodology outlined in the Decree of the State Minister for the Environment Number 115 of 2003. This index offers an integrated assessment of the river's water quality status, incorporating both natural and anthropogenic factors contributing to the observed pollution levels. The study aims to identify patterns and changes in the river's water quality and their implications for environmental sustainability and public health.

Through this detailed analysis, the research evaluates historical water quality data while emphasizing critical concerns related to pollution control and water resource management (Creswell and Creswell, 2018). The findings are intended to inform key stakeholders, including policymakers and local communities, about the current condition of the Batang Masumai River. Additionally, the study provides actionable recommendations for improving water quality and mitigating the impacts of pollution to ensure the river's sustainability for future generations.

2.2 Water Pollution Quality Index

The river water quality was evaluated through laboratory testing of seven parameters using methods based on Indonesian National Standards (SNI), including Temperature (SNI 06-6989.23:2005), pH (SNI 6989.11:2019), Total Dissolved Solids (TDS) (SNI 06-6989.27:2019), Total Suspended Solids (TSS) (SNI 06-6989.3:2019), Dissolved Oxygen (DO) (SNI 06-6989.14:2004), Biochemical Oxygen Demand (BOD) (SNI 6989.72:2009), and Chemical Oxygen Demand (COD) (SNI 6989.2:2019).

2.3 Water Quality Test Results

The results of the water quality analysis for the Batang Masumai River from 2021 to 2024 were evaluated against Class II water quality criteria as specified in the Appendix to Government Regulation Number 22 of 2021 on Water Quality Management and Water Pollution Control. Additionally, the analysis was compared with the 2022 standards established by the Environmental Protection Agency (EPA) and the World Health Organization (WHO). The water pollution quality index for the Batang Masumai River was calculated using the pollution index method, wherein the measured parameters were compared to the applicable water quality standards, specifically the environmental quality standards for aquatic ecosystems.

2.4 Pollution Index Calculation

The calculated pollution index is then analyzed to determine the pollution level and water quality status based on the Decree of the Minister of Environment Number 115 of 2003 on Guidelines for Determining Water Quality Status. The evaluation of the water pollution index considers the concentration of various water quality parameters. This formula is widely used in water quality monitoring methods in Indonesia, particularly in the Water Quality Monitoring System (SPQA), which refers to the Decree of the State Minister of Environment No. 115 of 2003. Basic formula for the Water Pollution Index (WPI) in Equation (1).

$$IPA = \sqrt{\frac{Ci}{Li}^2_M + \frac{Ci}{Li}^2_R} \tag{1}$$

The Water Pollution Index (WPI) is calculated using the ratios of actual pollutant concentrations (Ci) to the corresponding environmental quality standards (Li) set by applicable regulations. For parameters exceeding the threshold, the maximum ratio $(Ci/Li)M$ is used, while for parameters below the threshold, the average ratio $(Ci/Li)R$ is considered. The WPI is then assessed against specific criteria: a WPI value of ≤ 1 indicates good water quality (not polluted), values between 1 and 5 signify lightly polluted water, values between 5 and 10 indicate moderately polluted water, and a WPI greater than 10 reflects heavily polluted water. This approach provides a comprehensive evaluation of water quality by integrating both exceedances and compliance with environmental standards.

3. RESULT AND DISCUSSION

The results presented in Table 2 reveal significant variations in the water quality parameters of the Batang Masumai River from 2021 to 2024 when compared to the water quality standards specified in Government Regulation Number 22 of 2021, as well as the EPA and WHO standards from 2022. Most parameters, such as temperature, pH, and Total Dissolved Solids (TDS), remained within acceptable limits throughout the four-year period. However, Total Suspended Solids (TSS) values in 2021 (4956 mg/L) and 2024 (557 mg/L) significantly exceeded the permissible limits, indicating severe sedimentation or pollution from solid waste. Dissolved Oxygen (DO) levels improved over the study period, meeting EPA and WHO standards (≥ 5 mg/L) by 2024. Conversely, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were alarmingly high in 2021, suggesting substantial organic pollution at the time. However, these parameters showed notable improvement in subsequent years, aligning more closely with regulatory standards. This trend indicates progress in water quality management but highlights the need for ongoing monitoring and strengthened pollution control measures, particularly to address persistent issues with TSS and occasional deviations in COD levels.

3.1 Temperature

Compared to Class II water quality standards as stipulated in Government Regulation Number 22 of 2021, as well as EPA and WHO standards, any deviation from natural conditions indicates that the river water quality in 2021, with a temperature reaching 31°C, exceeded the allowable water quality standards for its designated use. An increase in water temperature leads to higher viscosity, enhanced chemical reactions, evaporation, and volatilization. It also reduces the solubility of gases in water and increases the metabolic and respiration rates of aquatic organisms (Wikurendra et al., 2022). Industrial, agricultural, and residential waste discharged directly into the Batang Masumai River, including liquid waste with elevated temperatures, poses a threat to the aquatic life in the river.

Temperature measurements in 2022, 2023, and 2024 showed values ranging from 26–27°C, indicating that wastewater temperature did not significantly impact river water quality during these years (Sharma et al., 2020). The temperature parameter remained within the acceptable limits set by Government Regulation Number 82 of 2001 on Water Quality Management and Water Pollution Control. The optimal temperature range for phytoplankton growth in aquatic environments is 20–30°C (Xu et al., 2022).

Figure 2 illustrates the test results for the water temperature parameters of the Batang Masumai River from 2021 to 2024, compared against the maximum temperature quality standard (32°C). In 2021, the water temperature reached 31°C, approaching the maximum threshold, which indicates a significant deviation from the natural state of the river. This high temperature could be attributed to the discharge of industrial and domestic waste with elevated temperatures, which not only alters the physical properties of the water but also has potential ecological consequences. Elevated temperatures increase evaporation, reduce the solubility of gases, and accelerate the metabolic rates of aquatic organisms, potentially leading to ecological stress. However, the subsequent years, 2022 and 2023, show a notable decrease in water temperature to 26–27°C, reflecting values within the permissible limits for Class II water quality standards, suggesting a reduced impact of thermal pollution during this period.

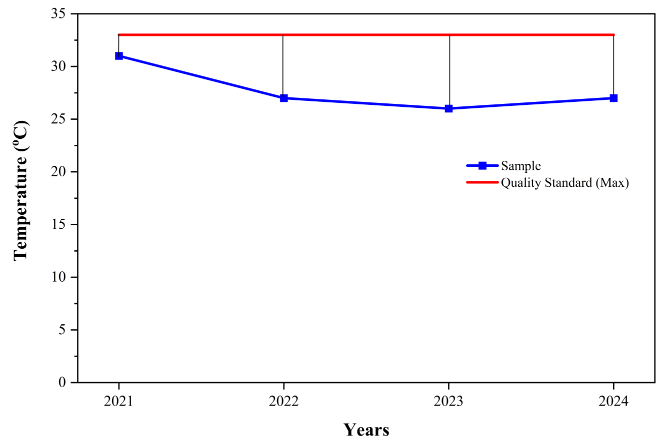

Figure 2. Test Results for Batang Masumai River Water Temperature Parameters in 2021-2024

The consistent temperature within the range of 26–27°C in 2022–2024, as depicted in the graph, aligns with the optimal temperature range for phytoplankton growth (20–30°C), indicating favorable conditions for aquatic life. This stabilization of temperature suggests improved waste management practices or a natural recovery process in the river system. However, despite being within acceptable limits, maintaining consistent monitoring is crucial, as the observed trends highlight the river's vulnerability to external disturbances. Further analysis and control measures are recommended to ensure that the river's temperature remains stable and continues to support both the ecological balance and the needs of the surrounding community.

3.2 pH (Acidity)

The water quality of the Batang Masumai River, based on the pH acidity parameter, remains within the acceptable water quality standards for its designated use. The pH parameter of wastewater originating from industrial, residential, and agricultural activities reached a value of 7.52. At the sampling locations, the pH parameter consistently

Table 2. Water Quality Test Results

Parameters	Year				Quality Standards PP Number 22 of 2021	EPA and WHO Quality Standards in 2022
	2021	2022	2023	2024		
Temperature	31 °C	27 °C	26 °C	27 °C	Deviation 3	≤ 32°C
pH	7.46	6.54	7.04	7.52	6-9	6.5 - 9.0
TDS	28.6 mg/L	126 mg/L	76 mg/L	97 mg/L	1000	≤ 500 mg/L
TSS	4956 mg/L	90 mg/L	194 mg/L	557 mg/L	50 mg/L	≤ 50 mg/L
DO	4.9 mg/L	6.2 mg/L	6 mg/L	8 mg/L	4 mg/L	≥ 5 mg/L
BOD	390 mg/L	3.4 mg/L	4 mg/L	4 mg/L	3 mg/L	≤ 5 mg/L
COD	780 mg/L	48 mg/L	8 mg/L	63 mg/L	25 mg/L	≤ 100 mg/L

Source: Environmental Agency of Merangin Regency

remained below nine, indicating that the wastewater is classified as alkaline based on its acidity level. The pH values of wastewater discharged into the Batang Masumai River ranged from 6.54 to 7.52. Wastewater from industrial, residential, agricultural, and other activities discharged into the river has the potential to alter the pH of the water and disrupt the lives of aquatic organisms that are sensitive to pH changes. However, water with a pH range of 6.54–7.52 supports fish populations, as their growth and reproduction remain unaffected (Malode et al., 2021).

The physical, chemical, and biological processes of organisms living in aquatic environments are greatly influenced by changes in water pH. The acidity level of wastewater, or the concentration of hydrogen ions, is reflected by the pH value of the water (Ma et al., 2020). Maintaining this pH range is crucial to sustaining a balanced ecosystem and ensuring the survival of aquatic species, as extreme pH fluctuations can have detrimental effects on the aquatic environment.

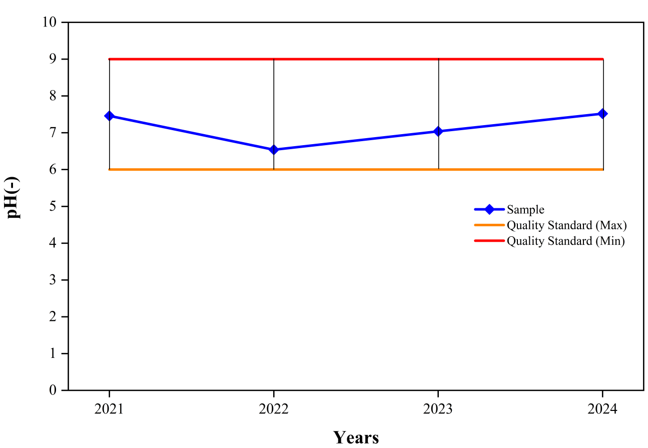

Figure 3. Results of the pH Test for the Acidity of the Batang Masumai River Water in 2021-2024

Figure 3 illustrates the pH test results for the acidity levels of the Batang Masumai River water from 2021 to 2024. The data indicate that the pH values remained consistently within the acceptable range defined by water quality standards, which is 6–9 according to Government Regulation Number 22 of 2021 and WHO standards. The pH levels ranged from 6.54 in 2022 to 7.52 in 2024, suggesting that the river's water maintained its suitability for aquatic life throughout the observed period. The slight fluctuations in pH levels between years could be attributed to natural variations or minor impacts from domestic, agricultural, and industrial waste discharges. Despite these inputs, the pH did not reach harmful levels, indicating the river's resilience and its ability to buffer against pH alterations caused by external influences.

The stable pH values between 6.54 and 7.52 highlight favorable conditions for the survival and reproduction of aquatic organisms, particularly fish, as this range is considered optimal for their growth (Hasan et al., 2022). The consistency in pH levels over the four years suggests effective management of pollution sources or a natural equilibrium in the river system. However, continued monitoring is essential, as significant deviations in pH could disrupt the delicate balance of aquatic ecosystems. The data reinforce the importance of controlling the discharge of wastewater with extreme pH levels to maintain the river's ecological integrity and prevent potential harm to aquatic organisms that are sensitive to pH changes.

3.3 TDS (Total Dissolved Solids)

The TDS parameter at the sampling locations showed several values that did not meet the quality standards. The TDS values from 2021 to 2024 for wastewater discharged into the Batang Masumai River ranged between 28.6 and 128 mg/L. According to Class II water quality standards, the permissible TDS level is 1000 mg/L. Over the period of 2021–2024, the TDS levels showed a decreasing trend. High TDS values in water can result from residues of inorganic materials and molecules caused by wastewater, such as detergents, surfactants dissolved in water, and soap molecules (Caesar et al., 2024).

Figure 4 illustrates the Total Dissolved Solids (TDS) test results for the Batang Masumai River from 2021 to 2024, compared with the maximum permissible TDS level of 1000 mg/L as outlined in Class II water quality standards. The TDS levels during this period ranged from 28.6 mg/L

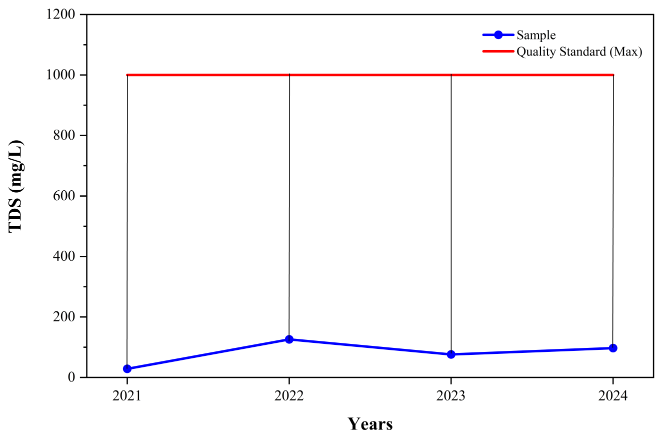

Figure 4. Total Dissolved Solids Test Results for Batang Masumai River water in 2021-2024

in 2021 to 128 mg/L in 2024, all of which are well below the regulatory limit. This indicates that the river's water quality, in terms of TDS concentration, meets the required standards for its designated use. The relatively low TDS levels suggest limited contributions of dissolved inorganic materials, such as salts, detergents, and surfactants, from human activities to the river system. Such a trend may indicate either effective pollution control measures or a low intensity of industrial and residential waste discharge directly into the river.

The data also reveal a slight increase in TDS levels in 2022, reaching 126 mg/L, before stabilizing in subsequent years. This temporary rise could be attributed to episodic events such as increased runoff during heavy rainfall, which may carry dissolved materials from surrounding areas into the river. Although the values remain within permissible limits, it is essential to monitor TDS levels continuously as high concentrations can impact aquatic ecosystems and reduce the usability of water for agricultural and industrial purposes. The consistently low TDS levels over the four-year period underscore the Batang Masumai River's capacity to maintain good water quality with respect to dissolved solids, supporting both ecological health and community water needs.

3.4 TSS (Total Suspended Solids)

Compared to Class II water quality standards as outlined in Government Regulation Number 22 of 2021, which sets a limit of 50 mg/L, the water quality of the Batang Masumai River in 2021 exceeded the permissible threshold for TSS (Total Suspended Solids), with a value of 4956 mg/L, rendering it unsuitable for its designated use (Figure 5). The TSS parameter for wastewater discharged at the seven sampling locations showed several values that did not meet the required standard. The TSS values from 2021 to 2024 for wastewater entering the Batang Masumai River ranged from 90 mg/L to 4956 mg/L, far exceeding the Class II standard of 50 mg/L.

The total suspended solids in water can be classified into four categories: TSS < 25 mg/L has no effect, TSS between 25–80 mg/L has a minor impact, TSS between 81–400 mg/L is considered poor, and TSS > 400 mg/L is deemed very poor (Adjovu et al., 2023b). Excessively high TSS concentrations hinder light penetration into the water, thereby halting the process of photosynthesis (Alfiah and Caroline, 2023). Elevated TSS levels, such as those observed in 2021, can severely disrupt aquatic ecosystems and reduce water quality, emphasizing the need for stricter pollution control and regular monitoring.

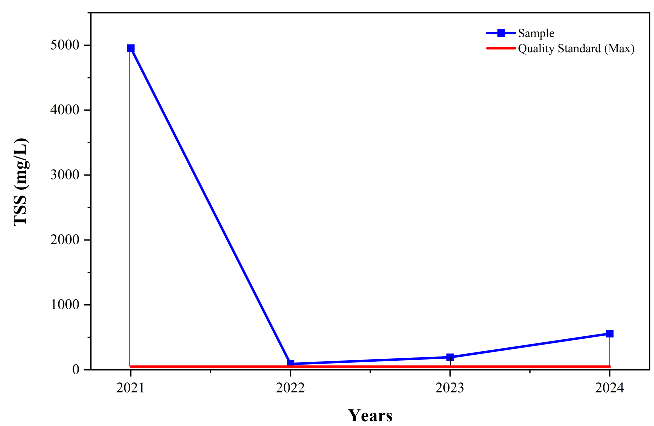

Figure 5. Total Suspended Solids Test Results for Batang Masumai River water in 2021-2024

The increase in TSS parameters originates from solids that cause water turbidity, which are insoluble and non-settleable, consisting of silt and microorganisms resulting from soil erosion or sedimentation. These solids generally include phytoplankton, zooplankton, animal waste, plant residues, animal remains, human waste, and industrial waste carried into the water. Suspended solids, in the form of particles carried by water flow, significantly affect the TSS levels in the water (Adjovu et al., 2023a). The impact of TSS pollution on water quality can lead to a decline in overall water quality (Subramaniam et al., 2023).

3.5 DO (Dissolved Oxygen)

The water quality condition of the Batang Masumai River, based on the DO (Dissolved Oxygen) parameter from 2021 to 2024, was above the quality standards for its designated use. The DO parameter for wastewater discharge at the sampling locations showed several values that did not meet the required quality standards.

The DO (Dissolved Oxygen) values from 2021 to 2024 for wastewater entering the Batang Masumai River ranged between 4.9–8 mg/L (Figure 6). According to Class II water quality standards, the DO parameter should be at least 4

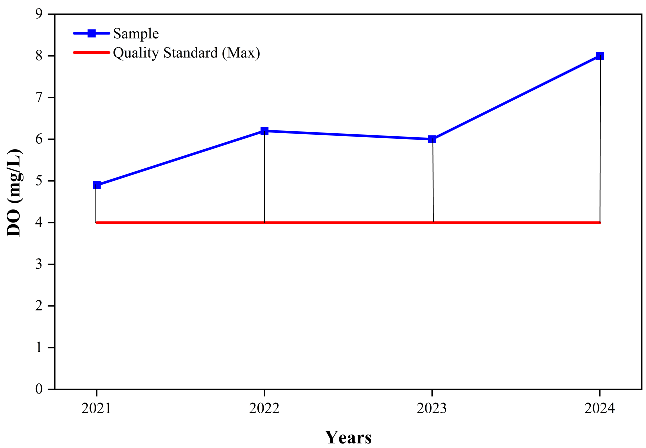

Figure 6. Dissolved Oxygen Test Results for Batang Masumai River water for 2021-2024

mg/L. Over the period of 2021–2024, there was a significant increase in DO levels. Wastewater affecting the DO parameter originates from activities such as industrial, residential, and agricultural practices, which, when discharged into water bodies, have the potential to alter DO levels and disrupt the life of aquatic organisms (Afolalu et al., 2022).

The minimum dissolved oxygen concentration required to support aquatic life should not fall below 6 mg/L (Abd El-Hack et al., 2022). All living organisms require DO for respiration, metabolic processes, material exchange, and energy production for growth and regeneration. In aerobic processes, oxygen is necessary to oxidize both organic and inorganic substances. Since oxygen from the surrounding air dissolves directly into seawater through diffusion, it is typically found in the surface layers. The dissolved oxygen requirement of an organism varies depending on its species, phase of life, and activity level (Akhter et al., 2021).

3.6 COD (Chemical Oxygen Requirement)

The COD (Chemical Oxygen Demand) parameter for wastewater discharge at the sampling locations showed several values that did not meet the quality standards. The COD values from 2021 to 2024 for wastewater entering the Batang Masumai River ranged between 8–780 mg/L. According to Class II water quality standards, the permissible COD level is 25 mg/L. From 2021 to 2024, COD levels increased significantly. This condition is undesirable for aquaculture and agricultural activities. Based on the measurements, the highest COD value recorded in 2021 was 780 mg/L (> 20 mg/L), indicating polluted water. Water with high COD levels is unsuitable for agriculture and aquaculture purposes (Mubarak et al., 2021).

Figure 7 illustrates the Chemical Oxygen Demand (COD) test results for the Batang Masumai River from 2021 to 2024. COD levels ranged from 8 mg/L to 780 mg/L, showing significant variability over the four years. The highest COD value was recorded in 2021 at 780 mg/L, far exceeding the Class II water quality standard of 25 mg/L. Such elevated levels indicate severe water pollution, suggesting a high concentration of organic and inorganic pollutants entering the river from various sources, including industrial, agricultural, and residential wastewater. High COD levels reflect the river's reduced ability to decompose organic matter, posing serious risks to aquatic ecosystems and diminishing the water's suitability for aquaculture and agricultural activities (Maphanga et al., 2022).

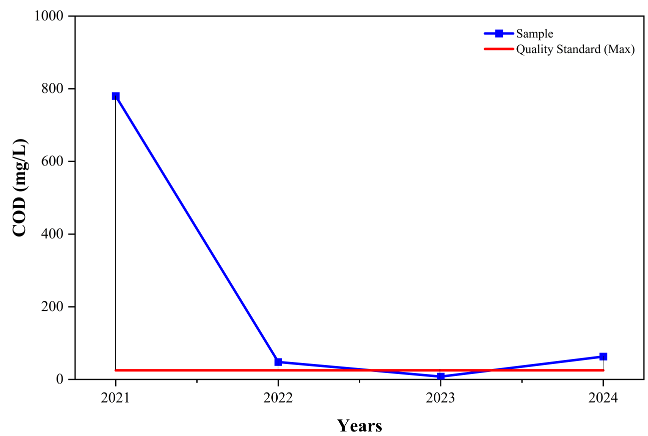

Figure 7. Chemical Oxygen Requirement Test Results for Batang Masumai River water for 2021-2024

The decline in COD levels after 2021 with values ranging from 8 to 63 mg/L in subsequent years, suggests some improvement in water quality management or reduced pollutant discharge into the river. However, despite the improvements, COD levels in 2022 and 2024 still exceeded the acceptable limit, emphasizing the need for stricter regulations and continuous monitoring. High COD concentrations not only disrupt aquatic life but also reduce water's usability for irrigation and fish farming. These findings underline the importance of implementing effective wastewater treatment systems and addressing the pollution sources to restore and maintain the Batang Masumai River's ecological balance and usability.

3.7 BOD (Biochemical Oxygen Requirement)

Compared to the monitoring results of the Batang Masumai River's water quality, the condition of the water quality from 2021 to 2024 has exceeded the permissible limits for its designated use. The BOD (Biochemical Oxygen Demand) parameter for wastewater discharge at the seven sampling locations showed several values that did not meet the quality standards. The BOD values from 2018 to 2020 for wastewater entering the Pucang River ranged from 4 mg/L to 390 mg/L. Higher BOD concentrations indicate that the water body is polluted. According to Class II water quality standards, water with low pollution levels and good quality should have BOD concentrations ranging from 0 to 3 mg/L.

In comparison water bodies with BOD concentrations above 3 mg/L are considered polluted. Wastewater from industrial, residential, agricultural, and other activities that affect the BOD parameter has the potential to alter the BOD levels in water and disrupt the life of aquatic organisms. BOD is a key indicator used to determine the pollution level of a water body. BOD analysis is conducted to measure the extent of water pollution and to design biological treatment systems for contaminated water. If BOD levels are high or exceed the allowable limit, aquatic plants or animals will struggle to survive, and if the levels surpass critical thresholds, they may not survive at all. This also adversely affects humans when using polluted river water (Kamarudin, 2020).

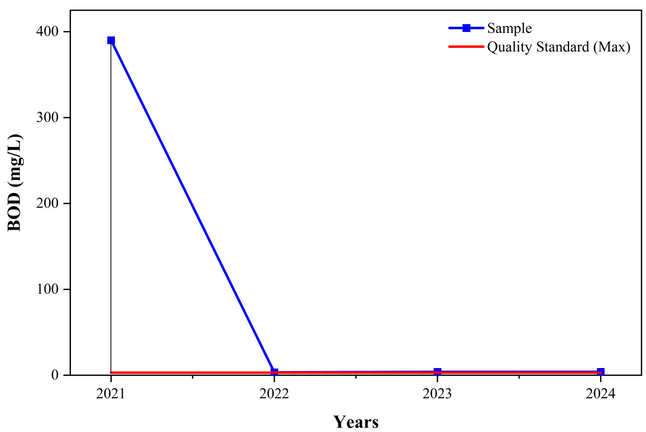

Figure 8. Biochemical Oxygen Requirement Test Results for Batang Masumai River water for 2021-2024

Figure 8 illustrates the Biochemical Oxygen Demand (BOD) test results for the Batang Masumai River from 2021 to 2024. BOD values during this period ranged significantly, reflecting variations in organic pollution levels in the river. In 2021, the BOD value reached a peak of 390 mg/L, far exceeding the Class II water quality standard of 3 mg/L. Such a high BOD level indicates a severe level of organic pollution, likely caused by untreated wastewater from industrial, residential, and agricultural activities entering the river. Elevated BOD levels point to increased microbial activity as microorganisms decompose organic matter, consuming dissolved oxygen in the process. This results in reduced oxygen availability for aquatic organisms, negatively affecting the ecosystem.

In subsequent years, BOD levels showed a marked decline, falling to 3.4–4 mg/L from 2022 to 2024, indicating some improvement in water quality. However, the values still remained slightly above the threshold for good water quality, suggesting that organic waste discharge into the river continued to impact the water to some extent. High BOD levels are not only detrimental to aquatic ecosystems but also pose risks for activities like aquaculture and agriculture, which depend on clean water. The data underscore the urgent need for proper wastewater treatment systems and stricter enforcement of pollution control measures to ensure the long-term sustainability of the Batang Masumai River's ecosystem and its surrounding communities.

3.8 Evaluation of Key Water Quality Parameters and Compliance with Standards

The evaluation of water quality parameters is a critical step in understanding the health and usability of aquatic ecosystems, especially in the Batang Masumai River. This study assessed seven key water quality parameters—temperature, pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD)—to determine the extent of pollution and compliance with the Class II water quality standards outlined in Government Regulation Number 22 of 2021. This section provides an in-depth discussion of the results and their implications.

The river's temperature is an important physical parameter that influences chemical reactions and biological processes in aquatic ecosystems. The measured temperatures in the Batang Masumai River ranged from 26°C to 31°C during the study period (2021–2024). In 2021, the recorded temperature of 31°C was slightly below the maximum standard of 32°C but significantly higher than the natural baseline, indicating the impact of thermal pollution, likely from industrial and domestic discharges. Elevated water temperatures can reduce the solubility of oxygen and increase the metabolic rate of aquatic organisms, leading to ecological stress. However, in subsequent years (2022–2024), temperatures stabilized between 26°C and 27°C, remaining well within the permissible limit. This improvement suggests better management of thermal waste discharge or natural recovery processes.

The pH values of the river ranged from 6.54 to 7.52, consistently within the acceptable range of 6–9 as specified in the standards. These results indicate that the river water is slightly alkaline, which is favorable for aquatic organisms and does not pose significant risks to the ecosystem. However, variations in pH across sampling sites and years could be attributed to localized discharges of wastewater containing detergents, surfactants, or agricultural runoff. While the observed pH levels are not immediately concerning, continuous monitoring is crucial to ensure that extreme pH fluctuations do not occur, as these can disrupt the river's ecological balance.

The TDS values in the Batang Masumai River remained relatively low throughout the study period, ranging from 28.6 mg/L to 128 mg/L, well below the Class II standard of 1000 mg/L. Low TDS levels indicate that the river has a low concentration of dissolved salts and inorganic materials, which is favorable for both aquatic ecosystems and human use. However, the slight increase in TDS values in 2022 suggests occasional contributions from runoff or wastewater containing dissolved materials. These findings highlight the river's resilience to significant dissolved pollutant loads but also stress the importance of protecting the river from future contamination.

TSS is a critical indicator of sediment pollution, and the results reveal significant concerns for the Batang Masumai River. In 2021, TSS levels reached an alarming 4956 mg/L, drastically exceeding the Class II standard of 50 mg/L. This indicates severe sedimentation and pollution caused by activities such as soil erosion, construction, and the discharge of untreated wastewater. High TSS levels impair water quality by increasing turbidity, reducing light penetration, and hindering photosynthesis. This, in turn, disrupts aquatic food chains and ecosystem functions. In the following years, TSS levels decreased significantly but remained above the standard, ranging from 90 mg/L to 557 mg/L, highlighting ongoing sedimentation and pollutant inputs.

Dissolved oxygen is a key parameter for assessing the ability of a water body to support aquatic life. DO levels in the Batang Masumai River ranged from 4.9 mg/L to 8 mg/L during the study period. While the levels were above the minimum standard of 4 mg/L, they fluctuated significantly, with lower values in 2021 indicating organic pollution and increased microbial activity consuming oxygen. By 2024, DO levels improved, reaching 8 mg/L, which is favorable for most aquatic organisms. This improvement suggests a reduction in organic pollutant loads or enhanced natural aeration processes in the river. However, maintaining high DO levels requires continuous efforts to minimize organic waste discharge into the river.

BOD values provide insight into the amount of organic pollution in a water body. The results reveal high BOD concentrations in 2021, reaching 390 mg/L, far exceeding the standard of 3 mg/L for Class II water. Such elevated BOD levels indicate heavy organic pollution, likely from untreated industrial and domestic wastewater. High BOD levels reduce dissolved oxygen availability, creating stress for aquatic organisms and potentially leading to hypoxic conditions. In subsequent years, BOD values decreased to 3.4–4 mg/L, reflecting some improvement in water quality. However, the values still exceeded the standard, suggesting that organic pollution sources persist, albeit at reduced levels.

COD measures the amount of oxygen required to oxidize both organic and inorganic materials in the water. The COD values in the Batang Masumai River ranged from 8 mg/L to 780 mg/L, with the highest value recorded in 2021. These levels far exceeded the Class II standard of 25 mg/L, indicating the presence of high levels of chemical pollutants, such as industrial chemicals, agricultural runoff, and household detergents. High COD values are detrimental to water quality and aquatic life, as they reflect the river's reduced ability to break down pollutants. Despite some improvement in COD levels in subsequent years, occasional exceedances of the standard highlight the need for stricter pollution control measures.

Table 3. Water Pollution Index Value

Year	Water Pollution Index Value	Water Quality
2021	100.54	Heavily Polluted
2022	1.98	Lightly Polluted
2023	4.02	Lightly Polluted
2024	11.36	Heavily Polluted

The Water Pollution Index values are presented in Table 3. The evaluation of key water quality parameters reveals significant pollution challenges in the Batang Masumai River, particularly in 2021, when several parameters exceeded the Class II water quality standards. While improvements in water quality were observed in later years, parameters such as TSS, BOD, and COD continue to pose risks to the river's ecological health and usability. These findings underscore the need for comprehensive pollution control strategies, including the treatment of industrial and domestic wastewater, erosion control measures, and continuous monitoring to ensure compliance with water quality standards and the sustainability of the river's ecosystem.

3.9 Impacts of Pollution on Aquatic Ecosystems and Resource Usability

Water pollution significantly affects aquatic ecosystems and the usability of water resources, as demonstrated by the findings from the Batang Masumai River. Pollution alters the physical, chemical, and biological characteristics of the water, disrupting the delicate balance that supports aquatic life and limiting the river's potential for domestic, agricultural, and industrial use. This section explores the impacts of pollution on aquatic ecosystems and resource usability, focusing on the observed deviations in key water quality parameters.

The high levels of Total Suspended Solids (TSS) observed in the Batang Masumai River, particularly in 2021, are a significant threat to aquatic ecosystems. Elevated TSS levels, which reached as high as 4956 mg/L, hinder light penetration into the water, disrupting photosynthesis for aquatic plants and phytoplankton. This reduction in primary production affects the entire aquatic food chain, from zooplankton to larger organisms such as fish. High TSS concentrations also increase sediment deposition on the riverbed, smothering benthic habitats and altering the physical environment for aquatic organisms. Sedimentation can destroy spawning grounds for fish and reduce the availability of food resources, leading to declines in biodiversity.

Dissolved Oxygen (DO) is another critical parameter directly impacted by pollution. DO levels in the river fluctuated between 4.9 mg/L and 8 mg/L during the study period, with lower levels in 2021 indicating organic pollution. Insufficient oxygen levels can create hypoxic conditions, particularly in deeper water layers, making it difficult for aquatic organisms to survive. Fish, which are highly sensitive to oxygen depletion, may experience stunted growth, reproductive failure, or mortality. Elevated Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels, observed during the study, exacerbate these conditions by depleting oxygen as microorganisms and chemical reactions break down organic and inorganic pollutants. Such conditions create stress for aquatic species and can lead to reduced populations or local extinctions.

The usability of the Batang Masumai River for domestic, agricultural, and industrial purposes is heavily compromised by the pollution levels. For domestic use, parameters such as TSS, COD, and BOD indicate poor water quality, making the river unsuitable for activities like bathing, washing, or drinking without extensive treatment. High COD levels, which reached 780 mg/L in 2021, reflect the presence of industrial and chemical pollutants that can pose serious health risks to humans if consumed. Similarly, elevated TSS levels reduce the aesthetic quality of the water and clog filtration systems, increasing the cost and complexity of water treatment for human use.

For agriculture the river's water quality is particularly critical, as it directly affects soil and crop health. High concentrations of suspended solids and chemical pollutants can settle in irrigation channels, reducing their efficiency and contaminating soils with harmful substances. Nutrient-rich pollutants, such as nitrates and phosphates, can lead to eutrophication, causing excessive algal blooms that further degrade water quality. These blooms can deplete oxygen levels, release toxins, and render the water unsuitable for irrigation. Livestock that rely on the river as a water source may also suffer health complications from ingesting contaminated water.

Aquaculture a significant economic activity in many riverine communities, is particularly vulnerable to pollution. Fish and other aquatic organisms require clean water with stable pH, low levels of suspended solids, and adequate oxygen. Elevated BOD and COD levels reduce dissolved oxygen availability, leading to fish kills and decreased productivity. Contaminants in the water can also bioaccumulate in fish, posing risks to human health when consumed. These conditions undermine the viability of aquaculture, reducing income for local communities and threatening food security.

Pollution in the Batang Masumai River has broader ecological implications, as rivers are interconnected with surrounding terrestrial and marine ecosystems. Contaminants discharged into the river eventually flow downstream, affecting larger water bodies, such as lakes or estuaries, and contributing to regional or even global environmental problems. For instance, the accumulation of pollutants can lead to the formation of hypoxic "dead zones" in downstream areas, where oxygen levels are too low to support most forms of life. This not only disrupts local ecosystems but also has economic implications, such as reduced fishery yields.

Sedimentation caused by high TSS levels can also impact river morphology, altering flow patterns and increasing the risk of flooding during heavy rains. Polluted sediments can accumulate in reservoirs or hydroelectric facilities, reducing their storage capacity and operational efficiency. These changes affect the river's ability to provide ecosystem services, such as flood regulation, clean water supply, and habitat provision, further diminishing its value as a natural resource.

The impacts of pollution on aquatic ecosystems and resource usability highlight the urgent need for sustainable river management. Effective wastewater treatment systems are essential to reduce the discharge of untreated industrial, agricultural, and residential waste into the river. Erosion control measures, such as reforestation and riparian buffer zones, can help reduce sedimentation and improve water quality. Regular monitoring and enforcement of water quality standards are also critical to ensure compliance and address emerging pollution sources promptly.

Community engagement and education are equally important in promoting sustainable practices and reducing pollution at the source. Raising awareness among local populations about the impacts of improper waste disposal and encouraging the adoption of environmentally friendly agricultural practices can significantly reduce pollution loads. Collaborative efforts among government agencies, industries, and local communities are needed to restore the Batang Masumai River's ecological health and ensure its long-term usability as a vital resource for the region.

The findings from the Batang Masumai River underscore the profound impacts of pollution on aquatic ecosystems and resource usability. High levels of suspended solids, organic pollutants, and chemical contaminants disrupt the river's ecological balance, reduce its usability for essential purposes, and pose risks to human and environmental health. Addressing these challenges requires a comprehensive approach that combines pollution control, sustainable resource management, and community involvement to restore and preserve the river's natural functions and benefits

4. CONCLUSIONS

The analysis of water pollution in the Batang Masumai River from 2021 to 2024 highlights significant challenges in maintaining water quality standards, particularly with Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD), which frequently exceeded permissible limits. Although some improvements, such as in Dissolved Oxygen (DO), were observed, human activities continue to disrupt aquatic ecosystems and hinder the river's usability for irrigation, aquaculture, and domestic purposes. To address these issues, immediate actions are needed, including strengthening wastewater treatment, enforcing pollution control regulations, promoting sustainable land-use practices, and increasing public awareness. Policymakers should prioritize monitoring systems and adopt an integrated watershed management approach. These findings underscore the importance of coordinated efforts to restore and sustain the river's ecological health and serve as a model for managing other river systems in Indonesia.

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REFERENCES

Abd El-Hack, M. E., M. T. El-Saadony, M. M. Nader, H. M. Salem, A. M. El-Tahan, S. M. Soliman, and A. F. Khafaga (2022). Effect of Environmental Factors on Growth Performance of Nile Tilapia (Oreochromis Niloticus). *International Journal of Biometeorology*, **66**(11); 2183–2194

Adjovu, G., H. Stephen, D. James, and S. Ahmad (2023a). Measurement of Total Dissolved Solids and Total Suspended Solids in Water Systems. *Remote Sensing*, **15**(14); 1–43

Adjovu, G. E., H. Stephen, and S. Ahmad (2023b). Spatiotemporal Variability in Total Dissolved Solids and Total Suspended Solids Along the Colorado River. *Hydrology*, **10**(6)

Afolalu, S. A., O. M. Ikumapayi, T. S. Ogedengbe, R. A. Kazeem, and A. T. Ogundipe (2022). Waste Pollution, Wastewater and Effluent Treatment Methods – An Overview. *Materials Today: Proceedings*, **62**(April); 3282–3288

Akhter, F., H. R. Siddiquei, M. E. E. Alahi, and S. C. Mukhopadhyay (2021). Recent Advancement of the Sensors for Monitoring the Water Quality Parameters in Smart Fisheries Farming. *Computers*, **10**(3); 1–20

Alfiah, T. and J. Caroline (2023). Total Suspended Solids (TSS) Spatial Distribution of Manganese in Resident Well Impacted by Residential Activity: A Case Study of Medokan Ayu District-Surabaya. *Paragraphs Environmental Design*, (July); 1–10

Anwar, M. N., M. Shabbir, E. Tahir, M. Iftikhar, H. Saif, A. Tahir, and A. S. Nizami (2021). Emerging Challenges of Air Pollution and Particulate Matter in China, India, and Pakistan and Mitigating Solutions. *Journal of Hazardous Materials*, **416**; 125851

Aydin, H., F. Ustaoğlu, Y. Tepe, and E. N. Soylu (2021). Assessment of Water Quality of Streams in Northeast Turkey by Water Quality Index and Multiple Statistical Methods. *Environmental Forensics*, **22**(1–2); 270–287

Caesar, N. R., U. Yanuhar, A. R. Faqih, S. Anitasari, G. Ciptadi, M. Musa, and N. P. Wardani (2024). Correlation Between Water Quality and Surfactant Pollution in the Porong River. *BIO Web of Conferences*, **117**; 1–8

Chabuk, A., Q. Al-Madhlom, A. Al-Maliki, N. Al-Ansari, H. M. Hussain, and J. Laue (2020). Water Quality Assessment Along Tigris River (Iraq) Using Water Quality Index (WQI) and GIS Software. *Arabian Journal of Geosciences*, **13**(14); 654

Creswell, J. (2016). *Research Design*. Retrieved from https://www.researchgate.net/publication/308915548

Creswell, J. W. and J. D. Creswell (2018). *Mixed Methods Procedures*. SAGE Publications

Elvania, N. C. (2022). Upaya Pengendalian Pencemaran Air Sungai Kalitidu di Desa Jelu, Kecamatan Kalitidu, Kabupaten Bojonegoro. *Media Ilmiah Teknik Lingkungan*, **7**(1); 17–23 (in Indonesia)

Ewaid, S. H., S. A. Abed, N. Al-Ansari, and R. M. Salih (2020). Development and Evaluation of a Water Quality Index for the Iraqi Rivers. *Hydrology*, **7**(3); 1–14

Hasan, J., D. C. Shaha, S. R. Kundu, F. M. Yusoff, Y. K. Cho, F. Haque, and M. S. I. Afrad (2022). Phytoplankton Community in Relation to Environmental Variables in the Tidal Mangrove Creeks of the Pasur River Estuary, Bangladesh. *Conservation*, **2**(4); 587–612

Jha, M. K., A. Shekhar, and M. A. Jenifer (2020). Assessing Groundwater Quality for Drinking Water Supply Using Hybrid Fuzzy-GIS-Based Water Quality Index. *Water Research*, **179**; 115867

Kamalia, D. and S. Sudarti (2022). Analisis Pencemaran Air Sungai Akibat Dampak Limbah Industri Batu Alam di Kecamatan Depok Kabupaten Cirebon. *Jurnal Enviscience*, **6**(1); 1–13 (in Indonesia)

Kamarudin, M. K. A. (2020). Seasonal Variation on Dissolved Oxygen, Biochemical Oxygen Demand and Chemical Oxygen Demand in Terengganu River Basin, Malaysia. *Journal of Environmental Science and Management*, **23**(2); 1–7

Kiran, A., G. Murtiza, A. Yousaf, M. Hussain, and E. Al Jbawi (2023). A Critical Analysis of Legal Responses to Water Pollution in Pakistan. *Cogent Social Sciences*, **9**(2); 2254944

Kumar, V., A. Sharma, R. Kumar, R. Bhardwaj, A. Kumar Thukral, and J. Rodrigo-Comino (2020). Assessment of Heavy-Metal Pollution in Three Different Indian Water Bodies by Combination of Multivariate Analysis and Water Pollution Indices. *Human and Ecological Risk Assessment*, **26**(1); 1–16

Ma, J., S. Wu, N. V. R. Shekhar, S. Biswas, and A. K. Sahu (2020). Determination of Physicochemical Parameters and Levels of Heavy Metals in Food Waste Water with Environmental Effects. *Bioinorganic Chemistry and Applications*, **2020**; 8886093

Malode, S. J., K. K. Prabhu, R. J. Mascarenhas, N. P. Shetti, and T. M. Aminabhavi (2021). Recent Advances and Viability in Biofuel Production. *Energy Conversion and Management: X*, **10**; 100070

Maphanga, T., B. S. Madonsela, B. S. Chidi, K. Shale, L. Munjonji, and S. Lekata (2022). The Effect of Rainfall on Escherichia Coli and Chemical Oxygen Demand in the Effluent Discharge from the Crocodile River Wastewater Treatment; South Africa. *Water (Switzerland)*, **14**(18); 2802

Mubarak, A. S., P. Esmaili, Z. S. Ameen, R. A. Abdulkadir, M. S. Gaya, M. Ozsoz, and S. I. Abba (2021). Metro-Environmental Data Approach for the Prediction of Chemical Oxygen Demand in New Nicosia Wastewater Treatment Plant. *Desalination and Water Treatment*, **221**; 31–40

Mubarok, M. U. (2025). Comparative Study of Artificial Intelligence (AI) Utilization in Digital Marketing Strategies Between Developed and Developing Countries: A Systematic Literature Review. *Ilomata International Journal of Management*, **6**(1); 1–23

Pradani, M. A., P. Wijayanti, and G. A. Tjahjono (2024). Analisis Kualitas Air Sungai Sawur Sebagai Upaya Pengendalian Pencemaran Air Di Kecamatan Sambungmacan Kabupaten Sragen Tahun 2023. *Indonesian Journal of Environment and Disaster*, **3**(1); 97–110

Rahmawati, S. H. and C. Puspitaningrum (2022). Analysis of Tofu Industrial Wastewater Treatment and Its Effectiveness on Society and the Environment in Bandar Lampung. *Open Science and Technology*, **2**(1); 2776–169

Rakhmawati, G. (2024). Analisis SWOT Potensi Sungai Karangampel Kidul di Kabupaten Indramayu. *Jurnal Teknik dan Science*, **3**(2); 10–19 (in Indonesia)

Sharma, R., R. Kumar, S. C. Satapathy, N. Al-Ansari, K. K. Singh, R. P. Mahapatra, and B. T. Pham (2020). Analysis of Water Pollution Using Different Physicochemical Parameters: A Study of Yamuna River. *Frontiers in Environmental Science*, **8**(December); 1–18

Siddique, I. (2024). Sustainable Water Management in Urban Areas: Integrating Innovative Technologies and Practices to Address Water Scarcity and Pollution. *SSRN Electronic Journal*, **8**(1); 172–178

Subramaniam, P., A. N. Ahmed, C. M. Fai, M. Abdul Malek, P. Kumar, Y. F. Huang, and A. Elshafie (2023). Integrated GIS and Multivariate Statistical Approach for Spatial and Temporal Variability Analysis for Lake Water Quality Index. *Cogent Engineering*, **10**(1); 2190490

Wikurendra, E. A., A. Syafiuddin, G. Nurika, and A. D. Elisanti (2022). Water Quality Analysis of Pucang River, Sidoarjo Regency to Control Water Pollution. *Environmental Quality Management*, **32**(1); 133–144

Wu, Z., X. Lai, and K. Li (2021). Water Quality Assessment of Rivers in Lake Chaohu Basin (China) Using Water Quality Index. *Ecological Indicators*, **121**; 107021

Xu, H., Q. Gao, and B. Yuan (2022). Analysis and Identification of Pollution Sources of Comprehensive River Water Quality: Evidence from Two River Basins in China. *Ecological Indicators*, **135**; 108561

