Analysis of Water Quality in the Riverside Residential Area of the Kahayan River, Palangka Raya

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Abstract

The Kahayan River plays an important role in the lives of the people of Palangka Raya City, particularly for residents living in riverside areas. The high dependence on the river, without being balanced by adequate sanitation systems and spatial planning, has caused various environmental and health problems, such as increased cases of diarrhea and digestive disorders. This study aims to evaluate the water quality of the Kahayan River using rapid assessment methods with a quantitative approach through laboratory testing. Sampling was conducted at three locations: Tumbang Rungan, Pahandut Seberang, and Bereng Bengkel. Analysis was performed on physicochemical parameters (temperature, pH, BOD, COD, and iron content) as well as microbiological parameters (number of E. coli bacteria). Results show that all water samples do not meet drinking water quality standards based on PP No. 22 of 2021. Low pH and high levels of COD and E. coli, particularly in Pahandut Seberang, reflect domestic waste pollution. Conversely, lower COD and BOD values in Bereng Bengkel indicate natural dilution processes. Based on these findings, efforts to improve sanitation infrastructure, change community behavior towards clean living, and optimize waste management are needed to reduce health risks from water pollution in Kahayan riverside settlement areas.

Keywords: Domestic Waste, Environmental Sanitation, Kahayan River, Water Quality.

1. Introduction

Rivers play an essential role in supporting ecosystem sustainability, community social life, and local economic activities, particularly for communities residing in riverbank areas. However, increasing anthropogenic pressure, especially from domestic activities and growth of residential areas without adequate sanitation infrastructure, has caused significant degradation of river water quality. Ecologically, the entry of household waste and agricultural runoff into river bodies has resulted in increased Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) values, indicating declining water quality and reduced river capacity to support aquatic life (Karnila, 2024). This pollution also contributes to the accumulation of heavy metals and pathogenic microorganisms (Wahyuni et al., 2023), as reflected in studies of the Ganges and Brahmaputra rivers showing destructive impacts on biodiversity due to chronic contamination (Dutta & Nayek, 2020).

The social implications of river water quality degradation are equally crucial. Communities dependent on rivers as primary water sources for domestic needs such as washing, bathing, and even consumption become the most vulnerable groups to diseases transmitted through contaminated water. Studies in Dhaka show that low-income communities face high health risks due to exposure to unsuitable water, with the most

significant impacts on vulnerable groups such as women and children (Hoque et al., 2021). Inequality in access to clean water and sanitation exacerbates social inequality, creating structural vulnerability cycles that are difficult to break.

From an economic perspective, rivers contribute significantly to community production activities, including agricultural irrigation and fishing. However, water pollution has reduced the quality of these resources, making water no longer suitable for consumption or use in agriculture and fisheries sectors, thus threatening food security and reducing income (Desrizal et al., 2019; Dutta & Nayek, 2020). This condition also impacts increased costs for water quality remediation and treatment of affected communities, which often do not match the economic benefits that can be obtained (Juita, 2017). Thus, declining river water quality due to domestic pressure is not only an environmental issue but also concerns public health, social justice, and sustainable economic development that requires holistic and cross-sectoral approaches in its management.

Various studies show that residential areas around rivers are one of the main contributors to water body pollution. Pratiwi et al. (2020) and Nurhidayati (2021) reveal that river water BOD and COD values have exceeded quality standard thresholds due to household waste discharged directly into rivers, with pollution levels in moderate to severe categories. Similar research by Yogafanny (2015), found significant increases in pollutant parameters such as phenol, nitrate, and total coliform in areas with dense population activities, showing strong influence of residential activities on water quality decline. Similarly, Fadhil et al. (2025) found that pollution increased significantly in downstream river areas adjacent to residential and intensive agricultural areas. The use of QUAL2Kw simulation models and Water Quality Index (WQI) calculations show that BOD and COD parameters exceed class II quality standards, caused by domestic waste flows and uncontrolled land conversion.

Jannah & Haribowo (2025) found that most observation points show light to moderate pollution status. They identified that the main factor causing pollution is community domestic activities not accompanied by availability of household liquid waste management facilities. Based on various findings, it can be concluded that river water pollution in residential areas is a serious problem that is systemic and requires scientifically-based data management. Therefore, comprehensive studies of river water quality in riverside residential areas are needed as a basis for formulating environmental sanitation policies, planning wastewater management infrastructure, and preventive efforts against public health risks due to water pollution.

The Kahayan River is the largest river crossing Palangka Raya City with a length of approximately 600 km, an average width of 450 meters, and depth reaching 7 meters. This river plays an important role as the main route for community activities, especially for residents living on its banks. Based on observations by UPR Faculty of Engineering students (2015), hundreds of floating houses and stilt houses stand along the riverbanks, with a population of about 7,860 people in Pahandut and Pahandut Seberang sub-districts. Community dependence on the river as a source of livelihood, transportation, and social interaction has driven the development of residential areas without adequate spatial planning. As a result, these areas become dense and unorganized, triggering environmental and health problems. Data from the Health Department shows high incidence rates of diseases such as diarrhea, typhoid, and intestinal infections. These problems are closely related to poor sanitation quality and environmental cleanliness. Therefore, rapid evaluation is needed to obtain an overview of water and sanitation conditions in these areas. This research was conducted using quantitative methods with laboratory examinations to assess the water quality conditions of the Kahayan River in Palangka Raya City, Central Kalimantan.

2. Methods

This study uses a quantitative approach with rapid assessment methods to evaluate the water quality of the Kahayan River crossing riverside residential areas in Palangka Raya City, Central Kalimantan. Evaluation was conducted through laboratory testing of water samples taken from three location points representing upstream, middle, and downstream parts of the river, namely Tumbang Rungan, Pahandut Seberang, and Bereng Bengkel. Location selection was based on population density levels and intensity of domestic activities potentially polluting the river environment. Data used in this study consists of primary data from laboratory test results, and secondary data obtained from government regulation documents, community health data from Palangka Raya City Health Department, and population data from the Central Statistics Agency.

Water sampling was done three times at each point, observing standard procedures for sampling, storage, and sample transportation to ensure valid test results. Water quality testing includes two parameter groups: physicochemical and microbiological parameters. Physicochemical parameters analyzed by temperature, pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and iron (Fe) content. Meanwhile, the microbiological parameter tested is the number of Escherichia coli (E. coli) bacteria per 100 mL of water sample. The reference standard used to assess test results is Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Implementation of Environmental Protection and Management, specifically on water quality standards for classes I to IV.

Data analysis was conducted descriptively and quantitatively by comparing laboratory test results against quality standards set by the government. Data is presented in graphical and narrative forms to illustrate differences in water quality between locations and identify pollution levels based on tested parameters. Additionally, to maintain data reliability and validity, sample replication, use of standardized measuring instruments, and data triangulation by comparing laboratory results with secondary data from related agencies were conducted. This approach aims to provide a comprehensive overview of Kahayan River water quality conditions and their implications for community health in riverside residential areas.

3. Results and Discussion

Analysis of river water sample physical conditions shows that main parameters such as temperature, turbidity, total dissolved solids (TDS), and dissolved oxygen (DO) provide clear indications regarding water quality and pollution potential. River water temperatures ranging from 15.2°C to 31°C as found in various studies, including in Manokwari (26.6°C–31°C) (Punjasawadwong et al., 2014) and in the Niger River (26.21°C) (Oseji et al., 2019), reflect tropical climate influences and potential thermal disturbance from human activities. Temperatures higher than normal can accelerate chemical reaction rates in water and reduce dissolved oxygen levels, negatively impacting aquatic organisms. Turbidity levels varying drastically from 0.29 to 107.28 NTU (Din et al., 2017; Oseji et al., 2019) show significant differences in suspended particle loads at various river locations.

High turbidity often becomes an indicator of solid waste entry, soil erosion, and other anthropogenic activities that worsen water quality. In terms of TDS, values ranging from 34.9 mg/L to 317 mg/L (Effiong et al., 2022) indicate variation in dissolved mineral levels and organic matter that can affect taste, odor, and even water toxicity if at high concentrations. Meanwhile, DO levels ranging from 0.03 mg/L to 8.9 mg/L (Din et al., 2017; Punjasawadwong et al., 2014) are of primary concern because values below minimum thresholds (about 5 mg/L for healthy waters) can cause stress or death in aquatic organisms. Very low DO values indicate

high organic pollution that depletes dissolved oxygen through decomposition processes. Thus, these four parameters synergistically provide a comprehensive picture of river physical conditions that not only reflect aquatic environmental quality but also serve as early indicators of aquatic ecosystem threats and human health risks.

In this study, water quality was obtained from laboratory testing results on water samples at 3 (three) points. The overview of river water sample physical conditions at Tumbang Rungan, Pahandut Seberang, and Bereng Bengkel is presented in Figure 1:

Figure 1. Physical Condition of River Water Samples at Tumbang Rungan, Pahandut Seberang, and Bereng Bengkel

Based on Figure 1, it can be observed that water conditions at Pahandut Seberang location appear more turbid compared to water samples from Tumbang Rungan and Bereng Bengkel. High turbidity levels indicate higher concentrations of suspended particles or organic matter, generally correlating with high domestic activities and household liquid waste discharge around the area. Water turbidity also becomes an initial indicator of pollution, which when confirmed through laboratory testing, is often accompanied by increased chemical and microbiological parameters.

In this study, water quality measurement was conducted based on physicochemical and microbiological parameters as stipulated in Government Regulation Number 22 of 2021 concerning Implementation of Environmental Protection and Management, specifically related to surface water quality standards. Physicochemical parameters tested include temperature, pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and iron (Fe) content, while microbiological parameters include the number of Escherichia coli bacteria per 100 mL of water. Significant turbidity levels in Pahandut Seberang are likely related to poor sanitation quality and high residential density, consistent with findings by Kospa & Rahmadi (2019) stating that water quality tends to decrease significantly in areas with direct domestic waste discharge activities into water bodies. Thus, visual analysis from Figure 1 provides initial indications of water pollution conditions reinforced by laboratory parameters, and emphasizes the importance of community-based pollution control in densely populated areas.

Table 2. Laboratory Water Quality Analysis Results

No	Parameter	Unit	Quality Standard Class	Laboratory Results		
				I	II	III
1	Temperature	°C	Deviation 3	27.63	27.77	28.33
2	pH		IV (6–9)	4.46	4.90	5.27
3	BOD	mg/L	I (2)	1.24	1.98	1.08
4	COD	mg/L	II (25), III (40)	28.8	46.63	33.90
5	Iron (Fe)	mg/L	I (0.3)	0.69	0.47	0.55
6	E. coli	count/100 ml	II (1000)	800	1000	767

Based on laboratory test results presented in Table 2, it can be analyzed that Kahayan River water quality at three sampling locations - Tumbang Rungan, Pahandut Seberang, and Bereng Bengkel - shows variations reflecting different pollution levels. Temperature parameters at all three locations range from 27.63°C to 28.33°C, still within normal range for tropical waters as explained by Mubarok & Suprayogi (2018), namely 25–32°C. However, water pH values show acidic conditions with ranges from 4.46 to 5.27, far below class IV water quality standard limits set in PP No. 22 of 2021, which is 6–9. This indicates that water at all three locations does not meet quality standards in terms of acidity.

Furthermore, BOD (Biological Oxygen Demand) values obtained range from 1.08 to 1.98 mg/L, still classified as class I category and showing that oxygen demand levels by microorganisms are still relatively low, not directly indicating severe organic pollution. Conversely, COD (Chemical Oxygen Demand) values range from 28.80 to 46.63 mg/L, indicating presence of organic and inorganic chemical compounds in high amounts, with some locations exceeding class II and III limits. The highest COD value was found in Pahandut Seberang, reinforcing suspicions that this area receives the largest domestic waste pollution load. Meanwhile, iron (Fe) content ranges from 0.55 to 0.69 mg/L, still acceptable according to class III quality standards.

Overall, these laboratory results reinforce visual observations of water physical conditions, particularly in Pahandut Seberang showing the highest turbidity levels. Low pH values and high COD levels become important indicators that organic and inorganic waste pollution, including from domestic sources, is a serious problem in the area. These findings align with previous research stating that river pollution in residential areas is closely related to minimal waste management systems and dense community activities around riverbanks (Astoeti et al., 2021). Thus, policy intervention and strengthening of environmental sanitation systems are needed to suppress potential for more severe pollution in the future.

Physicochemical parameters refer to physical properties of chemical compounds being studied, in this case water. In this study, physicochemical parameters measured include temperature, pH, BOD, COD, and Iron (Fe). Comparison results of water quality measurement from physicochemical parameters at 3 (three) research points are shown in Figure 2.
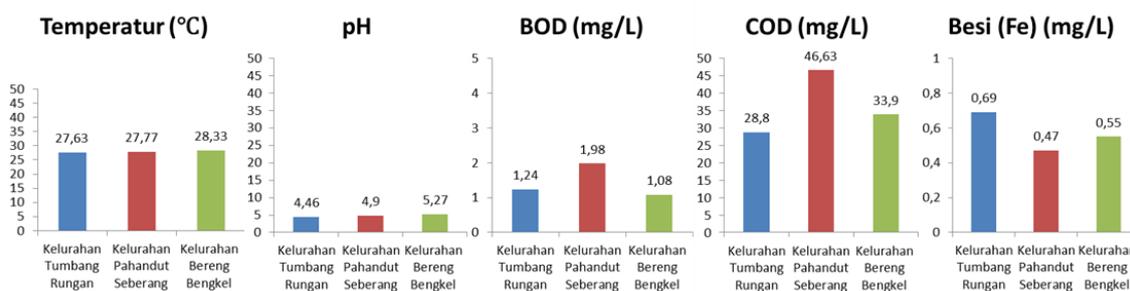

Figure 2. Comparison of Physicochemical Parameter Measurement Results at 3 (three) Research Points

From three sampling points including Tumbang Rungan, Pahandut Seberang, and Bereng Bengkel, physicochemical parameter information was obtained from each location. Temperatures obtained range from 27.63 - 28.33°C. According to Mubarok (2018), water temperatures in tropical areas ranging from 25 – 32 °C still meet requirements for aquatic organism life, so temperatures at the three locations are still normal for tropical areas. Water pH values obtained range from 4.46 – 5.27. According to PP. 22 of 2021 concerning Water Quality Management and Water Pollution Control, class IV water quality standards have pH

ranging from 6-9. This indicates that river water at all three locations does not meet quality standards and tends to be acidic considering the Kahayan river area is in a region with peat soil. BOD parameters obtained range from 1.08 – 1.98 mg/L, meaning according to PP. 22/2021 still classified as class I category. COD parameters obtained range from 28.8 – 46.63 mg/L, meaning according to PP. 22/2021 still classified as class II and III categories. Iron (Fe) parameters obtained range from 0.55 – 0.69 mg/L, meaning according to PP. 22/2021 still suitable for use.

Microbiological parameters refer to the presence or absence of micro-biological material in samples being studied, in this case water. In this study, microbiological parameters measured are the number of E. coli bacteria in every 100 mL sample. Water quality results for microbiological parameters at 3 (three) sampling points are presented in Figure 3.
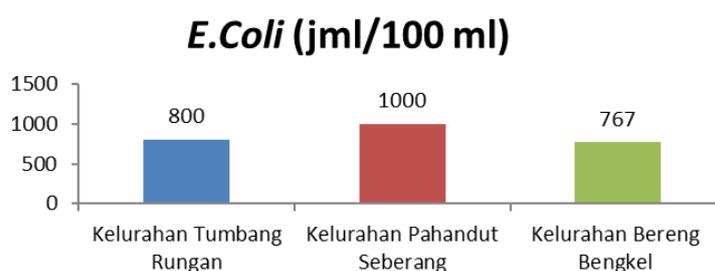

Figure 3. Water Quality for Microbiological Parameters

From all three sample locations, the number of E. coli bacteria in every 100 mL sample ranges from 767 – 1,000 count/100 mL. Since E. coli bacteria generally originate from digestion, this indicates that water at the three locations is contaminated by feces, in this case originating from community sewage waste. According to PP. 22 of 2021, water at all three locations is not suitable for drinking without undergoing treatment processes. Overall, analysis of physicochemical and microbiological parameters in the field based on river water quality standards according to PP. 22 of 2021 shows that water at all three locations is not suitable for drinking and has health risks if consumed directly without treatment processes.

Kahayan River water cannot be consumed because it does not comply with drinking water class quality standards according to PP 22/2021. Among the parameters used in water quality testing research, COD and E. coli content are the highest. This occurs especially in Pahandut Seberang Sub-district. Generally, accumulation/buildup of pollutants occurs from upstream to downstream. However, in this study, the area with the highest pollutant levels is in the middle. This is evidenced by decreased BOD and COD values in Bereng Bengkel (Downstream) which indicates natural dilution processes during river water flow. This dilution likely occurs due to reduced pollution input caused by fewer Bereng Bengkel residents compared to Pahandut Seberang. Additionally, the presence of tributaries around the Kahayan river causes increased river water discharge. This aligns with research by Mubarok (2018) where water quality at downstream sample points becomes better due to lower population density and increased water discharge from tributaries.

Research by Astoeti et al. (2021) states that high COD concentrations are caused by various activities and waste discharge, including home industry activities, settlements, and livestock farming. In line with this research, Kospa & Rahmadi (2019) state that COD will increase significantly if there are domestic waste flows and garbage accumulation. Behavior, lifestyle and habits, as well as sanitation conditions based on the availability of environmental sanitation facilities/infrastructure for household liquid waste management at the three locations are still in moderate category, so improvement is needed to reduce COD levels. For

waste management, Pahandut Seberang Sub-district needs to improve behavior, lifestyle and habits as well as availability of owned facilities/infrastructure.

E. coli bacteria examination cannot directly show the presence of pathogenic bacteria but can be used as an indicator of pathogenic organism presence (Marsono, 2009). Bacteriological quality of clean water has a relationship with diarrhea occurrence (Sidhi et al., 2016), so it is highly not recommended for consumption or activities related to hygiene. In waters with high microbiological parameters like Pahandut Seberang, there is great risk for diarrhea occurrence. This is evidenced by research results, where among the three locations, respondents experiencing diarrhea recently came from Pahandut Seberang.

Research results show that all water samples taken from Kahayan River areas, particularly in Pahandut Seberang and Bereng Bengkel regions, do not meet drinking water quality standards as regulated in PP No. 22 of 2021. This non-compliance is evident from various water quality parameters, especially low pH and high concentrations of Chemical Oxygen Demand (COD) and significant presence of Escherichia coli (E. coli). In Pahandut Seberang, average pH recorded around 4.90, far below the minimum threshold of 6.5 for drinking water, showing very acidic conditions and indicating heavy domestic waste contamination (Astoeti et al., 2021). Additionally, COD values at this location reach 46.63 mg/L, far exceeding the maximum limit of 25 mg/L for class II water, reflecting high organic pollutant loads from household activities without adequate waste treatment (Widyarani et al., 2022). E. coli concentrations reaching 1,000 per 100 mL further confirm fecal pollution due to poor sanitation, a problem commonly found in many urban areas in Indonesia (Kholila et al., 2021).

Conversely, in Bereng Bengkel area located further downstream, although pH values remain low (around 5.27) and E. coli remains high (around 767 per 100 mL), decreased COD concentrations (around 29.45 mg/L) and BOD (around 1.08 mg/L) were found. This decrease indicates natural dilution or self-purification processes commonly occurring in rivers with sufficient flow velocity and buffer vegetation (Pramaningsih et al., 2018). This phenomenon involves physical (dilution), chemical (sedimentation), and biological (degradation by microorganisms) processes that help reduce pollutant loads as river flow moves downstream. However, despite decreased pollutant levels, water quality in Bereng Bengkel still does not meet requirements for human consumption because microbiological and chemical parameters remain above safe thresholds. Therefore, these findings not only reflect local conditions but also provide a systemic picture of weak domestic waste management in Indonesia that directly impacts water resource quality and public health.

These research results provide significant scientific implications for various aspects of water resource management, environmental health, and sanitation governance in the Kahayan River area. The finding that all water samples do not comply with drinking water quality standards based on Government Regulation No. 22 of 2021, particularly low pH parameters, high Chemical Oxygen Demand (COD) concentrations, and significant presence of Escherichia coli (E. coli), reflects severe pollution conditions sourced from domestic waste. Epidemiologically, this poor water quality directly implies increased risk of waterborne diseases, commonly appearing in areas with inadequate sanitation. This condition shows that household wastewater management systems in the area are still not optimal and require strategic intervention through construction of communal-scale wastewater treatment plants (WWTP) and improvement of community-based sanitation facilities.

The decrease in COD and BOD levels in Bereng Bengkel area indeed shows natural dilution processes (self-purification), but this phenomenon cannot be used as a long-term solution because it is passive and does not solve the root causes of pollution. From

environmental governance perspectives, these findings indicate the need for strengthening regulations and law enforcement related to waste discharge into water bodies, and integration of cross-sectoral policies between technical agencies such as Environmental Services, Health Services, and Regional Planning Agencies. These research results become important foundations for more sustainable spatial planning, including arrangement of river border zones free from dense settlements, and development of data-based mitigation and adaptation policies on water quality. In academic contexts, this research also opens space for longitudinal and multivariate follow-up studies to evaluate water quality dynamics and effectiveness of policy interventions and waste treatment technology in urban river areas. Thus, implications of this research are not only limited to technical aspects of environmental management but also concern public policy formulation and infrastructure development supporting water resource sustainability and community health protection.

4. Conclusion

Research results on water quality at three riverside settlement locations along the Kahayan River in Palangka Raya City show that water conditions do not meet drinking water quality standards based on PP No. 22 of 2021. River water has high acidity levels (low pH), COD content exceeding thresholds, and significant numbers of E. coli bacteria, making it unsafe for consumption without treatment processes. The location with the highest pollution level was found in Pahandut Seberang Sub-district, consistent with high diarrhea cases in the area. On the other hand, lower BOD and COD levels in downstream areas (Bereng Bengkel) indicate natural dilution processes occurring due to reduced pollutants and additional water discharge from tributaries. These findings confirm the need for improved sanitation facilities, changes in community clean living behavior, and more effective waste management systems to reduce health risks from water pollution in riverside settlement areas.

Based on research findings, it is recommended that the government improve sanitation infrastructure, especially in Pahandut Seberang Sub-district, through provision of MCK (bathing, washing, toilet facilities) and domestic waste treatment. Community education about clean living behavior also needs to be intensified. Additionally, water quality monitoring systems must be strengthened, and riverbank environmental conservation encouraged to support natural dilution processes. Cross-sectoral collaboration becomes key in realizing sustainable and healthy river management for the community.

5. References

Astoeti, D. D., Gumiri, S., & Liswara Neneng, A. (2021). Analysis of Water Quality on Environmental Health of the Kahayan Riverside, Palangka Raya City, Central Kalimantan. *Rigeo*, *11*(5), 696–708. https://doi.org/10.48047/rigeo.11.05.66

Desrizal, D., Carlo, N., & Syah, N. (2019). The impacts of PETI on the Batang Hari River to the decline of water quality, land transfer function, socio-cultural life and the community economy. *Sumatra Journal of Disaster, Geography and Geography Education*, *3*(1), 54–61. https://doi.org/10.24036/SJDGGE.V3I1.182

Din, S. U., Ali, S., Nafees, M. A., Ali, H., Hassan, S. N., & Ali, Z. (2017). Physico-chemical assessment of water samples collected from some selected streams and rivers in district Gilgit, Pakistan. *Journal of Mountain Area Research*, *2*, 9–15. https://doi.org/10.53874/JMAR.V2I0.32

Dutta, S., & Nayek, S. (2020). Water quality of the ganges and brahmaputra rivers: an impact assessment on socioeconomic lives at Ganga–Brahmaputra River Basin. In

Sustainability in Environmental Engineering and Science: Select Proceedings of SEES 2019 (pp. 237–241). Springer. https://doi.org/10.1007/978-981-15-6887-9_26

Effiong, E. E., Ngah, S. A., Abam, T. K., & Ubong, I. U. (2022). Physicochemical Analysis of Samples of Water for Drinking and Sanitary Purposes in Selected Schools in Parts of Rivers State, Nigeria. *Environmental Contaminants Reviews (ECR)*, *5*(2), 72–77. https://doi.org/10.26480/ecr.02.2022.72.77

Fadhil, R., Yuliani, E., & Prayogo, T. B. (2025). Analisis Kualitas Air Menggunakan Metode Indeks Pencemaran, CCME-WQI, dan Qual2Kw Pada Sungai Sungai Metro, Kabupaten Malang, Jawa Timur. *Jurnal Teknologi Dan Rekayasa Sumber Daya Air*, *5*(1), 37–48. https://doi.org/10.21776/ub.jtresda.2025.005.01.005

Hoque, S. F., Peters, R., Whitehead, P., Hope, R., & Hossain, M. A. (2021). River pollution and social inequalities in Dhaka, Bangladesh. *Environmental Research Communications*, *3*(9), 95003. https://doi.org/10.1088/2515-7620/AC2458

Jannah, M. R., & Haribowo, R. (2025). Analisis Kualitas Air Menggunakan Metode Indeks Pencemaran Dan WQI Di Sungai Pilang, Pasuruan, Jawa Timur. *Jurnal Teknologi Dan Rekayasa Sumber Daya Air*, *5*(1), 647–654. https://doi.org/10.21776/ub.jtresda.2025.005.01.061

Juita, E. (2017). Studi Kualitas dan Penetapan Daya Tampung Beban Pencemaran Sungai Batang Kuranji. *Jurnal Spasial*, *1*(1), 1–15. https://doi.org/10.22202/JSL.2014.V%.I1.1570

Karnila, R. (2024). Kondisi Kualitas Sungai Bukit Batu Di Kabupaten Bengkalis. *Seminar SNAST (Seminar Nasional Aplikasi Sains Dan Teknologi)*, D140-148. https://doi.org/10.34151/prosidingsnast.v1i1.5012

Kholila, B. N., Soesilo, T. E. B., & Herdiansyah, H. (2021). The potential of in-silico approach to support government programs to achieve eco-friendly agriculture: Studies on urban agriculture. *IOP Conference Series: Earth and Environmental Science*, *716*(1), 12007. https://doi.org/10.1088/1755-1315/716/1/012007

Kospa, H. S. D., & Rahmadi, R. (2019). Pengaruh perilaku masyarakat terhadap kualitas air di Sungai Sekanak Kota Palembang. *Jurnal Ilmu Lingkungan*, *17*(2), 212–221. https://doi.org/10.14710/jil.17.2.212-221

Marsono, M. (2009). *Faktor-Faktor Yang Berhubungan Dengan Kualitas Bakteriologis Air Sumur Gali Di Permukiman Studi Di Desa Karanganom, Kecamatan Klaten Utara, Kabupaten Klaten*. Program Pascasarjana Universitas Diponegoro.

Mubarok, L. R., & Suprayogi, S. (2018). Kajian Karakteristik Pencemar Bagian Hulu Sungai Belik, Daerah Istimewa Yogyakarta. *Jurnal Bumi Indonesia*, *7*(4), 272532.

Nurhidayati, E. (2021). Penentuan Kualitas Permukiman Tepian Sungai Berdasarkan Kriteria Eco-Settlement Di Kelurahan Tambelan Sampit Kota Pontianak. *Jurnal Ilmiah Arsitektur*, *11*(2), 33–39. https://doi.org/10.32699/jiars.v11i2.2193

Oseji, M., Uwaifo, O. P., & Omogbeme, M. I. (2019). Assessment of physical and chemical characteristics of surface water from River Niger, Illushi, Edo State, Nigeria. *Journal of Applied Sciences and Environmental Management*, *23*(1), 195–199. https://doi.org/10.4314/JASEM.V23I1.29

Pramaningsih, V., Kurniawan, D., Yuliawati, R., Wahyuni, M., Habibi, M., & Apriliana, A. (2018). Source and Household Waste Management in Muara Bengkal Ilir, East Kalimantan. *Bali Medical Journal*, *31*, 40.

Pratiwi, A., Fachrul, M. F., & Hendrawan, D. I. (2020). Dampak Pemukiman Dan Kegiatan Di Tepi Sungai Terhadap Kualitas Air Sungai Baru Barat The Impact Of Settlement And Activities At The Riverbank On The Water Quality Of Baru Barat River. *Jurnal Teknik Lingkungan*, *26*(2), 49–60. https://doi.org/10.5614/j.tl.2020.26.2.4

Punjasawadwong, Y., Phongchiewboon, A., & Bunchungmongkol, N. (2014). Bispectral index for improving anaesthetic delivery and postoperative recovery. *Cochrane Database of Systematic Reviews*, *6*. https://doi.org/10.1002/14651858.CD003843.pub3

Sidhi, A. N., Raharjo, M., & Dewanti, N. A. Y. (2016). Hubungan kualitas sanitasi lingkungan dan bakteriologis air bersih terhadap kejadian diare pada balita di wilayah kerja puskesmas adiwerna kabupaten tegal. *Jurnal Kesehatan Masyarakat*, *4*(3), 665–676. https://doi.org/10.14710/jkm.v4i3.13480

Wahyuni, S., Yanti, N., & Idroes, G. M. (2023). Analysis of the Heavy Metal Content of Lead and Mercury in Freshwater Sea Shells in the Krueng Sabee River, Aceh Jaya. *Pharmacology, Medical Reports, Orthopedic, and Illness Details*, *2*(3).

Widyarani, Wulan, D. R., Hamidah, U., Komarulzaman, A., Rosmalina, R. T., & Sintawardani, N. (2022). Domestic wastewater in Indonesia: generation, characteristics and treatment. *Environmental Science and Pollution Research*, *29*(22), 32397–32414. https://doi.org/10.1007/s11356-022-19057-6

Yogafanny, E. (2015). Pengaruh aktifitas warga di sempadan sungai terhadap kualitas air Sungai Winongo. *Jurnal Sains & Teknologi Lingkungan*, *7*(1), 29–40. https://doi.org/10.20885/jstl.vol7.iss1.art3