



Temporal Dynamics of Total Organic Matter in the Brantas River, Kediri City, Indonesia

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ARTICLE INFO

Article History:

Received: July 23, 2025

Accepted: Sep. 30, 2025

Online: Oct. 30, 2025

Keywords:

Anthropogenic,
Brantas River,
Total organic matter,
Water quality

ABSTRACT

This study aimed to analyze the temporal dynamics of total organic matter (TOM) and to assess the level of organic pollution relative to water quality standards in the Brantas River ecosystem, Kediri City, Indonesia. The research was conducted in the downstream section of the Brantas River using a descriptive exploratory approach. The measured parameters included TOM, total suspended solids (TSS), turbidity, total solids (TDS), nitrate (NO_3^-), ammonia (NH_3), total oxygen (DO), pH, and temperature. Data were analyzed based on the classification system of the Indonesian Government Regulation No. 82/2001 concerning water quality management and pollution control. Results showed that the average concentration of TOM increased from 22.1mg/ L in the morning to 24.3mg/ L in the afternoon, indicating a 9.95% rise. TDS levels exhibited a minor change between morning (419mg/ L) and afternoon (423mg/ L) with a 0.95% increase. Nitrate concentrations slightly decreased from 3.5 to 3.8mg/ L, while TSS increased from 8.9 to 11.8mg/ L during the same period. These variations reflect the influence of diurnal anthropogenic activities such as TOMestic wastewater discharge, small-scale industrial effluents, and agricultural runoff on the temporal fluctuations of water quality. The findings highlight the importance of continuous monitoring of organic matter dynamics as an indicator of pollution in the Brantas River to support sustainable watershed management in Kediri City.

INTRODUCTION

Urban river basins in Southeast Asia are experiencing rapid transformations driven by population growth, land-use change, and industrial development. The Brantas River, as the longest and one of the most economically vital rivers in East Java, Indonesia, plays a critical role in supporting TOMestic, agricultural, and industrial water demands for

millions of residents. It flows through several major cities, including Malang, Blitar, and Kediri, before reaching the coastal estuary at Surabaya (**WorldBank, 2018**). Previous studies have primarily emphasized the hydrological and sedimentation challenges of the Brantas River system; however, less attention has been given to the temporal dynamics of total organic matter (TOM) under the influence of increasing urbanization and wastewater discharge (**Putri *et al.*, 2021**).

Urbanization along the Brantas River has accelerated significantly in recent decades. Rapid expansion of residential areas, industrial zones, and commercial infrastructure has altered the natural landscape, replacing vegetated areas with impervious surfaces that enhance runoff and pollutant transport (**Pribadi & Pauleit, 2015**). In Kediri City, for instance, TOMestic wastewater from densely populated settlements, small-scale food industries, and laundry businesses often flows directly into drainage canals connected to the Brantas River (**Sutjiningsih *et al.*, 2020**). Such unregulated discharges contribute high organic loads, nutrients, and suspended solids that directly affect water quality. According to the Ministry of Environment and Forestry (**KLHK, 2022**), the Brantas is among Indonesia's strategic but critically polluted rivers, reflecting the growing challenge of maintaining water quality in urban catchments.

From a scientific standpoint, total organic matter (TOM) serves as an important indicator of riverine ecological health, influencing oxygen demand, light penetration, and microbial activity (**Fellman *et al.*, 2010**). While many studies have quantified the spatial variability of organic pollutants in the Brantas and other Indonesian rivers, few have examined the temporal fluctuation of TOM concentrations in relation to diurnal or anthropogenic activity cycles. For example, previous monitoring programs have largely focused on seasonal variation (rainy and dry season) or pollutant load estimation (**Harsono *et al.*, 2020**), without addressing short-term changes within a single day caused by daily household or industrial activities. This represents a critical knowledge gap, as diurnal variation may provide early warning signals of organic input pulses that are otherwise masked in coarse temporal sampling frameworks.

The novelty of this study lies in its temporal-scale analysis of TOM variation across daily cycles in an urban river segment a perspective rarely addressed in Indonesian water-quality studies. By analyzing morning and afternoon samples over multiple observation periods, this research identifies how anthropogenic activities (TOMestic discharge, industrial operation, agricultural runoff) influence the diurnal fluctuation of organic pollutants in an urban river system. Such an approach bridges the gap between hydrological monitoring and ecological assessment by linking short-term human activity patterns with physicochemical water quality parameters.

Therefore, the objective of this study was to determine the temporal pattern of total organic matter concentration and associated water-quality parameters (TDS, TSS, NO_3^- , NH_3 , DO, pH, temperature) in the Brantas River, Kediri City, Indonesia. Furthermore, this study aimed to evaluate the organic pollution status based on national water-quality

standards (**Government Regulation No. 82/2001**) and to provide scientific insights for sustainable urban river management. By achieving these objectives, this paper contributes to a more comprehensive understanding of how urbanization and daily human activities influence the temporal dynamics of TOM in one of Indonesia's most important river systems.

MATERIALS AND METHODS

Study area and sampling period

Water sampling was carried out twice daily, in the morning (06:00) and afternoon (18:00), to capture diurnal variations in water quality parameters that correspond to fluctuations in human activities along the river. Morning samples represent baseline conditions before most domestic and industrial activities begin, while afternoon samples reflect the period of peak anthropogenic discharge such as household wastewater, market runoff, and small-scale industrial effluents. Sampling was conducted monthly from June to September 2025, and the results presented in this study represent the mean values from four monthly observation periods. The research site is located in the downstream segment of the Brantas River within Kediri City, East Java, Indonesia (7°48'41.7"S; 112°00'25.7"E) a densely populated and industrialized urban area receiving inputs from domestic, agricultural, and small-scale industrial sources.

Water samples were collected directly from midstream using 1,500mL polyethylene bottles, previously rinsed with river water to avoid contamination. For total oxygen (DO) analysis, samples were preserved in 140mL glass Winkler bottles without headspace to prevent gas exchange. The collected samples were immediately transported to the Water Quality Laboratory, Faculty of Fisheries and Animals Sciences, Islamic Lamongan University, for physicochemical analysis within 24 hours. Sampling was conducted under consistent weather conditions to minimize external variability.

Water quality parameters were determined using both *in-situ* and *ex-situ* measurements. *In-situ* parameters included temperature and pH, measured directly at the sampling site using calibrated portable meters. *Ex-situ* analyses included total organic matter (TOM), total suspended solids (TSS), total solids (TDS), turbidity, nitrate (NO_3^-), ammonia (NH_3), and total oxygen (DO).

Water quality analysis

Total organic matter (TOM)

TOM concentration was determined following the Indonesian National Standard (SNI) 06-6989.22-2004 using the permanganate oxidation method. A 100mL aliquot of each water sample was transferred into a 300mL Erlenmeyer flask, to which three boiling chips were added. The sample was treated with 0.01 N KMnO_4 solution until a faint pink color appeared, followed by the addition of 5mL of 8N sulfuric acid (H_2SO_4). The

mixture was heated at $105 \pm 2^\circ\text{C}$ on an electric hot plate for several minutes until the hydrogen sulfide odor disappeared. Then, 10mL of 0.01 N KMnO_4 was added and boiled for 10 minutes, followed by 10mL of 0.01 N oxalic acid solution. The sample was titrated with 0.01 N KMnO_4 until a faint pink endpoint appeared. The volume of KMnO_4 used was recorded to calculate TOM concentration (mg/L).

Temperature, pH, turbidity, and total solids (TDS)

Temperature and pH were measured *in situ* using a Hanna HI98194 multiparameter meter, while turbidity and TDS were analyzed with a portable turbidity meter (HACH 2100Q) and TDS meter (Lutron CD-4301), respectively. All instruments were calibrated before use.

Total oxygen (DO)

DO concentration was determined using the Winkler titrimetric method (SNI 06-6989.14-2004). Samples were fixed immediately upon collection by adding 1mL manganous sulfate (MnSO_4) and 1mL alkali-iodide-azide solution, followed by 1mL sulfuric acid to dissolve the precipitate. Fifty milliliters of the fixed sample was titrated with 0.025 N sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) solution until the blue color just disappeared. The DO concentration (mg/L) was calculated according to the standard formula:

$$\text{DO (mg/L)} = V \times N \times F$$

Where, V is the volume of $\text{Na}_2\text{S}_2\text{O}_3$ used (mL), N is the normality of $\text{Na}_2\text{S}_2\text{O}_3$, and F is the correction factor (bottle volume divided by the difference between bottle volume and reagent volume).

Total suspended solids (TSS)

TSS was analyzed according to SNI 06-6989.27:2004 (equivalent to APHA 2540 C-2012). Pre-weighed Whatman GF/A (934-AH) glass-fiber filters were used. Each water sample was homogenized using a magnetic stirrer, and an aliquot was filtered under vacuum. The filter was rinsed three times with 10 mL distilled water, dried in an oven at $103\text{--}105^\circ\text{C}$ for 1 hour, cooled in a desiccator, and re-weighed until a constant mass was achieved. TSS (mg/L) was computed using:

$$\text{TSS} = \frac{(A - B) \times 1000}{V}$$

Where, A = mass of filter + residue (mg), B = mass of clean filter (mg), and V = volume of filtered sample (mL).

Nitrate (NO_3^-)

Nitrate concentration was measured using a UV-Vis spectrophotometer (Shimadzu UV-1280) at 410 nm wavelength according to SNI 6989.79:2011. Samples were filtered through 0.45 μm membranes prior to measurement.

Data analysis

Temporal variations of each water-quality parameter were analyzed by comparing morning and afternoon concentrations across the sampling period. Statistical comparisons were conducted using descriptive analysis and percentage change between time intervals. Water quality classification was determined according to Government Regulation of the Republic of Indonesia No. 82/2001 on Water Quality Management and Pollution Control. Organic pollution status was further evaluated based on the Decree of the Minister of Environment No. 16/2016 concerning Environmental Quality Standards for Surface Water.

RESULTS

Temporal variations of water quality parameters

The results of water quality measurements including total organic matter (TOM), nitrate (NO_3^-), total solids (TDS), total suspended solids (TSS), total oxygen (DO), turbidity, pH, and temperature showed noticeable temporal variability between morning and afternoon observations. TOM concentration ranged from 18.8– 25.9mg/ L in the morning, with a mean value of 22.1mg/ L, and 20.3– 27.7mg/ L in the afternoon, averaging 24.3mg/ L. Nitrate concentrations were between 2.6– 5.4mg/ L in the morning (mean 3.5mg/ L) and 2.8– 5.6mg/ L in the afternoon (mean 3.8mg/ L). TDS ranged from 371– 507mg/ L in the morning (mean 419mg/ L) and 321– 528mg/ L in the afternoon (mean 423mg/ L).

Similarly, TSS levels varied between 6.4– 13.6mg/ L in the morning (mean 8.9mg/ L) and 8.6– 20.2mg/ L in the afternoon (mean 11.8mg/ L). DO concentration increased from 3.2– 4.1mg/ L (mean 3.5mg/ L) in the morning to 4.0– 5.7mg/ L (mean 4.8mg/ L) in the afternoon. Turbidity ranged from 19.5–29.7 NTU in the morning to 20.3–35.1 NTU in the afternoon, with respective means of 24.5 NTU and 28.7 NTU. pH values remained stable between 7.3–7.8, while water temperature ranged from 27– 29.5°C with a mean of 28°C. Overall, most parameters showed a moderate increase from morning to afternoon, indicating a clear diurnal pattern likely associated with anthropogenic activity intensification during daytime hours (Fig. 1).

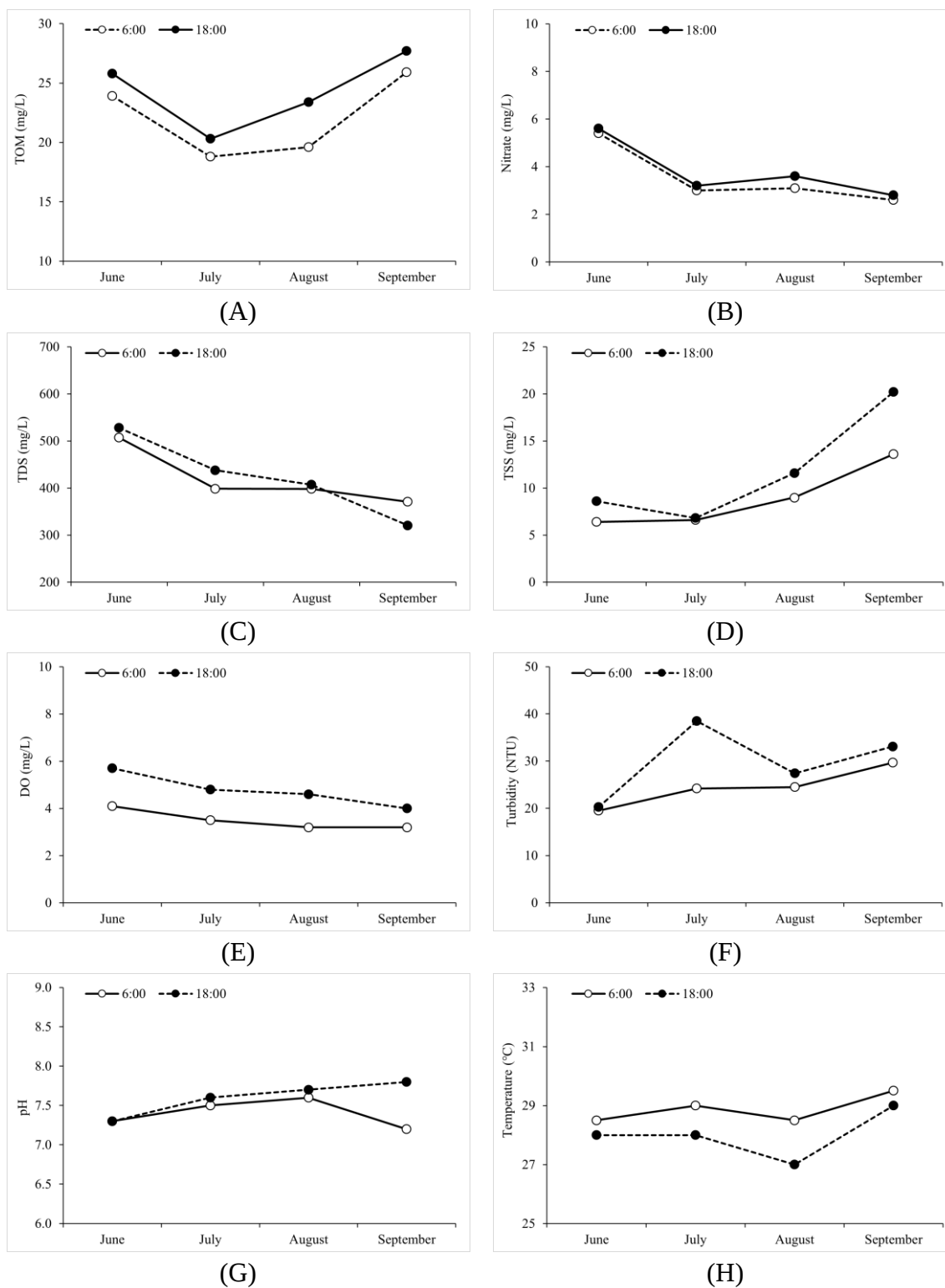


Fig. 1. Temporal variation of water quality: (A) TOM; (B) Nitrate; (C) Total dissolved solids; (D) Total suspended solids; (E) Dissolved oxygen; (F) Turbidity; (G) pH; (H) Temperature.

Relationship between TOM and nitrate

A weak correlation was observed between TOM and nitrate concentrations throughout the observation period (Fig. 2). The increase in TOM from morning to afternoon was not followed by a proportional increase in nitrate levels. This finding suggests that nitrogen mineralization and nitrification processes in the river were not occurring efficiently under the prevailing environmental conditions, possibly due to oxygen limitations or rapid organic matter turnover in the water column.

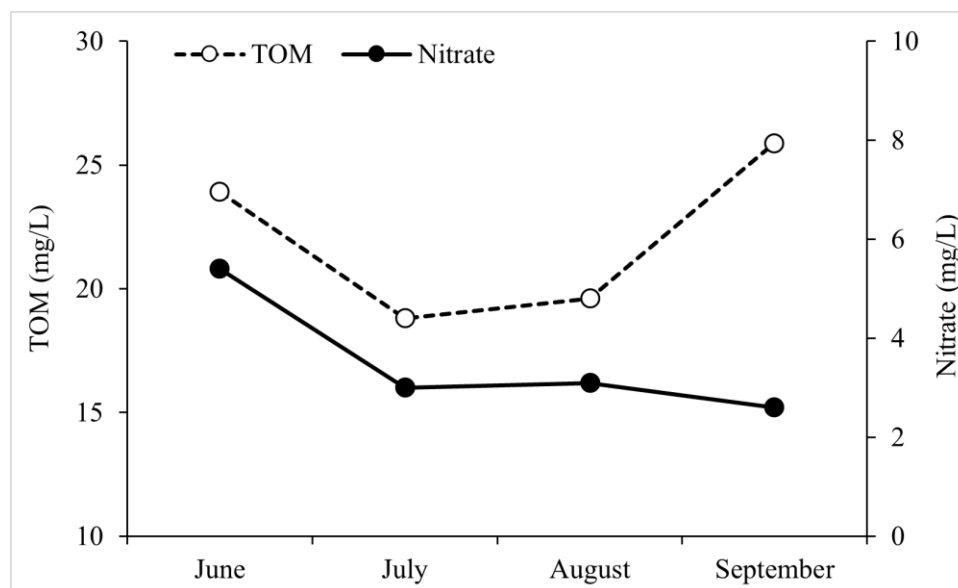


Fig. 2. Relationship between dissolved organic matter (TOM) and nitrate (NO_3^-) concentrations

Relationship between TDS and TSS

The relationship between TDS and TSS (Fig. 3) demonstrated that as suspended solids increased, the concentration of dissolved solids did not exhibit a parallel rise. This pattern indicates that mineralization and sediment resuspension processes were not strongly coupled in the Brantas River's downstream segment. Instead, the results reflect short-term increases in particulate matter mainly of anthropogenic origin rather than dissolution-driven processes.

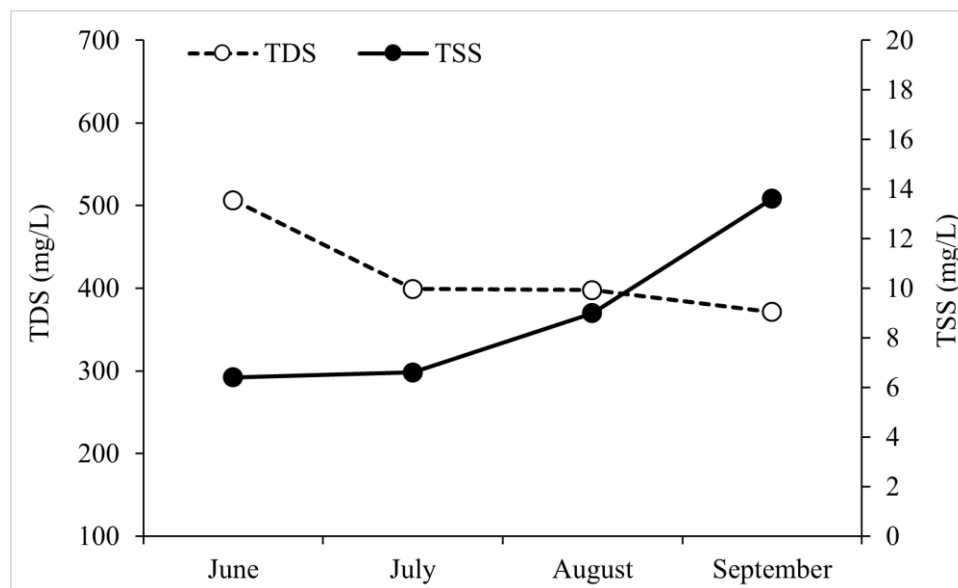


Fig. 4. Relationship between total dissolved solids (TDS) and total suspended solids (TSS)

DISCUSSION

Fluctuation of dissolved organic matter (TOM)

Temporal fluctuations in TOM concentration in the Brantas River revealed higher values in the afternoon compared to the morning. This pattern aligns with previous findings that organic matter concentrations tend to rise during periods of heightened human activity (**Amin, 2012**). In Kediri City, these daily variations likely stem from increased wastewater discharge from households, local food industries, laundry services, and markets, all of which intensify during the daytime. TOMestic and industrial effluents contribute high organic and nutrient loads that elevate the river's biochemical oxygen demand (BOD) and TOM content.

The increase in TOM concentration is closely linked to enhanced microbial activity, particularly heterotrophic bacteria that decompose dissolved and particulate organic matter, consuming oxygen in the process (**Al Zamzami et al., 2025; Ismail et al., 2025**). This microbial decomposition elevates the biochemical oxygen demand, which in turn affects dissolved oxygen dynamics throughout the diurnal cycle. Despite the afternoon rise in TOM, the concurrent increase in dissolved oxygen (DO) suggests that photosynthetic oxygen production and turbulent reaeration effectively offset microbial oxygen consumption in this flowing-water environment (**Silalahi, 2009**).

Similar TOM concentration ranges have been reported in other urban rivers in Indonesia. **Supriyantini et al. (2017)** observed values between 10.7– 50.0mg/ L in Semarang's estuarine systems, indicating that the Brantas River's downstream section exhibits moderate organic pollution. Elevated TOM levels in the afternoon may also reflect increased surface runoff during urban peak hours, carrying organic debris and suspended particulates into the river.

From an ecological standpoint, the rise in TOM influences oxygen dynamics by increasing microbial oxygen consumption. Nevertheless, the observed increase in DO during the afternoon suggests that reaeration and photosynthetic oxygen production may compensate for organic oxygen demand in this flowing-water system (**Silalahi, 2009**). This finding aligns with the characteristics of the Brantas as a turbulent, well-aerated river, which facilitates continuous oxygen exchange between water and air. These results emphasize the dynamic balance between organic loading, microbial oxygen demand, and physical reaeration processes in maintaining riverine oxygen equilibrium a relationship that is critical for managing pollution in urbanized tropical watersheds.

Variation of suspended and dissolved solids

Elevated TSS levels in the downstream Brantas section are indicative of sediment inputs from urban runoff and bank erosion. The catchment area surrounding Kediri includes densely built-up zones with limited vegetation cover, where soil erosion and waste discharge readily increase particulate matter concentrations. **Agustira and Lubis (2013)** noted that land-use conversion from vegetated to impervious surfaces significantly increases suspended sediment loads in tropical rivers.

Interestingly, while TSS values increased from morning to afternoon, TDS did not follow the same trend. This inconsistency implies that suspended particles largely composed of fine organic or inorganic debris did not undergo substantial dissolution or mineralization within short timeframes. According to **Widigdo (2001)**, the relationship between TSS and TDS is not always linear, as particle composition, density, and surface reactivity differ. The Brantas River's flow regime and sediment composition likely maintain much of the particulate load in suspension, leading to elevated turbidity with minimal increases in dissolved solids.

High turbidity can restrict light penetration, reducing photosynthetic activity and consequently influencing oxygen and nutrient dynamics (**Asrini et al., 2017**). Nonetheless, the persistence of relatively high DO concentrations in the afternoon suggests that reaeration processes remain TOMinant in maintaining oxygen balance within the system.

Anthropogenic influences and implications for river management

The consistent increase in TOM, TSS, and turbidity toward the afternoon underscores the influence of urban daily rhythms on water quality. This pattern demonstrates that wastewater inflow, industrial operations, and surface runoff contribute to diurnal fluctuations that can cumulatively affect riverine ecosystems. Although the magnitude of changes within a single day appears modest, prolonged and repetitive exposure can alter microbial community structures, nutrient cycling, and sediment oxygen demand (**Timm et al., 2001**).

From a management perspective, these findings emphasize the necessity of real-time or high-frequency monitoring in urban river systems. Conventional weekly or monthly sampling regimes may overlook critical short-term variations that signal pollution events. Integrating temporal analyses such as those used in this study could improve the detection of pollution pulses and guide regulatory responses by local authorities such as the East Java Environmental Agency (DLH Provinsi Jawa Timur).

Thus, the temporal behavior of TOM in the Brantas River serves as both an indicator and a diagnostic tool for assessing the effectiveness of waste management practices in Kediri's urban catchment. Targeted mitigation efforts such as decentralized wastewater treatment, riparian buffer restoration, and community-based pollution control could significantly reduce organic and particulate loading discharged to the river.

CONCLUSION

TOM concentrations in the Brantas River, Kediri City, exhibited a consistent increase from morning to afternoon, rising from an average of 22.1 to 24.3mg/ L (a 9.95% increase). This diurnal trend reflects intensified anthropogenic inputs, particularly TOMestic wastewater and small-scale industrial discharges, during daytime hours. Although the river's high flow and reaeration capacity help maintain DO above critical thresholds, the observed fluctuations in TOM, TSS, and turbidity indicate ongoing organic enrichment in the downstream segment.

According to the Government Regulation No. 82/2001 and Ministerial Decree No. 16/2016, the Brantas River at Kediri remains within Class II water quality limits but is approaching the upper threshold for organic pollution. Continuous monitoring and implementation of low-cost pollution control strategies are therefore essential to preserve the ecological function of this urban river system.

Acknowledgments

The authors would like to express their sincere appreciation to the Faculty of Fisheries and Animal Science, Lamongan Islamic University for providing laboratory facilities and technical assistance during water-quality analysis.

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