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Phytoplankton Diversity in Pelayaran River in Relation to Water Quality

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Abstract
The Pelayaran River located in Sidoarjo Regency, East Java runs through residential areas and rice fields. This river is used intensively by the community for irrigating rice fields and fish farming. However, increased human activity and change in land use affects negatively river ecosystem consisted of various aquatic organisms, including phytoplankton. Phytoplankton are highly sensitive to environmental changes, making them useful biological indicators. This study aims to analyze phytoplankton diversity and monitor water quality. This study uses descriptive observation methods at three stations. Phytoplankton diversity is calculated using the Shannon-Wiener formula, and water quality parameters are compared with PP No. 22 of 2021. The study identified 11 genera of phytoplankton across 7 classes. Phytoplankton diversity was 1.721, which is classified as moderate and slightly polluted water. Almost all parameters exceeded the quality standards, with only BOD and pH meeting the criteria.

Keywords: Plankton diversity; water quality; Pelayaran river; conservation
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INTRODUCTION

Water is vital for life, filling 71% of the Earth's surface. Only 2.5% of the Earth's water is accessible as fresh water, with most of it trapped within ice caps and glaciers (Mishra, 2023). According to Rahmatiyah et al. (2024), water is crucial for biological and cellular processes as well as for controlling climate and global temperature through heat absorption and release. Rivers are freshwater ecosystems that are vital to chemical and hydrological cycles. They act as catchment areas for water, and both natural and human activity have a major impact on their conditions. Rivers are essential for providing clean water and serving as a home for a variety of plants and animals (Kılıç, 2020).

Pelayaran fiver is located in Sidoarjo Regency, East Java. The nearby towns utilize the river as a source of clean water, for floating net-cage aquaculture, and to irrigate rice fields. Because this river is situated in an urban area, a variety of substances may find their way into the water. The stability of the freshwater environment may be affected by significant human disturbance along the river. Access to water may be strained by expanding populations, increasing waste and endangering ecological diversity (Kılıç, 2020). Pollution in rivers is mainly caused by human waste, particularly agricultural and urban waste (Anh, et al., 2023). The habitat and population of plankton and other aquatic organisms are threatened by degrading waterway conditions.

Plankton plays important role as bioindicators of biological disturbances in aquatic environments due to their sensitivity to changing environmental conditions. Plankton are microscopic organisms in aquatic ecosystems that drift through water currents. Phytoplankton are autotrophic planktons due to their chlorophyll content, which enables them to function as primary producers in the food chain of aquatic ecosystem. In addition, they also play an essential role in providing oxygen and regulating the carbon cycle (Sarker et al., 2023). Biological, physical, and chemical substances affected plankton growth rates, including temperature, water transparency, pH, and oxygen (Ankita et al., 2021). Previous studies in the Lamong River revealed 13 phytoplankton genera (Firmansyah & Wisanti, 2025).

The aquatic environment is threatened by human population growth in residential area. Therefore, it is crucial to evaluate river quality through biological, chemical, and physical water indicators. Due to limited data on phytoplankton communities in the Pelayaan River, it was necessary to conduct research on phytoplankton diversity and the physical-chemical parameters of the water to provide information on water conditions in the river.

MATERIALS AND METHODS

This analytical observational study was conducted in April 2025. Three stations with different conditions and uses around the river, at residential and agricultural areas were examined. Each station has six sampling points. Station 1 located at coordinate 7°24'23"S 112°31'52"E upstream of the river in a residential area, station 2 at coordinate 7°23'58"S 112°33'52"E located near an agricultural area and floating net cages, and Station 3 at coordinate 7°23'23"S 112°34'33"E and located in a residential area with more waste in the river flow (Figure 1).

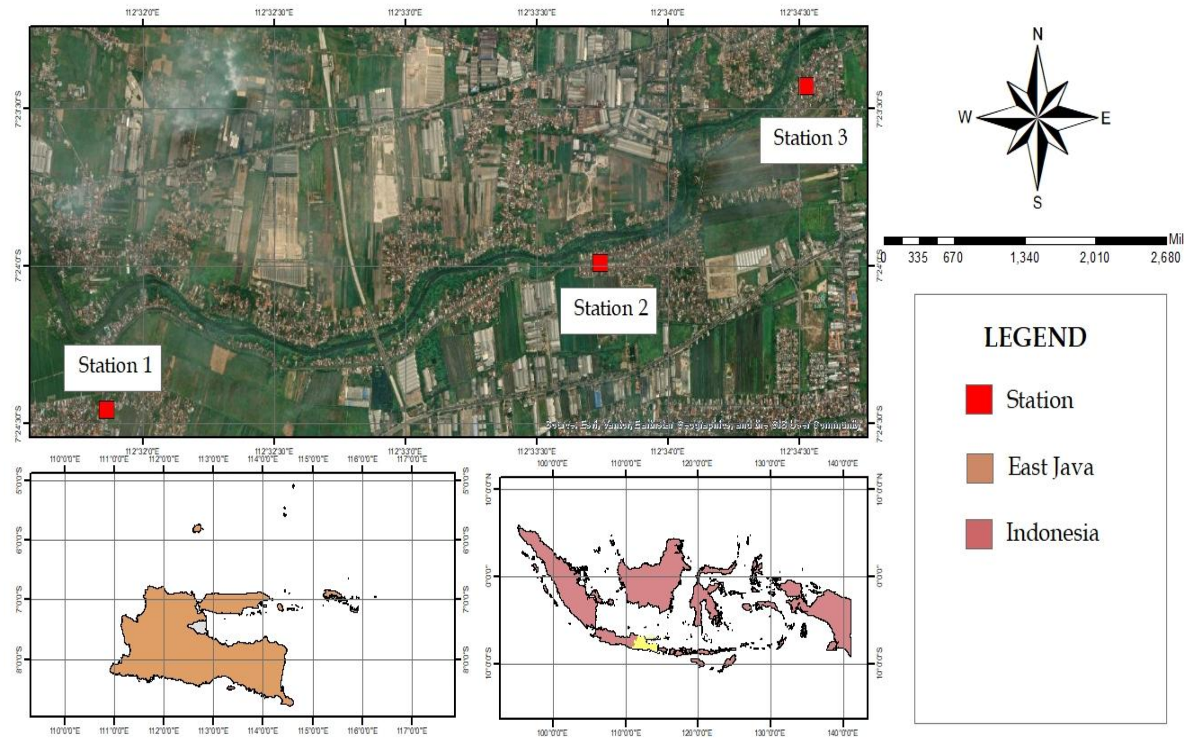

Figure 1. Sampling site

The sampling process was carried out from 09.00 to 11.30 WIB. A plankton net was used to gather plankton samples after river water was filtered ten times with a 10-liter container. Water samples were collected in 100-ml bottles and placed in 15-ml vials. After adding three drops of 4% formalin, the samples were labeled with the sampling point. Plankton was identified using the identification books by Sulastri (2018) and Vuuren et al. (2006). Direct measurements of pH, temperature, transparency, current velocity, DO, and BOD were made in the sampling site. Water quality measurements were compared to standards as established in PP No. 22 of 2021.

The Shannon-Wiener plankton diversity index was used to examine plankton diversity based on identification results. The diversity index values were adjusted using the Shannon-Wiener index and pollution level criteria by Lee et al. (1978) using the following formula:

$$H' = \sum_{t=1}^{S} Pi \ln Pi$$

Note:
H' = Shannon-Wiener diversity index
Pi = number of individuals of the i species
N = total number of individuals
S = number of genera

RESULTS

Plankton identification in the Pelayaran River, Sidoarjo, resulted in 11 genera belonging to 7 classes of phytoplankton: Bacillariophyceae (5 genera), Cyanophyceae (1 genera), Chlorophyceae (1 genera), Zygnematophyceae (1 genera), Trebouxiophyceae (1 genera), Ulvophyceae (1 genera), and Euglenophyceae (1 genera) (Figure 2). According to the identification results, the Bacillariophyceae class is dominant (Table 1).

Table 1. Distribution of plankton at each station in the Pelayaran River

No	Classes	Family	Genera	Station		
				I	II	III
1	Bacillariophyceae	Bacillariaceae	*Nitzschia*	✓	✓	✓
2		Fragillariaceae	*Synedra*	✓	✓	✓
3			*Diatoma*		✓	
4		Naviculaceae	*Frustulia*	✓	✓	
5			*Navicula*	✓	✓	✓
6	Cyanophyceae	Oscillatoriaceae	*Oscillatoria*	✓	✓	✓
7	Chlorophyceae	Chlamydomonaceae	*Chlamydomonas*	✓	✓	✓
8	Zygnematophyceae	Gonatozygaceae	*Gonatozygon*	✓		
9	Trebouxiophyceae	Oocystaceae	*Oocystis*		✓	
10	Ulvophyceae	Cladophoraceae	*Rhizoclonium*		✓	
11	Euglenophyceae	Euglenaceae	*Trachelomonas*	✓		

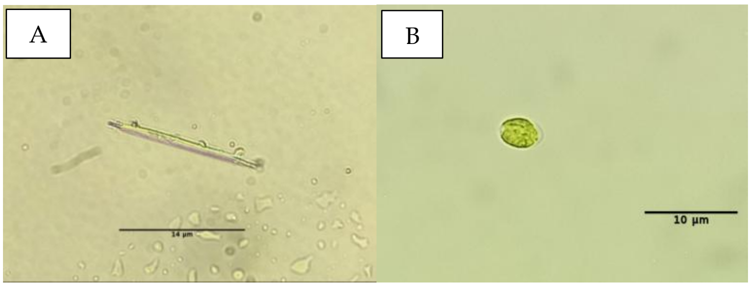

Figure 2. Phytoplankton found (A) *Synedra*, (B) *Chlamydomonas*

The Pelayaran River's average diversity index was found at 1.721. This value implied the three research stations had moderate plankton diversity. Station 2 had the highest diversity index (1.985), while Station 3 had the lowest (1.412) (Table 2). The results of physical and chemical measurements of water in the Pelayaran River compared to PP No. 21 of 2021 on the Implementation of Environmental Protection and Management indicated that temperature and DO have exceeded the quality standards (Table 3).

Table 2. Plankton diversity index in Pelayaran River

Station	Diversity Index	Mean
Station 1	1.766	
Station 2	1.985	1.721 ± 0.28
Station 3	1.412	

Table 3. Result of physical and chemical measurements of water parameters

No.	Parameters	Average*			
		Station 1	Station 2	Station 3	Quality Standard
1	Temperature (C)	29.2	29.6	30.1	22-28
2	Current velocity (m/s)	0.25	0.27	0.24	-
3	Transparency (cm)	12	15.9	11.1	-
4	pH	7.19	7.14	7.18	6-9
5	Dissolved Oxygen (mg/l)	2.53	2.77	2.46	Minimum 6 mg/L
6	Biological Oxygen Demand (mg/l)	1.38	1.34	1.46	Maximum 2 mg/L

*)Note: The water quality standards refer to Government Regulation No. 22 of 2021.

DISCUSSION

According to the result, eleven genera of phytoplankton found were from seven classes. Navicula was the most commonly found genera. However, none of the three stations found zooplankton. Because the sample period was from morning to noon, the zooplankton had already anchored itself at the river's bottom. This is supported by Rusdiyani and Purnomo (2020), zooplankton typically migrate toward the water column's surface at night and to the bottom from morning to midday. Variations in phototactic responses also influence the presence of phytoplankton and zooplankton. Phytoplankton have positive phototaxis toward light for photosynthesis, thus, they move to surface during the day to receive the most sunlight. In contrast, zooplankton moves away from light due to negative phototaxis. The results of this study showed lower plankton community diversity than that reported by Uhibbulloh & Purnomo (2025) in the Kromong River, Pacet, where 20 genera of phytoplankton were identified. The low diversity of the plankton community was possibly caused by the amount of waste entering the water body, given the river's location in a residential area.

The results of plankton identification conducted at the three stations show that the Bacillariophyceae class dominates plankton. Bacillariophyceae, or diatoms, are a cosmopolitan group of microalgae found in various types of water bodies, both freshwater and marine. Bacillariophyceae are divided into orders Pennales and Centrales. A characteristic feature of this class is the silica components in the cell wall (Lee et al., 2023). Diatoms' prevalence indicates that the river ecosystem supports their growth and reproduction. Bacillariophyceae was found widespread and thrives in contaminated habitats. Diatoms respond to harsh conditions by increasing mucus production on their surface (Rahman et al., 2022) as protective measure.

The composition of plankton populations in the water reflects to the quality of aquatic ecosystems. Environmental conditions affect plankton diversity and composition. Plankton plays an important part in the food chain, so its presence can be used to estimate river fertility or pollution levels. Poor waste disposal practices and dumping household waste into rivers from local community might harm aquatic ecosystems due to rising amounts of organic matter and toxic compounds in the water. (Maulana and Kuntjoro, 2023). Consistent with Yulianto and Purnomo (2023), anthropogenic activities and river environmental conditions affected number and composition of plankton in the water. Additionally, the availability of nutrients like phosphate and nitrate and each plankton species capacity to consume these nutrients determine the diversity of plankton in the water. The average plankton diversity index of the Pelayaran River was 1,721±0.28 (Table 2). The result 1 > H' > 2 showed moderate diversity according to the Shannon-Wiener diversity index. However, based on the pollution criteria by Lee et al. (1978), the Pelayaran River was classified as slightly polluted.

Recorded temperature in Pelayaran river varied between 29.2 and 30.1°C (Table 3). The temperature was highest at Station 2 and lowest at Station 1. According to Johnson et al. (2024), rising water temperatures might be affected by altered land use and climate. Some areas see stronger sunlight as a result of the loss of trees close to the river. Temperature of water significantly affects the growth and metabolism of various plankton. For example, ideal temperatures accelerate photosynthesis rate in tropical phytoplankton. According to Hao et al. (2024), an increase in water temperature affects the respiration and photosynthesis of phytoplankton, which speeds up their growth and reproduction. However, these rates will begin to decline once a certain point is reached.

The average range of the current velocity measurement values was 0.24–0.27 m/s (Table 3), categorized as moderate to slow. Water currents greatly affect the life and distribution of aquatic organisms such as plankton. Unequal distribution of plankton is caused by variations in the currents at the surface and bottom. Adequate currents at the surface of river can increase the distribution of plankton in a body of water, due to the passive nature of plankton (Widianingsih et al, 2007).

The brightness measurements of the Pelayaran River ranged from 11.1 cm to 15.9 cm (Table 3). By raising suspended particle levels, anthropogenic activities and natural changes can reduce river brightness (Yamamichi et al, 2021). The weather at the time of observation also influences river brightness. The river water becomes muddy due to the community's waste. Because excessive turbidity hinders light penetration, it can be detrimental to aquatic life (Lednicka et al, 2022). Low light levels can lower photosynthesis and phytoplankton metabolism.

Acidity (pH) levels in the Pelayaran River ranged from 7.14 to 7.19 (Table 3). In compliance with PP No. 22 of 2021, this pH value still satisfies the river pH quality standard of 6–9. Photosynthesis, temperature, and human waste all have an impact on the pH of water. According to Gurning et al.(2020), plankton tolerate pH values ranging from 6 to 8. For aquatic life to survive, pH is crucial. Acidic water resulted from pH lowering can result in negative effect by interfering with the rate of many biological processes such as growth, respiration, and metabolism (Alhassan & Matias-Peralta, 2015).

The dissolved oxygen level was found to be reduced, ranging from 2.46 to 2.77 mg/L (Table 3), which did not fulfill the requirements established by PP No. 22 of 2021. Natasha and Adharini (2022) indicated that domestic organic waste originating from urban areas could decrease oxygen supply, consequently disturbing ecological water conditions. Low levels of dissolved oxygen in water indicate that the river water has been contaminated by pollutants. The decomposition of organic matter and the metabolism, respiration, and growth of aquatic species depend heavily on the availability of dissolved oxygen in aquatic environments (Adithiya et al, 2023).

The BOD concentration was within the standard range at 1.32 to 1.46 mg/l, with a maximum of 2 mg/l (Table 3). Because station 3 is in a residential neighbourhood with several community waste disposal activities, it has a high BOD concentration. Large amounts of domestic and agricultural garbage in rivers may eliminate the level of oxygen in the water, which can lower BOD levels and endanger the aquatic environment (Vigiak et al., 2019). Waterways with significant BOD levels contain many pollutants, and because microorganisms need oxygen to break down organic material, this lowers oxygen concentrations (Napitupulu & Putra, 2024).

Land use varied among these three observation sites, which included residential areas, aquaculture with floating nets, and near agricultural land. Station 1 had a generally clean river and was located in a residential area. However, based on observation during the study, local residents still disposed waste into the water. The phytoplankton diversity at Station 1 was 1.766, classified as moderate. Station 2 is located near an agricultural area within a floating net cage. A few aquatic vegetation was observed, however most of the surface remains clear. Water quality might also be affected by waste from rice fields. Station 2, with index of 1.985, had the highest phytoplankton diversity due to ecosystem conditions supported the growth of phytoplankton. Station 3 was located in residential area with heavy pollution. Station 3 had index of 1.412 and showed the lowest level of diversity. Because of the poor water and plenty of rubbish, only a few plankton species could be observed from this site. As stated by Almroth & Eggert (2019), rubbish in water bodies affects negatively to aquatic organisms.

Several of the standard specifications for qater quality as established by government have been surpassed in the study, indicating a decline in river conditions. Furthermore, the number of plankton species decreased at different observation point, implying a potential disruption to ecosystem resilience. Resulting waste from human behavior contributes significantly to river ecological disruption (Ahn et al, 2023). However, many living beings, including human, can be harmed by contaminated waters. The findings of the study reveal how critical plankton communities are in determining the environmental condition of the river. A few tolerant plankton are indicators of environmental pressure. The health of all living creatures depends on the regular management and monitoring of river quality.

CONCLUSION

The Pelayaran River in Sidoarjo, East Java was found to have a moderate plankton diversity of 1.721 and mild water pollution. Based on PP No. 22 of 2021, the pH and BOD parameters met the criteria, while dissolved oxygen and temperature did not comply with quality standards.

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CONFLICT OF INTEREST

There is no conflict of interest

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