



Phytoplankton Composition and Abundance as an Indicator of Water Quality in The Post-Sand Mining Swamp of Kranjingan, Jember

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ARTICLE INFO

E-ISSN: 2721-0804
P-ISSN: 2723-6838
Vol. 6, No. 2, December 2024
URL: <https://usnsj.id/index.php/biology/index>

Suggestion for the Citation and Bibliography

Citation in Text:

Purwandari, (2024)

Bibliography:

Purwandari, A.R. (2024). Phytoplankton Composition and Abundance as an Indicator of Water Quality in The Post-Sand Mining Swamp of Kranjingan, Jember. *Journal of Biological Science and Education*, 6(2), 99-107

Abstract

The analysis of water quality in the post-sand mining swamp of Kranjingan indicates that the aquatic environment is in relatively good condition, with a neutral to slightly alkaline pH, stable temperature, and total dissolved solids (TDS) within acceptable limits. Although slight variations were observed between stations, particularly at Station 4, which recorded the highest TDS value, the overall water conditions still support the sustainability of the aquatic ecosystem and allow for various sustainable utilizations. The study's objective is to analyze the water quality in the post-sand mining swamp of Kranjingan and evaluate the sustainability of the aquatic ecosystem in the area. This research also aims to understand the composition and abundance of phytoplankton to determine the trophic status of the ecosystem. The study results show that the composition and abundance of phytoplankton in the post-mining swamp exhibit oligotrophic characteristics, with a dominance of the Cyanophyta phylum, particularly *Microcystis*. The highest phytoplankton diversity was found at Station 2, while Station 4 demonstrated relatively stable abundance. These findings provide essential insights into the management and utilization of post-sand mining swamps for both ecological and economic purposes.

Keywords: Phytoplankton, Water Quality, Post-Sand Mining Swamp, Kranjingan, Jember

A. Introduction

An ecosystem is an ecological system consisting of reciprocal relationships between living organisms and their environment. One of the most important ecosystems is the aquatic ecosystem, which includes various organisms such as fish, shrimp, and crocodiles that interact with abiotic components like water, air, and light. Aquatic ecosystems can be categorized into marine and freshwater ecosystems, with freshwater ecosystems further divided into two main types: lentic (standing water) and lotic (flowing water) systems (Yanti et al., 2024).

Natural water bodies such as swamps play a significant ecological role, particularly as habitats for various aquatic organisms. One of the key components of aquatic ecosystems is phytoplankton, which functions as a primary producer. Phytoplankton serves as a food source for other organisms and can be used as a bioindicator of water quality. The diversity and abundance

of phytoplankton can reflect environmental conditions and the trophic status of a water body (Anhar et al., 2023). The study's objective is to analyze the water quality in the post-sand mining swamp of Kranjingan and evaluate the sustainability of the aquatic ecosystem in the area. This research also aims to understand the composition and abundance of phytoplankton to determine the trophic status of the ecosystem.

Post-sand mining swamps are an example of water bodies that undergo ecological changes due to mining activities. The mining process can increase the concentration of organic matter and nutrients in the water, ultimately affecting the abundance and composition of aquatic organisms, including phytoplankton. Therefore, analyzing the abundance and composition of phytoplankton in post-sand mining swamps can be an effective approach to estimating the trophic status of these waters.

Estimating trophic status based on phytoplankton abundance involves identifying dominant phytoplankton species, assessing their relative abundance, and measuring diversity levels. This information can be used to evaluate water fertility and its potential utilization. A well-defined understanding of the trophic status of post-sand mining swamps allows for optimal management and utilization strategies, such as fish farming or ecotourism development.

This study was conducted in the Post-Sand Mining Swamp of Kranjingan, Jember, to assess the water conditions based on water quality, as well as the composition and abundance of phytoplankton. The findings of this study are expected to serve as a reference for the management of post-mining aquatic environments and to support conservation and rehabilitation efforts for swamp ecosystems.

B. Literature Review

An aquatic ecosystem refers to the interaction between aquatic organisms, such as fish, crocodiles, shrimp, and others, with non-living components like rocks, air, and water. Aquatic ecosystems include freshwater and marine ecosystems. Freshwater habitats are generally classified into two categories: lentic systems (ponds, lakes, swamps, reservoirs) and lotic systems (rivers). Lentic systems are characterized by standing water with little to no flow, while lotic systems have a significant water current, classifying them as flowing water ecosystems (Sri Wahyuni & Rosanti Dewi, 2016).

A swamp is a waterlogged area that forms naturally, either permanently or seasonally, due to obstructed drainage and is characterized by distinct physical, chemical, and biological properties (Lestari et al., 2021).

Plankton are organisms that float or drift in the water and play an essential role in aquatic ecosystems. Their movement is relatively passive, as they are carried by water currents. Plankton consist of phytoplankton and zooplankton. Phytoplankton serve as primary producers that can convert inorganic substances into organic matter through photosynthesis. They play a crucial role in the food chain as primary consumers within aquatic ecosystems (Sri Wahyuni & Rosanti Dewi, 2016).

Phytoplankton are vital organisms in aquatic life. They are also the largest contributors of oxygen in a water body. Their ability to perform photosynthesis makes them the initial energy capturers from sunlight, playing a key role in sustaining aquatic ecosystems (Leidonald et al., 2022). Additionally, as primary producers in the food chain, phytoplankton contribute to ecosystem balance due to their large biomass. In the food chain, phytoplankton serve as a food source for zooplankton, fish larvae, and other herbivorous organisms (Yanti et al., 2024).

The composition and abundance of phytoplankton can indicate water quality. Phytoplankton diversity serves as a benchmark for assessing pollution levels in a water body, while their abundance reflects phytoplankton density in a specific area (Balqis et al., 2021).

Water quality can be defined as the threshold of water parameters that determine its suitability for specific uses (Pohan et al., 2017). These concentration limits are established based on scientific research findings (Kospa & Rahmadi, 2019). Organic matter causes environmental changes such as water eutrophication, leading to increased primary productivity and the loss of benthic fauna diversity (Rina et al., 2023).

The physical, chemical, and biological conditions of a water body can serve as indicators of phytoplankton composition and abundance, providing insight into water quality assessment (Yanti et al., 2024). The abundance of phytoplankton in a water body is closely related to environmental conditions (Pipit Muliyah et al., 2020). Human activities generating domestic waste also contribute pollutants that alter the physical, chemical, and biological properties of groundwater.

C. Methodology

1. Research Design

This study was conducted using a survey method with purposive sampling, based on the environmental conditions of the water body. Sample collection was carried out in the post-sand mining swamp located in Kranjingan Subdistrict, Summersari District, Jember. Samples were taken from four stations, each representing different activities in the area. The method in this study involves measuring water pH, water temperature, and TDS.

The sampling stations in the swamp are as follows: Station 1 is the inlet area where water enters from an underground spring. Station 2 is the central part of the swamp, frequently used for community activities. Station 3 is a section of the swamp utilized by the local community as a fishing area. Meanwhile, Station 4 serves as the swamp's outlet, used by residents as a source of irrigation for rice fields (**Figure 1**).



Figure 1. Map of Water Quality and Phytoplankton Sampling Locations

2. Instruments

This study was conducted at the Integrated Laboratory of PGRI Argopuro University, Jember. The equipment used in this study included sample bottles, a 60-mesh plankton net, a 10-liter plastic bucket, a dropper pipette, a Sedgwick-Rafter chamber, a microscope, a digital camera, and writing materials. The reagent used in this study was Lugol's solution. Water samples were collected using a 10-liter bucket three times. Phytoplankton samples were taken by selecting specific sampling stations. The water samples were then filtered using a 60-mesh plankton net and collected in sample bottles. The phytoplankton samples were immediately preserved with three drops of Lugol's solution. Each sample was labeled with the sampling location and date before being observed under a microscope. Water quality parameters, including pH, temperature, and TDS, were measured at each observation station using a pH meter, a mercury thermometer, and a TDS meter. The results were then recorded.

Phytoplankton identification was conducted using a microscope, and species were determined based on the identification guide by Mizuno (1979). The individual count was performed using a Sedgwick-Rafter chamber with the Strip Counting method. The procedure involved placing 1 mL of the water sample into the chamber and then observing it under a microscope. The number of phytoplankton cells per liter of water was calculated using the formula by Edmonson (1971):

$$N = \left(\frac{ns \times va}{vs \times vc} \right)$$

Description:

N = Number of plankton per liter of the water sample

ns = Number of individual plankton observed in the Sedgwick-Rafter chamber

va = Volume of concentrated water in the sample bottle (25 mL)

vs = Volume of water in the Sedgwick-Rafter chamber (1 mL)

vc = Volume of filtered water (30 L).

3. *Technique of Data Analysis*

Data analysis in this study used descriptive. The data collected is analyzed and interpreted, then described to describe the conditions that occur in the research subjects. The trophic status analysis based on phytoplankton abundance follows the guidelines of Landner (1978), which classify water bodies as follows:

- a. Oligotrophic waters: Low-nutrient waters with a phytoplankton abundance ranging from 0 to 2,000 individuals per milliliter (ind/mL).
- b. Mesotrophic waters: Moderately fertile waters with a phytoplankton abundance ranging from 2,000 to 15,000 ind/mL.
- c. Eutrophic waters: Highly fertile waters with a phytoplankton abundance of more than 15,000 ind/mL.

D. Findings and Discussion

1. *Findings*

Phytoplankton Species Composition

The research results indicate that the phytoplankton composition in the post-sand mining swamp of Kranjingan Subdistrict, Summersari District, Jember varies across the sampling stations. In general, the identified phytoplankton belong to four main phyla: **Chlorophyta, Chrysophyta, Cyanophyta, and Pyrrophyta**. The phytoplankton composition based on its phylum can be easily observed in Table 1.

Table 1. Phytoplankton Phyla Found at Each Station

Phytoplankton Phylum	Station 1	Station 2	Station 3	Station 4	Total Genus
Chlorophyta	6	10	23	5	44
Chrysophyta	4	20	1	6	31
Cyanophyta	7	3	1	3	14
Phyrophyta	1	0	0	0	1
Rhodophyta	0	0	2	0	2

The Chlorophyta phylum had the highest number of genera across all stations, with a total of 44 genera. Station 3 exhibited the highest composition (23 genera), indicating a high diversity of green algae in the area. The Chrysophyta phylum also showed high diversity, particularly at Station 2 with 20 genera, suggesting water conditions favorable for diatom growth. The Cyanophyta phylum was more dominant at Station 1 with 7 genera, indicating that the environment at this station supports the growth of blue-green algae, which can thrive in extreme conditions. The Pyrrophyta phylum was only found at Station 1 with a single genus (*Peridinium*), suggesting that dinoflagellates are less developed in this aquatic environment. The Rhodophyta phylum was found only at Station 3 with two genera, indicating the presence of red algae, although in small numbers.

Overall, the waters in the post-sand mining swamp exhibited varying levels of phytoplankton diversity across different stations, with Chlorophyta and Chrysophyta being the dominant phyla. This indicates that the aquatic ecosystem still has the potential for primary productivity, although it is classified as oligotrophic with low fertility levels.

At Station 1, the phytoplankton community was dominated by Chlorophyta, Chrysophyta, and Cyanophyta, with relatively high diversity. Commonly found genera included *Chlorella*, *Genicularia*, *Microcystis*, and *Oscillatoria*.

Station 2 exhibited the highest phytoplankton diversity compared to other stations, with a dominance of the Chrysophyta phylum, consisting of various genera such as *Synedra*, *Navicula*, and *Nitzschia*. This suggests that the water conditions in the central part of the swamp support a more diverse phytoplankton community.

At Station 3, the Rhodophyta phylum was detected, which was absent in other stations, although present in smaller numbers. Chlorophyta remained the dominant phylum, with the presence of genera such as *Spirogyra*, *Pandorina*, and *Apatococcus*.

At Station 4, phytoplankton was dominated by three main phyla: Chlorophyta, Cyanophyta, and Chrysophyta. The genera *Oscillatoria*, *Spirulina*, and *Cyclotella* were relatively abundant, indicating adaptation to the environmental conditions in the swamp outlet area, which is used for irrigating local rice fields. A more detailed overview of the phytoplankton composition at each station can be seen in (Figure 2).

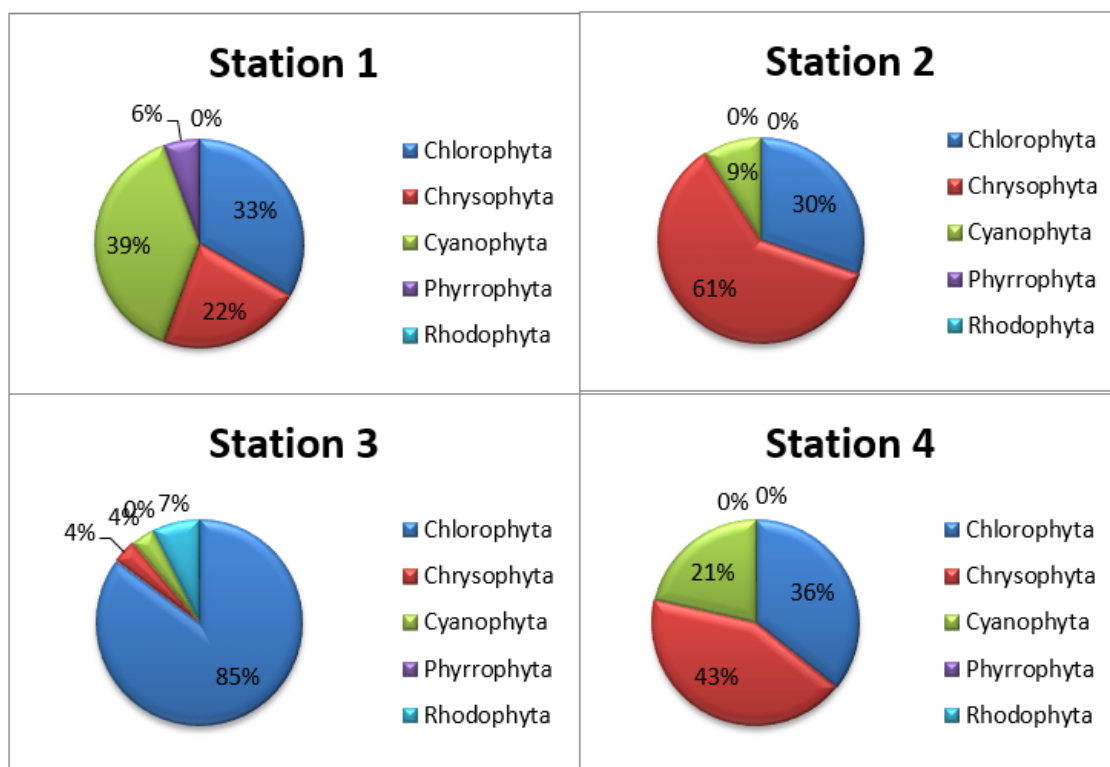


Figure 2. Phytoplankton Species Composition Each Station

Phytoplankton Abundance and Trophic Status

The abundance of phytoplankton at each station showed a relatively variable range. Station 1 had an abundance of 1,738 – 1,943 ind/ml, Station 2 had 1,547 – 1,767 ind/ml, Station 3 had 1,740 – 1,829 ind/ml, and Station 4 had 1,650 – 1,828 ind/ml.

According to Landner (1978), water bodies with phytoplankton abundance below 2,000 ind/ml are classified as oligotrophic waters, meaning they have a low fertility level. This indicates that the post-sand mining swamp at the research site has limited nutrient content, which in turn restricts phytoplankton growth.

The dominance of Cyanophyta, particularly *Microcystis*, may indicate that, despite being classified as oligotrophic, there is a potential increase in nutrients in certain areas due to human activities, such as using the swamp as a water source and fishing area.

The dominance of Cyanophyta, especially *Microcystis*, requires attention, as some species within this genus are known to produce toxins that can be harmful to aquatic ecosystems and human health. Additionally, the oligotrophic condition suggests that the water body has low fertility levels, making it less optimal for fish farming activities unless water quality improvements are implemented through proper management strategies.

Water Quality of the Post-Sand Mining Swamp

The water quality of the post-sand mining swamp in Kranjingan, Jember was assessed based on several parameters, including pH, temperature, and Total Dissolved Solids (TDS). These parameters provide an overview of the physical and chemical conditions of the water, as well as its potential utilization for ecosystems and human activities.

a. Water pH

pH is an indicator of the acidity or alkalinity of a water body. The average pH range recorded at each station is as follows: Station 1 had an average pH of 7.21, Station 2 recorded 7.20, Station 3 had an average pH of 7.34, and Station 4 showed the highest average pH of 7.52 (Figure 3).

Based on the water quality standards in Government Regulation No. 82 of 2001, waters with a pH between 6.5 - 8.5 are still classified as suitable for aquatic life, as well as for domestic and agricultural use. All stations had neutral to slightly alkaline pH values, indicating that the swamp water conditions are relatively stable and support the existence of aquatic organisms.

The slightly higher pH at Station 4 (pH 7.52) compared to the other stations is likely due to the outflow carrying dissolved particles from the swamp or the influence of agricultural activities that use additives such as fertilizers, which can increase water alkalinity.

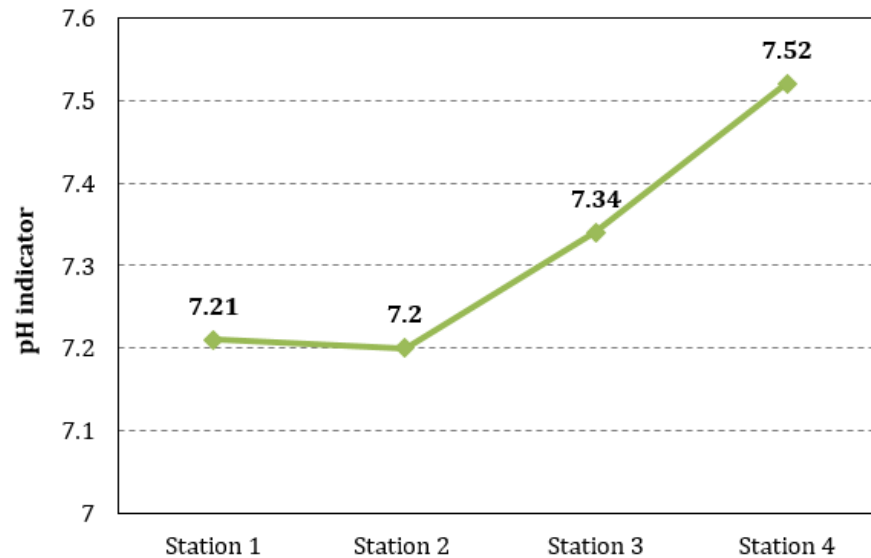


Figure 3. Average pH of Kranjingan Swamp Water at Each Observation Station

b. Water Temperature

Water temperature affects the metabolic activity of aquatic organisms and the solubility of oxygen in water. The average temperature data obtained at each station are as follows: Station 1 had an average temperature of 28°C, Station 2 had an average temperature of 28°C, Station 3 had an average temperature of 27°C, and Station 4 had an average temperature of 29°C. A clear illustration of the average temperature at each station can be seen in Figure 4.

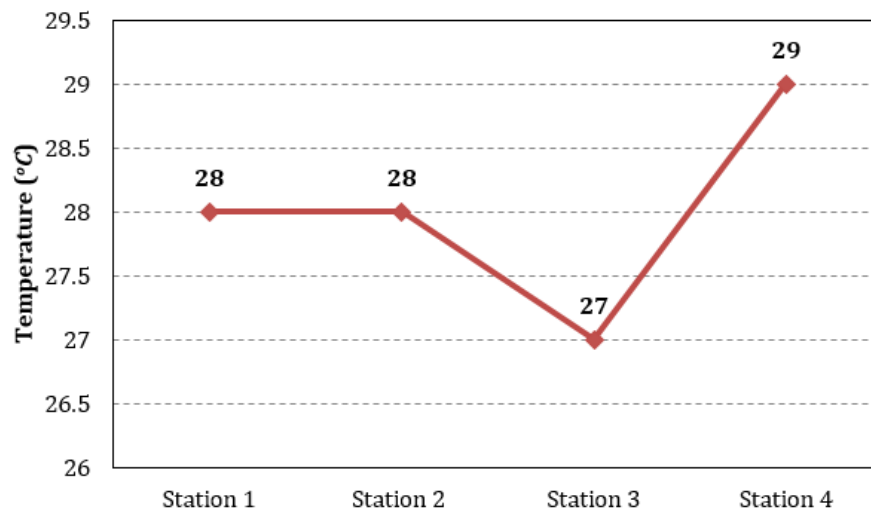


Figure 4. Average Water Temperature of Kranjingan Swamp at Each Observation Station

The water temperature in the post-sand mining swamp falls within the normal range for freshwater ecosystems, which is around 25–30°C. The relatively stable temperature at Stations 1 and 2 indicates that the water flow from underground springs and the central swamp area does not experience significant fluctuations.

However, the temperature at Station 3 is slightly lower (27°C), which is likely due to the presence of vegetation providing shade or slower water movement in the fishing area. In contrast, the temperature at Station 4 is slightly higher (29°C), possibly due to more intense sunlight exposure and the influence of irrigation activities that increase the evaporation process.

c. TDS (Total Dissolved Solids)

Total Dissolved Solids (TDS) is a measure of the amount of dissolved substances in water, including minerals, salts, and organic matter. The average TDS values obtained at each station are as follows: Station 1 recorded an average TDS of 279 mg/L, Station 2 recorded 281 mg/L, Station 3 recorded 280 mg/L, and Station 4 recorded 293 mg/L. A clear depiction of the average TDS at each station can be seen in Figure 5.

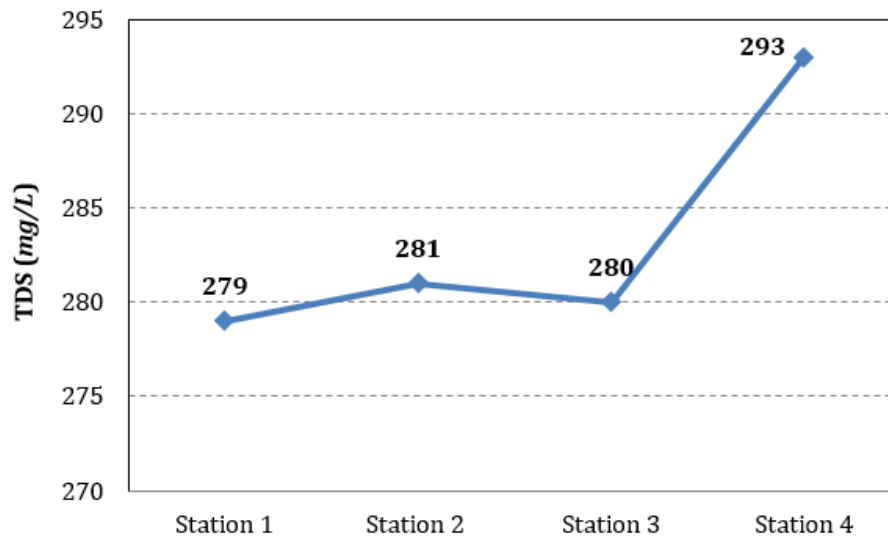


Figure 5. Average TDS of Kranjingan Swamp Water at Each Observation Station

According to WHO drinking water quality standards, TDS levels below 500 mg/L are considered good and safe for consumption. In the context of wetland ecosystems, these TDS values indicate that the water still has low to moderate levels of dissolved substances, suggesting no significant pollution.

The highest TDS value was found at Station 4 (293 mg/L), which may be attributed to agricultural activities contributing to increased dissolved substances from fertilizers and sediments carried by water flow.

2. Discussion

Overall, the waters in the post-mining swamp exhibit varying levels of phytoplankton diversity at each station, with dominance by Chlorophyta and Chrysophyta. This indicates that the aquatic ecosystem still has the potential for primary productivity, despite being classified as an oligotrophic water body with low fertility levels.

The waters in the post-mining swamp exhibit varying levels of phytoplankton diversity at each station, with dominance by Chlorophyta and Chrysophyta. This indicates that the aquatic ecosystem still has the potential for primary productivity, despite being classified as an oligotrophic water body with low fertility levels this is in line with (Yanti et al., 2024).

Referring to Figure 5, the graph shows an increase in TDS at Station 2, followed by a decrease at Station 3. This phenomenon may be influenced by several factors, including rock weathering and the presence of carbonate deposits at Station 2, which could contribute to the rise in TDS.

According to Landner's classification, waters with phytoplankton abundance below 2,000 ind/ml are categorized as oligotrophic, meaning they have low fertility levels. This indicates that the post-mining sand swamp in the study area has limited nutrient content, which in turn restricts phytoplankton growth (Lestari et al., 2021).

The dominance of Cyanophyta, particularly *Microcystis*, may serve as an indicator that, despite being classified as oligotrophic, certain areas could be experiencing nutrient enrichment due to human activities, such as the use of the swamp for irrigation and fishing (Anhar et al., 2023).

The dominance of the Cyanophyta phylum, especially *Microcystis*, requires attention since some species within this genus are known to produce toxins that could pose risks to aquatic ecosystems and human health, this research in line with (Sri Wahyuni & Rosanti Dewi, 2016). Additionally, the oligotrophic conditions suggest that the waters have low fertility levels, making them less suitable for fish farming unless water quality is improved through proper management this is in line with research conducted by (Anhar et al., 2023).

By understanding the trophic status and phytoplankton composition of this post-mining sand swamp, management strategies can be implemented, such as nutrient monitoring to regulate the input of organic matter and domestic waste, ensuring ecosystem balance. If the swamp is to be utilized for aquaculture in the future, efforts to enhance water productivity through natural fertilization or ecosystem-based biomanipulation will be necessary. By preserving the existing phytoplankton composition, the swamp can also be developed into a conservation-based ecotourism area that supports environmental sustainability and the well-being of the local community.

Based on pH, temperature, and TDS data, the water quality of the post-mining Kranjingan swamp can be categorized as relatively good, with stable conditions. The water conditions support aquatic life, as the pH is neutral to slightly alkaline and the temperature remains within the optimal range for freshwater ecosystems. Human activities are also known to influence water characteristics, particularly at Station 4, where a slight increase in pH and TDS was observed, likely due to irrigation and agricultural activities, this is in line with research conducted by (Rina et al., 2023).

Based on these parameters, Kranjingan Swamp has significant potential for various uses, including fishing, irrigation, and ecotourism development. This is supported by the absence of significant indicators of pollution based on the analyzed water quality parameters.

To maintain water quality and ensure that the swamp continues to support the aquatic ecosystem, several management measures should be implemented in the future. One key step is regular monitoring of water quality parameters to detect potential changes resulting from human activities. Sustainable wetland ecosystem management is also necessary, such as preserving natural vegetation around the swamp to reduce the impact of agricultural runoff. Additionally, future efforts should focus on waste and sedimentation management, particularly in areas that serve as water outlets, to prevent a significant increase in dissolved substances.

E. Conclusion

The composition and abundance of phytoplankton in the post-mining sand swamp exhibit the characteristics of an oligotrophic water body, dominated by the Cyanophyta phylum, particularly *Microcystis*. The highest phytoplankton diversity was found at Station 2, while Station 4 showed relatively stable abundance. These results provide important insights into the management and utilization of the post-mining sand swamp for both ecological and economic purposes. The analysis of water quality in the post-mining Kranjingan swamp indicates that the water is in relatively good condition, with a neutral to slightly alkaline pH, stable temperature, and TDS levels within acceptable limits. Although there are slight variations between stations, particularly at Station 4, which recorded the highest TDS value, overall, the water still supports the sustainability of the aquatic ecosystem and can be sustainably utilized for various purposes.

Acknowledgment

I would like to express my sincere gratitude to Universitas PGRI Argopuro Jember for its invaluable support and encouragement in conducting this research.

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