



Post-Revitalization Water Quality of Situ Bagendit: An Integrated Approach to Aquatic and Plankton Parameters

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ARTICLE INFO

Keywords: Bioindicator, Cyanophyceae, Eutrophication, Freshwater Ecosystem, Sustainable Environmental Management

Received : 5 June

Revised : 23 July

Accepted: 23 August

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ABSTRACT

Situ Bagendit, a key freshwater ecosystem in West Java, underwent revitalization from 2020 to 2022 to restore ecological functions and socio-economic benefits. This study evaluated its post-revitalization water quality by integrating physicochemical parameters and plankton communities. Water samples were collected from five stations during August–October 2023, measuring COD, nutrients, water clarity, and chlorophyll-a, while plankton were identified microscopically and analyzed using the Shannon–Wiener index. Results showed the lake improved from hypereutrophic to eutrophic status, with reduced but still elevated nutrient levels, COD exceeding Class II standards, and Cyanophyceae dominance. Although community structure showed partial recovery, persistent eutrophication risks remain. These findings highlight the partial effectiveness of revitalization and the need for continuous nutrient management to sustain ecological recovery

INTRODUCTION

Lakes are vital ecosystems that serve as habitats for aquatic biodiversity, regulate biogeochemical processes, and support the livelihoods of surrounding communities by providing clean water (Odum & Srigandono, 1993; Surtikanti, 2014). Indonesia is home to 5,807 lakes, with 571 located in West Java, making the province one of the regions with the highest concentration of lakes in the country (LIPI, 2020). Among these, Situ Bagendit in Garut Regency holds ecological and socio-economic importance. Since 2000, it has been managed by the Garut Regency Tourism and Culture Office and was officially designated as a protected area in 2013 through Regional Regulation No. 1/2013. The surrounding communities rely on the lake for agriculture, fisheries, domestic water supply, and education (Kamaludin et al., 2018).

Previous studies revealed that the water quality of Situ Bagendit had reached a hypereutrophic state (Amelia et al., 2012). Eutrophication, driven by nutrient enrichment (nitrogen and phosphorus), often triggers algal blooms, which negatively affect fisheries, disrupt food webs, reduce tourism value, and pose health risks to humans. In response, Situ Bagendit underwent revitalization between 2020 and 2022, focusing on infrastructure development such as selfie towers, amphitheaters, floating mosques, docks, and culinary areas. However, these interventions on the lake's body and shoreline areas could potentially improve or worsen water quality as shown in Figures 1.

One effective method for evaluating lake condition is an integrated approach that combines physicochemical parameters with biological indicators such as plankton. As primary producers, plankton are highly sensitive to environmental changes and play a central role in energy transfer within aquatic ecosystems (Nontji, 2006). Assessing both abiotic conditions and plankton communities provides more comprehensive insights into the ecological integrity of lakes. To date, this study represents the first post-revitalization assessment of Situ Bagendit's water quality.

Despite revitalization, recent observations indicate that the lake still faces ecological stress, as reflected in persistent macrophyte growth and relatively high turbidity levels. Given that Situ Bagendit functions as both a protected area and a critical water resource for surrounding communities, maintaining its ecological balance is essential. This study therefore aims to evaluate the current water quality of Situ Bagendit by integrating physicochemical parameters with plankton community assessments in order to provide a scientific basis for future management strategies.



(Personal Documentation, 2023)

Figure 1. Revitalization of Situ Bagendit, Amphitheater, Selfie Tower, Floating Culinary Area

LITERATURE REVIEW

Eutrophication and Lake Degradation

Eutrophication is a common ecological issue in tropical and temperate lakes, resulting from excessive nitrogen and phosphorus inputs that trigger algal blooms, hypoxia, and loss of biodiversity. Amelia et al. (2012) documented the hypereutrophic status of Situ Bagendit, emphasizing the link between nutrient enrichment and ecological decline. Such conditions also reduce tourism attractiveness and increase public health risks.

H1: Higher nutrient concentrations (nitrogen and phosphorus) significantly increase the risk of eutrophication in Situ Bagendit.

Revitalization and Water Quality Management

Lake revitalization programs are often introduced to restore ecological integrity while promoting socio-economic functions. In the case of Situ Bagendit, revitalization projects between 2020–2022 primarily focused on infrastructure development. However, studies suggest that infrastructure-driven revitalization without integrated ecological management may have mixed impacts, either improving water quality through regulation or exacerbating degradation by increasing anthropogenic pressures.

H2: Revitalization projects focusing on infrastructure development without ecological considerations may fail to significantly improve lake water quality.

Plankton as Bioindicators

Plankton play a pivotal role in aquatic ecosystems as primary producers and indicators of ecological change. Their abundance and diversity reflect nutrient dynamics, pollution levels, and overall lake health. Nontji (2006) highlighted plankton sensitivity to environmental stressors, while other studies emphasize their value in monitoring eutrophication and trophic states.

H3: Plankton community composition and diversity can serve as reliable indicators of post-revitalization water quality in Situ Bagendit.

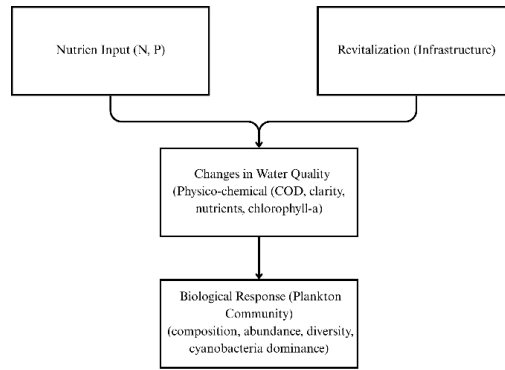
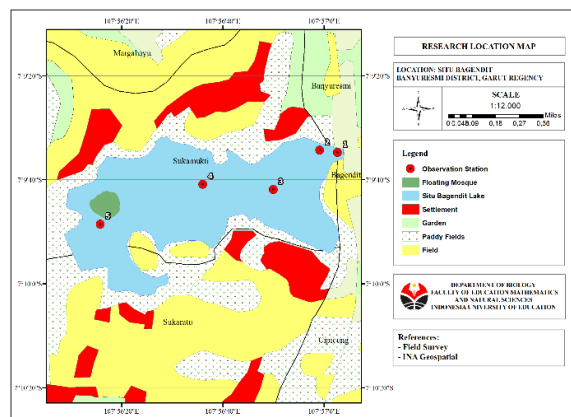


Figure 2. Conceptual Framework

METHODOLOGY

This study was conducted at Situ Bagendit, located in the Banyuresmi District, Garut Regency, West Java. The research was carried out over three periods, August, September, and October of 2023. A purposive sampling approach was applied, dividing the lake into five sampling stations selected based on anthropogenic activities and revitalization efforts. The first station is located at the water outlet and the amphitheater area, the second station is situated in the waters around the selfie tower, the third station is near the floating kiosks, the fourth station is in the central part of the lake, which is covered with water hyacinth and lotus, and the fifth station is at the edge of the lake, near the water inlet and the floating mosque. Stations 1, 2, 3, and 5 are directly affected by revitalization activities, such as the construction of the amphitheater, selfie tower, addition of floating kiosks, and establishment of the floating mosque. The geographical layout of these research stations is shown in Figure 3.



(Personal Document, 2023)

Figure. 3 Research Location Map

A multifunction water quality tester was used to measure pH, Total Dissolved Solid (TDS), conductivity, and water temperature. Dissolved oxygen in the water was measured using a DO meter (Lutron DO-5510). A Secchi disk was used to measure water clarity. Total nitrogen, total phosphorus, and chlorophyll-a were measured using national standards tested by a third party,

namely the Bandung City Hydrology and Water Environment Laboratory. Plankton sampling used a plankton net with a mesh size of 25 µm assisted by a five-liter bucket. Plankton identification used an electric microscope at 40x and 100x magnification. Plankton count calculations used Sedgewick Rafter Counting Cells.

Up to 50 liters of water was extracted from each station and subsequently filtered through a plankton net. The filtrated water samples were then preserved in vials without any additional treatment. Subsequent to this, direct microscopic identification was conducted utilizing a light microscope. A 1 ml water sample was extracted from the vial and deposited onto a Sedgewick Rafter Counting Cell (SRCC). The plankton identified within the SRCC container were meticulously counted and recorded. Plankton identification was performed in accordance with the guidelines outlined in Nontji (2006), Hertika et al. (2021), and Sachlan (1982).

RESULT

Aquatic Parameters

The analysis of physical and chemical parameters indicated that most values remained within the thresholds of Class II water quality standards. However, three parameters, namely COD, water transparency, and total nitrogen, exceeded the permissible limits and indicated ongoing anthropogenic pressures on the ecosystem. In addition, elevated chlorophyll-a concentrations were recorded, suggesting increased phytoplankton biomass and indicating that the lake remains in a eutrophic condition. A detailed summary of the measured aquatic parameters is presented in Table 1, providing a comprehensive overview of the water quality status during the study period.

Table 1. Aquatic Parameters

Parameter	Water Quality Standard*	Range Value of Each Station				
		1	2	3	4	5
Dissolved Oxygen (mg/L)	4	6,5-7,4	6,5-6,6	6,1-6,6	5,7-6,3	7,5-8,6
pH	6 - 9	7-7,4	6,9-7,3	6,8-7	6,4-6,8	6,4-6,8
Water Temperature (°C)	Dev 3	23,3-24,1	23,6-24,7	23,6-24,9	23,4-25	22,3-24,9
Conductivity (µs/cm)	-	547,3-589	545,3-611,6	542,6-627,6	583,3-592,7	592,6-605,6

Parameter	Water Quality Standard*	Range Value of Each Station				
		1	2	3	4	5
Total Dissolved Solid (ppm)	1000	273-307	272-304	270-310	289-314	222-301
COD (mg/L)	25	35	38	37	36	30
Water Clarity (cm)	400	77-89	81-105	129-131	123-131,5	63-87
Total Fosfat (mg/L)	0,03	0,023	0,016	0,015	0,016	0,020
Total Nitrogen (mg/L)	0,75	1,91	1,90	1,91	2,12	1,32
Chlorophy l-a (mg/m ³)	50	4,8	4,0	7,1	7,0	16

* Water Quality Standards for Lakes in Government Regulation No. 22 Of 2021

Plankton Data

The composition of plankton in the revitalized waters of Situ Bagendit comprises both phytoplankton and zooplankton. The Table 2, inform the number of species and individuals identified in Situ Bagendit across all sampling sessions.

Table 2. Number of Species and Number of Individuals of Plankton

Plankton	Number of Species	Number of Individuals
Fitoplankton	72	372
Zooplankton	15	39
Total	87	411

According to Table 2, Situ Bagendit's waters harbor a total of 87 plankton types, comprising 72 phytoplankton species and 15 zooplankton species. The overall count of plankton individuals tallied 411, with 372 being phytoplankton and 39 zooplankton individuals. Plankton abundance for each sampling period is shown in the following figure:

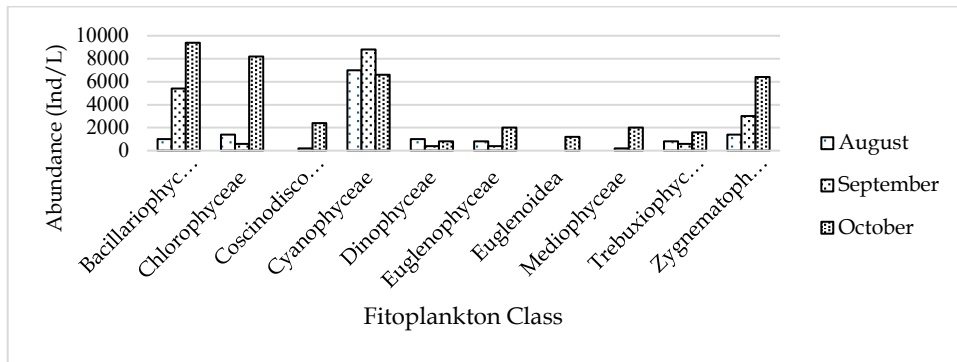


Figure 4. Phytoplankton Abundance

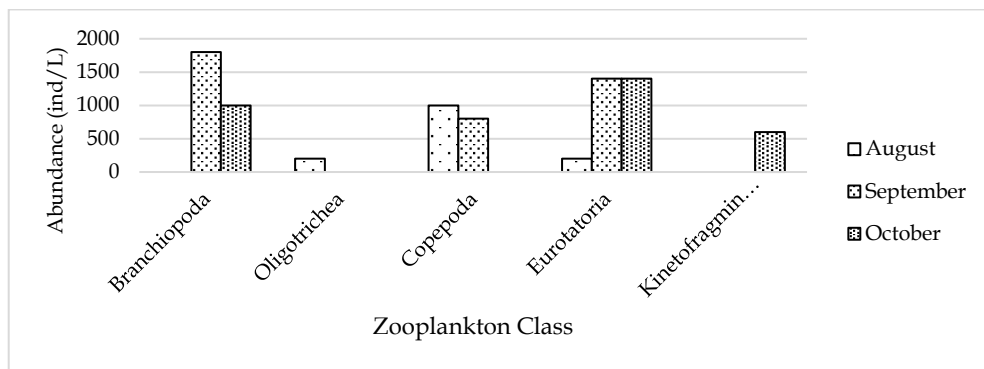


Figure 5. Zooplankton Abundance

Based on Figures 4 and 5, phytoplankton were found to belong to 10 classes, while zooplankton consisted of 5 classes. The phytoplankton classes identified include Bacillariophyceae (19 species), Chlorophyceae (16 species), Coscinodiscophyceae (3 species), Cyanophyceae (7 species), Dinophyceae (3 species), Euglenophyceae (5 species), Euglenoidea (1 species), Mediophyceae (2 species), Trebouxioophyceae (3 species), and Zygnematophyceae (13 species). The zooplankton classes identified include Branchiopoda (2 species), Kinetofragminophora (1 species), Oligotrichea (1 species), Copepoda (4 species), and Eurotatoria (7 species). Plankton abundance fluctuated across sampling periods, with the third sampling showing the highest plankton abundance. Phytoplankton abundance ranged from 9,200 to 36,400 ind/L, with an average of 19,666 ind/L over the three sampling events. Zooplankton abundance varied from 1,400 to 4,000 ind/L, with an average of 2,800 ind/L. The highest plankton abundance was observed in the Cyanophyceae class, with a peak of 22,800 ind/L. This class is commonly found in eutrophic lakes. Cyanophyceae comprised seven distinct plankton species, with varying abundances, as detailed in Figure 6.

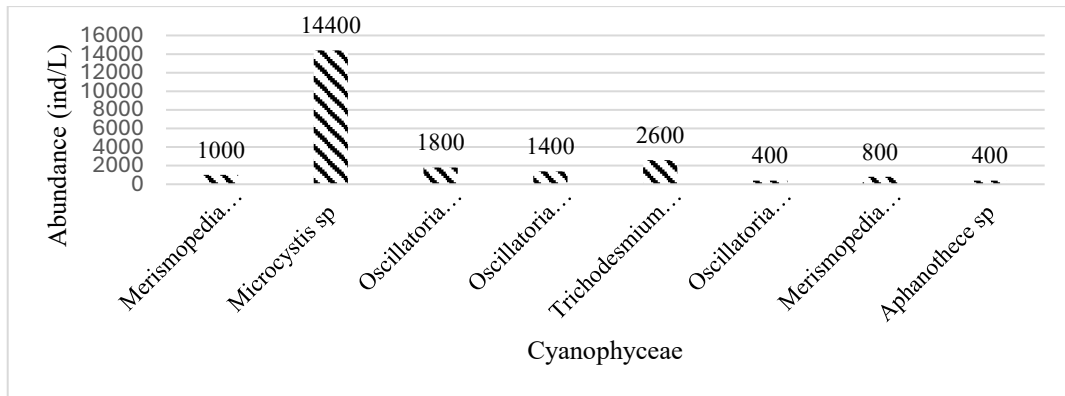


Figure 6. Abundance of Phytoplankton Class Cyanophyceae

The Cyanophyceae class consisted of seven phytoplankton species, with *Microcystis* sp. being the most abundant, at 14,400 ind/L. The plankton Diversity Index increased at each sampling period, as can be seen in Figure 7.

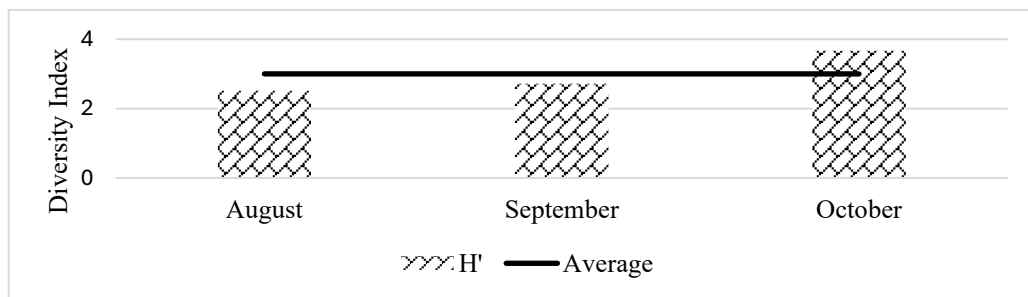


Figure 7. Plankton Diversity Index

The highest plankton diversity was observed in the third sampling conducted in October, which also recorded the greatest abundance. The average diversity across all three samplings falls within the medium diversity level.

DISCUSSION

Aquatic Parameters

Based on the analysis of three key aquatic parameters, namely Chemical Oxygen Demand (COD), water clarity, and total nitrogen levels, Lake Situ Bagendit does not meet Class II water quality standards. The elevated COD levels are attributed to waste generated from tourism activities and agricultural runoff from the surrounding area of Situ Bagendit. Elevated COD values indicate pollution that can negatively impact the plankton community (Walmsley et al., 1984). This parameter aligns with Class III water quality standards, as outlined in the Minister of Environment and Forestry Regulation No. 22 of 2021, which restricts water use to freshwater fish farming and irrigation, excluding recreational tourism (Ministry of Environment and Forestry, 2009). Excessive nitrogen concentrations in the lake (ranging from 1.9 to 2.12 mg/L) exceed established thresholds, promoting the proliferation of aquatic plants like water hyacinth. Although water hyacinth absorbs nitrogen, its decomposition paradoxically increases nitrogen levels, leading to ecosystem toxicity (Palmer, 1969). The lake's surface is largely covered by water hyacinth and lotus plants,

occupying more than half of the water body. Agricultural practices is suspected to contribute to elevated nitrogen levels, fueling excessive phytoplankton growth (Nontji, 2006). Nitrogen emissions from motorboats also exacerbate nitrogen accumulation in the lake.

The average water clarity in Situ Bagendit is 101.9 cm, significantly below the quality standard of 400 cm. This low water clarity is attributed to siltation throughout the lake, caused by the accumulation of decaying water hyacinth and lotus plants in the sediment layer. This process also affects solute concentrations in the lake (Hertika et al., 2022). High water turbidity further contributes to poor clarity. While Situ Bagendit's clarity is below 250 cm, it remains adequate for plankton life (Putri et al., 2020). The three parameters, COD, total nitrogen, and clarity, do not meet Class II water quality standards, indicating that Situ Bagendit's water is not suitable for water-based recreation. These conditions pose potential health risks, such as skin problems for tourists. Research by Hertika (2021) shows that increased COD and nitrogen levels can lead to dermatitis and eye irritation.

Chlorophyll-a, an important parameter in evaluating water quality and phytoplankton presence, typically ranges from 4–16 mg/m³ in Situ Bagendit. Chlorophyll-a, a pigment involved in photosynthesis, serves as a marker for phytoplankton biomass, providing insight into their abundance and productivity (Surtikanti, 2014). Notably, a higher chlorophyll-a concentration was observed at station five, indicating a larger phytoplankton population at this location. This observation correlates with increased dissolved oxygen (DO) levels, suggesting an active phytoplankton metabolic process. In line with Sayekti's research (Ministry of Environment and Forestry, 2009), higher chlorophyll-a levels indicate an expanding phytoplankton community. Station five, located along a waterway receiving nutrient inputs from river discharge, plays a significant role in the observed increase in chlorophyll-a levels. The parameters of total nitrogen, chlorophyll-a, and water clarity indicate that Situ Bagendit is eutrophic, as defined by the Ministry of Environment and Forestry (2009) and Carlson (1996)

A closer examination of the sampling stations revealed site-specific factors influencing the elevated COD values. For example, floating food stalls located at station three contributed domestic waste from tourism activities, while newly constructed infrastructure from the revitalization program facilitated the direct entry of organic waste into the lake. Such waste included food residues, cigarette butts, boat fuel residues, and agricultural runoff, all of which increase organic loading and chemical oxygen demand. These findings are consistent with Muthifah et al. (2018), who demonstrated that high COD levels in lakes are primarily driven by domestic waste inputs. The relatively uniform COD concentrations across stations also indicate that pollution pressure is distributed evenly throughout the water body.

Elevated COD values in Situ Bagendit were closely associated with high conductivity levels, which ranged between 542.6 and 627.6 $\mu\text{S}/\text{cm}$, substantially higher than those reported in other Indonesian lakes such as Situ Kuru (207–216 $\mu\text{S}/\text{cm}$; Haribowo et al., 2023) and Lake Diatas (80–100 $\mu\text{S}/\text{cm}$; Irwan & Afdal,

2016). Conductivity reflects the concentration of dissolved ions in the water, and its strong correlation with COD indicates the presence of excessive inorganic salts and organic pollutants. High conductivity and total dissolved solids can negatively affect plankton communities, many of which are intolerant of elevated ionic concentrations (Hertika et al., 2022).

Station four exhibited the highest total nitrogen concentrations, coinciding with dense coverage of water hyacinth. While this macrophyte can absorb nitrogen, its decomposition after senescence re-releases nitrogen into the water column, thereby maintaining high nutrient levels. Similar processes have been documented by Putri et al. (2020), who found that the decomposition of *Eichhornia crassipes* elevates nitrogen concentrations and contributes to ecosystem toxicity. Additional nitrogen inputs likely originated from excessive fertilizer application, particularly urea used in nearby agriculture, as well as nitrogen emissions from fossil fuel combustion by motorboats frequently operating along the lake. These inputs collectively accelerate phytoplankton proliferation and increase the risk of harmful algal blooms (Nontji, 2006; Indrayani et al., 2015).

With respect to water clarity, the measured average of 101.9 cm categorizes Situ Bagendit as hypertrophic according to the classification of the Ministry of Environment and Forestry (2009), which defines lakes with <250 cm transparency as highly eutrophic. The reduced clarity is primarily caused by high turbidity and siltation from the decomposition of water hyacinth and lotus plants, which accumulate as organic detritus in the sediment layer (Juwitanti et al., 2013). Although this transparency is well below the Class II standard of 400 cm, it remains above the critical threshold of 25 cm considered harmful for plankton survival (Maniagasi, 2013).

Finally, rainfall conditions during the study period further influenced abiotic parameters. All sampling campaigns were conducted during months with low precipitation (<100 mm), which corresponds to the dry season in West Java (Hertika et al., 2022). The lowest rainfall was recorded in September 2023 during the third sampling, when dissolved oxygen (6.8 mg/L), water temperature (24.6 °C), and light intensity (82,145 lux) reached their highest values. Reduced rainfall likely enhanced light penetration, thereby promoting phytoplankton photosynthesis and elevating oxygen concentrations in the water column. Similar patterns have been reported by Krismono and Sugianti (2007), who found that reduced rainfall increases light penetration and water temperature, ultimately enhancing plankton productivity.

Plankton Data

Based on the analysis, there was a significant difference in the population sizes of phytoplankton (372 individuals) and zooplankton (39 individuals). This difference reflects the primary role of phytoplankton as primary producers in aquatic ecosystems (Nontji, 2006; Adani et al., 2013). The low zooplankton population is believed to be related to negative phototaxis, as well as other environmental factors such as high levels of nitrogen and phosphorus, which favor phytoplankton growth but can limit zooplankton populations (Ministry of

Environment and Forestry, 2009). During the dry season, which was the data collection period for this study, increased sunlight intensity enhanced phytoplankton photosynthetic activity. Simultaneously, human activities, particularly in the tourism sector at Situ Bagendit, tend to intensify, potentially enriching the nutrient content in the water. This aligns with previous research by Nirmalasari et al. (2016), which found that phytoplankton abundance was higher in the dry season than in the rainy season. This difference is attributed to reduced light intensity and lower temperatures during the rainy season, which inhibit phytoplankton growth.

Among the ten phytoplankton classes identified, Bacillariophyceae exhibited the highest species richness, with 19 species. This dominance suggests that Bacillariophyceae possess strong adaptability to diverse aquatic environmental conditions. Species within this class have a widespread distribution across various aquatic ecosystems due to their high ecological tolerance. Under polluted conditions, Bacillariophyceae can survive by producing mucus, which imparts a sticky characteristic to the water (Sayekti et al., 2015).

Overall, seven phytoplankton classes and one zooplankton class, Eurotatoria, were consistently found in each sampling period. Variability in the presence of other plankton species is likely influenced by environmental factors and the vertical migration of zooplankton. These migrations can occur daily or seasonally, regulated by biological rhythms and environmental factors such as light intensity, water temperature, predator abundance, and nutrient availability (Nontji, 2006; Ministry of Environment and Forestry, 2009).

The analysis revealed that phytoplankton abundance ranged from 200 ind/L to 9,400 ind/L. The Cyanophyceae class had the highest abundance, reaching 22,800 ind/L over three sampling periods. This prevalence is attributed to high nitrogen levels from agricultural runoff into Situ Bagendit. This finding is consistent with Masithah (2023), which identified that high concentrations of inorganic nitrogen are the primary factor influencing the abundance of Cyanophyceae. Additionally, sunlight intensity ranging from 57,002 to 82,145 lux contributed to the proliferation of this class. This observation is supported by Nirmalasari et al. (2016), which found that Cyanophyceae tend to dominate in calm waters with high sunlight exposure.

According to Figure 4, Eurotatoria was the most abundant zooplankton class, with densities reaching 3,000 individuals per liter, consistently found in all sampling periods. As part of the phylum Rotifera, Eurotatoria primarily inhabits freshwater environments (Masithah, 2023). Its abundance in aquatic ecosystems is likely influenced by abiotic conditions conducive to its growth, such as optimal

dissolved oxygen and pH levels. Zooplankton typically thrive in dissolved oxygen concentrations ranging from 5.00–7.00 mg/L, which aligns with the dissolved oxygen levels in Situ Bagendit, recorded between 5.7–8.6 mg/L (Carlson & Simpson, 1996). Within the Eurotatoria class, *Diaphanosoma brachyurum* was the most dominant species, with densities reaching 2,000 individuals per cubic meter. The increased population of this species is likely influenced by seasonal factors, particularly the dry season (Nirmalasari, 2018).

The Cyanophyceae class, which comprises eight phytoplankton species, serves as a key indicator of eutrophication in Situ Bagendit, alongside Bacillariophyceae (Masithah, 2023). Among the various identified Cyanophyceae species, *Microcystis* sp. was the most dominant, with an abundance reaching 14,400 ind/L. The presence of *Microcystis* sp. is closely associated with eutrophication and the potential formation of Harmful Algal Blooms (HABs) (Adani et al., 2013). Its rapid proliferation is driven by increased waste input, which disrupts the nutrient balance in the water. The high abundance value of *Microcystis* sp. in aquatic ecosystems is attributed to its ability to float, allowing optimal light exposure for photosynthesis. Masithah (2023) demonstrated that the presence of domestic and industrial waste accelerates the proliferation of *Microcystis* sp. Its robust pectin-based cell wall provides protection from environmental stress, enabling the species to survive under various aquatic conditions (Nontji, 2006). However, excessive *Microcystis* sp. populations pose a significant threat to aquatic ecosystems due to their ability to produce microcystin, a toxic compound that can cause mass fish mortality due to poisoning (Amelia et al., 2012). Furthermore, the presence of *Microcystis* sp. negatively affects fishery quality, as it produces β -cyclocitral, a compound responsible for musty odors in fish and shrimp consumed by humans (Masithah, 2023). This highlights that the dominance of *Microcystis* sp. not only impacts aquatic ecosystems but also has economic and food quality implications for the fisheries sector.

Based on the analysis results, the average plankton diversity index in Situ Bagendit is 3, which falls within the moderate category and indicates moderate community stability (Odum & Srigandono, 1993). This condition is likely influenced by the high availability of nutrients, particularly nitrogen, which originates from human activities such as agricultural waste, domestic household waste, and tourism-related waste (including food remnants, cigarette butts, and boat engine fuel residues). The excessive presence of nitrogen in the water can stimulate the growth of phytoplankton, including diatoms and cyanobacteria, ultimately contributing to an increase in plankton diversity (Nontji, 2006).

The plankton diversity index in Situ Bagendit showed a consistent increase across sampling sessions, with the highest value recorded during the third sampling session (3.670). This increase is presumed to be associated with optimal abiotic conditions for plankton growth. During the third sampling, sunlight intensity reached 82,145 lux, the highest among all sessions, which is known to enhance phytoplankton growth (Surtikanti, 2014). Additionally, dissolved oxygen (DO) levels peaked at 6.8 mg/L, providing favorable conditions for phytoplankton respiration. Research by Oktavia et al. (2015) indicates that higher DO levels are generally correlated with increased plankton diversity.

According to rainfall data, all sampling activities in this study were conducted during periods of low precipitation, with monthly rainfall below 100 mm, which is classified as the dry season in the region (Hertika et al., 2022). The lowest rainfall was recorded in September 2023, coinciding with the third sampling. Under these conditions, several abiotic factors exhibited their highest values, including dissolved oxygen (6.8 mg/L), water temperature (24.6 °C), and sunlight intensity (82,145 lux). The reduced rainfall likely enhanced light penetration into the water column, thereby improving photosynthetic efficiency of phytoplankton and resulting in higher oxygen production. Similar findings were reported by Krismono and Sugianti (2007), who observed that lower rainfall increases both light penetration and water temperature, thereby stimulating the proliferation of aquatic biota, including plankton.

However, the plankton diversity index alone is not a definitive indicator of ecosystem quality, as it primarily reflects the degree of species variation rather than overall environmental health. While the study results indicate moderate plankton diversity in Situ Bagendit, a significant presence of plankton species recognized as indicators of pollution and eutrophication suggests potential environmental degradation. A similar phenomenon has been observed in Lake Rawa Pening, which has a plankton diversity index of 2.8, also classified as moderate, but is dominated by pollution-indicating plankton species (Astuti, 2009). Although the diversity index provides an overview of species variation, it does not fully capture the spatial heterogeneity of plankton assemblages within the lake.

In Situ Bagendit, plankton distribution exhibits clear spatial differences, with higher abundance typically recorded in inflow areas and near macrophyte-dominated zones compared to the outlet. Such heterogeneity reflects localized variations in nutrient input and hydrodynamic conditions, which in turn influence community structure and productivity. Beyond temporal fluctuations, spatial heterogeneity among sampling stations in Situ Bagendit also played an important role in shaping plankton composition and abundance. The results

showed that the inlet area (station 5) and the outlet near the main tourist entrance (station 1) consistently supported higher plankton diversity and abundance compared to other sites. Station 5, which directly receives inflow from Copong Dam and surrounding agricultural fields, was particularly influenced by nutrient-rich runoff. Fertilizers and organic matter carried from rice paddies are known to elevate concentrations of nitrogen and phosphorus, thereby enhancing phytoplankton productivity. This finding is in agreement with Anggraini et al. (2017), who emphasized that agricultural effluents contribute to the nutrient supply required for plankton metabolism. Similarly, station 1, located at the outlet with intense tourist activity, exhibited elevated plankton abundance. The outlet functions as a collecting point, concentrating nutrients and suspended organic matter transported from across the lake before discharge. Human activities in this area, including boating and aquaculture, further increase nutrient loading and likely contribute to the proliferation of eutrophication-indicating taxa. Both stations also underwent major revitalization projects, such as the construction of the floating mosque at station 5 and the development of a tourist pier and amphitheater at station 1. These infrastructural changes potentially altered hydrological dynamics and enhanced surface runoff, thereby accelerating nutrient input (Piranti et al., 2018).

In contrast to these nutrient-enriched and human-influenced zones, other stations exhibited markedly lower plankton abundance due to physical and biological constraints. Stations with restricted light penetration or intense competition from aquatic macrophytes displayed relatively lower plankton diversity and abundance. Station 2, located under the newly constructed photo-spot bridge, receives limited sunlight exposure. Reduced irradiance in this area diminishes water temperature and constrains photosynthetic activity, ultimately suppressing phytoplankton growth. Station 4, heavily dominated by *Eichhornia crassipes* and lotus plants, exhibited similarly low plankton abundance. Dense macrophyte cover not only competes with plankton for available nutrients but also shades the water column, limiting photosynthetic efficiency. The findings are consistent with Piranti et al. (2018), who reported that floating aquatic vegetation alters nutrient dynamics and light penetration, thereby reducing phytoplankton productivity. Surtikanti (2014) also noted that dense macrophyte mats can form physical barriers to light, further hindering phytoplankton growth in shallow lake ecosystems.

Overall, these spatial differences highlight the importance of hydrological setting and anthropogenic influence in determining plankton distribution within Situ Bagendit. Inflow and outflow zones serve as nutrient-enriched hotspots, while shaded or macrophyte-dominated areas represent zones of reduced productivity. Such heterogeneity indicates that the ecological condition of the

lake cannot be generalized from a single sampling site but must be interpreted in relation to localized drivers. This pattern aligns with Tang et al. (2019), who demonstrated that plankton communities in shallow eutrophic lakes are strongly shaped by spatial variations in nutrient availability and habitat conditions. Therefore, the spatial distribution of plankton in Situ Bagendit reflects the combined impact of natural hydrological processes, agricultural runoff, tourism activities, and infrastructural developments introduced during the revitalization program.

Based on the analysis of aquatic parameters, the water quality in Situ Bagendit falls below the class II standard, which is designated for recreational, fisheries, livestock, and crop irrigation purposes. Elevated Chemical Oxygen Demand (COD) and total nitrogen content may pose potential risks to skin health. According to the trophic status criteria established by the Ministry of Forestry and Environment, Situ Bagendit is classified as a eutrophic water body, with nitrogen levels of ≤ 1.9 mg/L and water clarity of < 250 cm. The chlorophyll-*a* concentration supports this classification, indicating eutrophic conditions (Carlson, 1996). Organic pollution runoff from tourism and agricultural activities is considered the primary factor contributing to the lake's elevated trophic status.

Several plankton species have been identified as key indicators of eutrophication due to their ability to thrive in polluted environments. Among all the plankton species detected at the monitoring sites, four emerged as primary indicators of eutrophication and pollution: *Nitzschia palea* (15 individuals) and *Nitzschia acicularis* (17 individuals) from the class Bacillariophyceae, as well as *Microcystis* sp. (72 individuals) and *Oscillatoria lacustris* (9 individuals) from the class Cyanophyceae. These species are commonly found in eutrophic or polluted waters, as they possess adaptation mechanisms that enable them to survive in degraded water conditions (Nontji, 2006). The sheath structure of *Oscillatoria* allows it to persist in extreme environments (Kamilah et al., 2014). *Microcystis* sp. thrives in nitrogen-rich waters and has the ability to produce harmful toxins (Masithah, 2023). *Nitzschia* sp. exhibits exceptional resistance to pollution, demonstrating its adaptability to suboptimal ecological conditions (Awal et al., 2014).

In addition to these species, other planktonic indicators of pollution were recorded in Situ Bagendit, including *Cyclotella* sp., *Navicula* sp., *Melosira* sp., and *Pinnularia nobilis*. The presence of these diatoms further substantiates the indication of eutrophication (Soeprbowati, 1996). Similar assemblages have been reported in Lake Rawa Pening, which has long been characterized as a eutrophic system (Soeprbowati & Suedy, 2011). Moreover, *Trichodesmium thiebautii* was detected at several sampling stations with an abundance of 13

individuals. This cyanobacterium is recognized as a driver of Harmful Algal Blooms (HABs) in Indonesian waters. Its ability to reproduce rapidly and release toxins poses a significant threat to aquatic ecosystems and aquaculture. Historical outbreaks of *T. thiebautii* in 1991 in Jakarta Bay and Lampung waters triggered severe eutrophication and substantial losses to shrimp farming (Praseno & Sugestiningih, 2000; Nontji, 2006). Its occurrence in Situ Bagendit reinforces the lake's vulnerability to harmful bloom events.

Beyond biotic indicators, several abiotic parameters measured in this study did not comply with the Class II water quality standards stipulated in Government Regulation No. 22 of 2021, which apply to recreational waters. Chemical oxygen demand (COD) reached 35.2 mg/L, transparency was only 101.9 cm, and total nitrogen concentration was 1.83 mg/L. Such values indicate that the water quality of Situ Bagendit does not yet meet the requirements for safe recreational use. Hertika et al. (2022) noted that deviations in abiotic parameters from established water quality criteria may elevate the risk of skin-related diseases for humans. When evaluated based on total nitrogen, transparency, and chlorophyll-a concentrations, Situ Bagendit also falls within the eutrophic category, consistent with the classification of the Ministry of Environment and Forestry (2009) and Carlson (1996).

Taken together, these results demonstrate that despite improvements following the recent revitalization program, Situ Bagendit remains ecologically stressed. Organic pollution from tourism activities and agricultural runoff continues to exert pressure on the ecosystem. The presence of abundant aquatic plants, elevated nutrient concentrations, and pollution-indicating biota are all characteristic of eutrophic lakes (Irianto & Triweko, 2011; Surtikanti, 2014).

The analysis of plankton abundance further supports this conclusion. Compared with the abundance thresholds established by Goldman and Horne (Walmsley et al., 1984), the lake is confirmed as eutrophic. Across three sampling sessions, average phytoplankton abundance reached 19,666 individuals/L, while zooplankton abundance averaged 2,800 individuals/L, values that reflect the fertility of the ecosystem (Surtikanti, 2014). In comparison, studies conducted before revitalization reported phytoplankton abundances of 25,196 individuals/L and zooplankton abundances of 9,996 individuals/L, classifying the lake as hypereutrophic (Kurniawan, 2019). The current findings therefore suggest an improvement in water quality, with the trophic status shifting from hypereutrophic to eutrophic. This change indicates a decline in nutrient concentrations and pollutant inputs, reflecting the partial effectiveness of revitalization measures.

CONCLUSIONS AND RECOMMENDATIONS

The results show that Situ Bagendit is classified as eutrophic, with water quality falling below Class II standards due to high COD, excessive total nitrogen, and low transparency. Elevated chlorophyll-a levels confirm high phytoplankton productivity, while the dominance of *Microcystis* sp. indicates a risk of Harmful Algal Blooms (HABs). The presence of pollution indicator diatoms further supports ongoing eutrophication. Although conditions have improved from hypereutrophic to eutrophic after the revitalization program, continuous monitoring is needed to control pollution and safeguard ecosystem health.

ADVANCED RESEARCH

This study was limited to three months in the dry season with sampling restricted to surface waters in the morning. Future research should cover multiple seasons, include depth-stratified sampling, and incorporate collections at different times, including nocturnal periods, to better capture plankton dynamics and community composition.

ACKNOWLEDGMENT

This research was supported by the Ministry of Education, Culture, Research, and Technology through the 2023 BIMA Dikti grant. The authors gratefully acknowledge Abdul Faqih, Fathan Ahmad, Fajri Khairul, and Aulia Khairunnisa for their assistance in sampling and laboratory work.

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