AL-KAUNIYAH: Jurnal Biologi, 19(1), 2026, 52-62
Website: https://journal.uinjkt.ac.id/kauniyah/index
P-ISSN: 1978-3736, E-ISSN: 2502-6720

ABUNDANCE, DIVERSITY, AND WATER QUALITY ASSESSMENT OF EPILITHIC DIATOMS AS BIOINDICATOR IN THE DEM RIVER, GLOTHAK WATERFALL, WAGIR DISTRICT, MALANG REGENCY

KOMUNITAS DIATOM EPILITIK SEBAGAI BIOINDIKATOR SUNGAI DEM, AIR TERJUN GLOTHAK, KECAMATAN WAGIR, MALANG

Tyas Nyonita Punjungsari*, Muhammad Ainul Ghurry
State Islamic University of Maulana Malik Ibrahim (UIN) Malang, Gajayana St, No. 50, Dinoyo, Lowokwaru, Malang, East Java, 65144
**Corresponding author:* tyasnyonita@uin-malang.ac.id

Submitted: 30 October 2024; Revised: 23 September 2025; Accepted: 27 September 2025

Abstract

The Dem River, originating from the Coban Glothak Waterfall, is an important water source for local communities. However, the rapid growth of tourism in the Coban Glothak area raises concerns regarding potential water pollution. To evaluate the river's ecological condition, this study analyzed biological, physical, and chemical parameters with a focus on epilithic diatoms as bioindicators. An exploratory design was applied across three representative stations, each subdivided into three sampling points. Biological analysis involved measuring abundance, diversity, and dominance of diatoms using PAST software. Physical and chemical parameters included temperature, pH, total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), nitrate (NO_3), and phosphate (PO_4). Results showed that epilithic diatom abundance was relatively high at all stations, but a decreasing trend was observed from station 1 to station 3, reflecting spatial variations in environmental conditions. The diversity index consistently exceeded 1.5, indicating a fairly diverse diatom community and suggesting supportive water conditions for aquatic organisms. Low dominance values at all stations revealed no species over-dominance, reflecting balanced ecological conditions. Furthermore, the physical and chemical measurements aligned with class 2 and 3 water quality standards, confirming that the Dem River remains suitable for sustaining aquatic life with reasonable diversity.

Keywords: Dem River; Diversity index; Epilithic diatom; Glothak waterfall

Abstrak

Sungai Dem yang berasal dari Air Terjun Coban Glothak merupakan sumber air penting bagi masyarakat setempat. Namun, peningkatan aktivitas pariwisata di kawasan Coban Glothak menimbulkan kekhawatiran terkait potensi pencemaran air. Untuk menilai kondisi ekologi sungai, penelitian ini menganalisis parameter biologi, fisika, dan kimia dengan fokus pada diatom epilitik sebagai bioindikator. Desain penelitian yang digunakan adalah eksploratif pada tiga stasiun representatif, masing-masing dibagi menjadi tiga titik pengambilan sampel. Analisis biologi dilakukan dengan mengukur kelimpahan, indeks keanekaragaman, dan dominansi diatom menggunakan perangkat lunak PAST. Parameter fisika dan kimia yang diuji meliputi suhu, pH, total padatan terlarut (TDS), oksigen terlarut (DO), kebutuhan oksigen biologis (BOD), kebutuhan oksigen kimia (COD), nitrat (NO_3), dan fosfat (PO_4). Hasil penelitian menunjukkan kelimpahan diatom epilitik relatif tinggi pada semua stasiun, namun mengalami penurunan dari stasiun 1 hingga stasiun 3, yang mencerminkan variasi kondisi lingkungan di sepanjang sungai. Indeks keanekaragaman yang selalu di atas 1,5 menunjukkan komunitas diatom yang cukup beragam serta kondisi air yang mendukung kehidupan organisme akuatik. Nilai dominansi yang rendah pada semua stasiun menandakan tidak ada spesies yang mendominasi berlebihan, yang merefleksikan kondisi ekologi seimbang. Selain itu, parameter fisika dan kimia sesuai dengan baku mutu air kelas 2 dan 3, sehingga Sungai Dem masih layak untuk mendukung kehidupan akuatik dengan tingkat keanekaragaman yang memadai..

Kata Kunci*: Coban Glothak; Diatom epilitik; Indeks keanekaragaman; Sungai Dem*

Permalink/DOI: https://doi.org/10.15408/kauniyah.v19i1.42143

INTRODUCTION

The Dem River in Malang, East Java, Indonesia, is a relatively lesser-known river compared to other major rivers in the region. It flows through parts of Malang, contributing to the local ecosystem and serving as a water source for the surrounding communities. The river is part of the natural landscape of Malang, which is known for its scenic beauty, including mountains, waterfalls, and other water bodies.

Coban Glothak is a waterfall that is the connected with Dem River. It is one of many waterfalls (known locally as "*Coban*") in the region, which is famous for its natural beauty and attracts tourists, especially those interested in nature and adventure tourism. An Increase in tourism activity leads to another problem for the surrounding ecosystem; the increase in human activity, including potential littering and pollution, can degrade the water quality of Coban Glothak, and it will affect aquatic life (Junaedi & Sulistiani, 2023).

To ensure whether the aquatic ecosystem balance in the Coban Glothak area is still uncontaminated, testing can be conducted using living organisms known as bioindicators. Water that is sensitive to ecosystem imbalances is referred to as a bioindicator (Fitria & Wulandari, 2020). Organisms that can be used as bioindicators should have high sensitivity to environmental changes, specific sensitivity to one or more pollutants, be easy to find and widely distributed, but also have limited environmental tolerance and ecological relevance. Epilithic diatoms are a specific group of diatoms that grow on rock surfaces in aquatic environments, making them particularly suitable as bioindicators. Unlike other diatoms, epilithic diatoms are highly sensitive to changes in water quality, such as nutrient levels and pollution, due to their habitat on solid substrates. Their ability to reflect subtle environmental shifts makes them a more reliable indicator for monitoring ecosystem health compared to diatoms in general (Sari & Rahayu, 2024)

Epilithic diatoms are highly sensitive to changes in water quality, including changes in pH, temperature, salinity, and nutrient concentrations such as nitrate and phosphate (Mann & Vanormelingen, 2013). Epilithic diatoms (diatoms that attach to submerged surfaces such as rocks or aquatic vegetation) are among the most effective biological indicators for assessing freshwater quality due to their high sensitivity to environmental change and their ability to respond rapidly to pollution (Rimet & Bouchez, 2012; Lobo et al., 2016). These periphytic communities reflect long-term ecological conditions and can provide more stable indicators than planktonic or free-floating forms. The structure and composition of epilithic diatom communities vary in response to specific physical and chemical parameters, including nutrient concentration, pH, dissolved oxygen, and organic matter load (Kelly et al., 1998; Potapova & Charles, 2003).

Species within these communities offer valuable ecological insights. For instance, *Achnanthidium minutissimum* typically thrives in oligotrophic and well-oxygenated waters, and is widely recognized as a positive indicator of high water quality (Prygiel & Coste, 1993). In contrast, *Navicula tripunctata* is moderately tolerant and often associated with slightly enriched environments, making it an indicator of transitional conditions between clean and polluted waters (Wetzel, 2001). Meanwhile, *Gomphonema parvulum* is highly tolerant of organic pollution and eutrophic conditions, frequently found in rivers impacted by domestic waste or nutrient enrichment (serving as a negative indicator of degraded water quality) (Kelly et al., 2009).

In Indonesia, the use of epilithic diatoms as bioindicators has gained traction in recent years. Research by Wibowo and Mutaqin (2020) in the Brantas River, which flows through the Malang region of East Java, successfully applied epilithic diatom indices to assess spatial variations in water quality. Similarly, Suhendar et al. (2012) investigated epilithic diatoms in the Citarum River Basin and demonstrated strong correlations between diatom assemblages and water chemistry parameters, underscoring their utility in biomonitoring programs. Although macroinvertebrates have traditionally dominated bioassessment protocols in Indonesia (Kurniawan et al., 2021), epilithic diatoms offer distinct advantages due to their rapid reproductive cycles, habitat specificity, and ability to signal both acute and chronic disturbances.

Given these attributes, the focus on epilithic diatoms in this study is not only ecologically justified but also methodologically consistent with emerging best practices in biomonitoring of tropical freshwater systems (Patrick & Reimer, 1966). Their species composition (especially the relative abundance of indicator species) provides a nuanced and integrative measure of ecological status, particularly useful in river systems subject to increasing anthropogenic pressures, such as those found in and around Malang, East Java.

Therefore, it is necessary to conduct research on the water quality of the Dem River in the Coban Glothak area using epilithic diatom bioindicators. Epilithic diatoms are particularly suitable for this study, not only because of their high sensitivity to changes in water quality, but also due to their stability and ability to reflect long-term environmental conditions. Unlike other bioindicators that may be more influenced by short-term fluctuations, epilithic diatoms provide a more reliable indication of both acute and chronic water quality changes over time. Their attachment to submerged surfaces ensures that they integrate information about water quality across different seasons and environmental conditions, making them a stable and effective tool for monitoring the health of aquatic ecosystems in the Dem River (Rimet & Bouchez, 2012; Lobo et al., 2016). Additionally, epilithic diatoms respond to nutrient levels, organic matter, and other pollutants, allowing for a comprehensive assessment of water quality (Stoermer & Smol, 2004). The bioindicator analyses that can be employed include community species analysis through species identification and calculating diversity indices (Rott & Skerlep, 2014). Analysis of species dominance and abundance is also necessary to determine if specific groups of epilithic diatoms dominate the ecosystem. Lastly, physical and chemical factor analyses should be performed, including temperature, potential of hydrogen (pH), total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), nitrate (NO_3), and phosphate (PO_4).

MATERIALS AND METHODS

Study Area

This study was conducted during the rainy season in March 2022. The locations for water sampling and epilithic diatom collection on rock substrates were situated along the Dem River Glothak Waterfall in Wagir District, Malang Regency. The selection of observation stations was based on the water conditions, land use, and community activities around the Dem River sub-watershed in Wagir District. Three observation stations were chosen: S07°98.647’ E112°51.580’ (station 1/Coban glotak tourism development), S07°99.596’ E112°53.046’ (station 2/agricultural and plantation area), and S08°00.094’ E112°53.917’ (station 3/residential area). Each station is then further divided into 3 substations, with each substation spaced 5 m apart. Substation 1 is located 5 m from the coordinate point of station 1. Similarly, substation 2 is located 5 m from substation 1, and so on, until the final point at substation 3 of station 3. Substations are additional points within each station that are designated to help obtain more consistent and measurable data. For example, if there are 3 substations within 1 station, the data can be averaged to reduce the influence of extreme values and produce a more accurate estimate. The map of the study area was prepared using the open-source software QGIS (version 3.34.9.1) (Figure 1).

Data Collection

The sampling of epilithic diatoms was conducted at three observation stations, with each station divided into three substations, spaced 5 m apart. The selection of these sampling locations was based on the need to represent a variety of environmental conditions within the study area. Each station was strategically chosen to capture different water quality gradients and habitat types that are typical for the ecosystem under investigation. The first station is located near the Coban Glothak Waterfall tourist area, the second station is near the rice field area, and the third station is in a residential area. The 5 m spacing between substations within each station allowed for a more fine-scale assessment of diatom community variations across relatively small distances (Figure 1), providing insights into how local environmental factors may influence diatom distribution (Prahardika & Setyawan, 2022). Samples were collected from the surface of rocks at the riverbed, with each rock having a surface area of 100 cm², and 3–5 rocks were sampled. The rock surfaces were scrubbed using a toothbrush (Castillejo et al., 2018). Distilled water was then flowed over the scrubbed area of the rock surface.

The rinse water was collected in a 20 mL sample bottle and labeled according to the respective observation stations (Prahardika & Setyawan, 2020). The collected samples were preserved using 1% Lugol's solution and stored at 4 °C in a cool box.

Water samples of 1,500 mL were collected for chemical parameter analysis. The water samples were taken using plastic bottles that were wrapped with black plastic to prevent light penetration, then labelled for each station and stored in a cool box. The chemical parameters tested included DO, BOD, COD, nitrate (NO_3), and phosphate (PO_4). The physical parameters were measured directly at the study site. The physical parameters measured were water temperature, which was recorded with a thermometer, pH measured with a pH meter, and TDS measured with a TDS meter.

Data Analysis

The identification of epilithic diatoms was based on the morphological characteristics of the frustules, as well as features such as the raphe, valve, apices, and 31 striae. Identification was conducted using the diatom identification guide by Taylor and Cocquyt (2016); Krammer and Lange-Bertalot (1988), and Spaulding et al. (2010). Diatom abundance was analyzed using the Lackey Drop Macrotransect Counting (LDMC) method from the American Public Health Association (APHA) (1992).

The species diversity index (H') was calculated using the Shannon-Weiner formula, and the phytoplankton dominance index was calculated using Simpson's formula (D) (Odum, 1996). The relationship between diatom abundance and nitrate and phosphate concentrations was determined using the coefficient of determination (R^2). To assess the strength of the relationship, the correlation coefficient (r) was used, where the value of r ranges from 0 to 1, and the strength of the relationship is categorized into four levels: weak, moderate, strong, and very strong (Sabri & Hastono, 2007). For ease of analysis, the PAST software (version 4.03) was used.

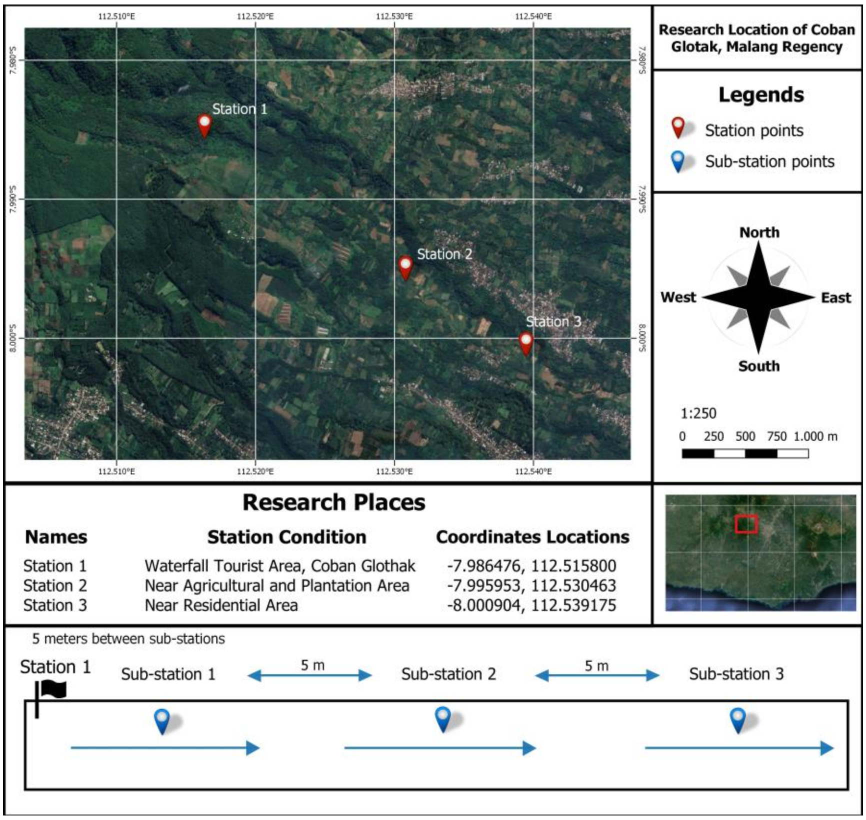

Figure 1. Sampling station location, location points of the stations used (a), and sampling method at each station (b). Each station is then further divided into 3 substations, with each substation spaced 5 m apart. Substation 1 is located 5 m from the coordinate point of station 1. Similarly, substation 2 is located 5 m from substation 1, and so on, until the final point at substation 3 of station 3

RESULTS

From the sub-waters of the Coban glotak river, nine epilithic diatom genera were identified, including *Amphora, Cocconeis, Craticula, Fragilaria, Frustulia, Navicula, Nitzschia, Rhoicosphenia, and Hippodonta* (Figure 2). They are all members of the class *Bacillariophyceae*, commonly referred to as 'diatoms.' *Bacillariophyceae* are a class of algae within the phylum *Bacillariophyta*. These microorganisms are primarily found in aquatic environments, including freshwater, marine, and even damp terrestrial habitats. Diatoms are notable for their unique silica cell walls, known as frustules, which feature intricate and often beautiful patterns. These frustules are composed of two overlapping parts, resembling a petri dish, and can vary greatly in shape and size.

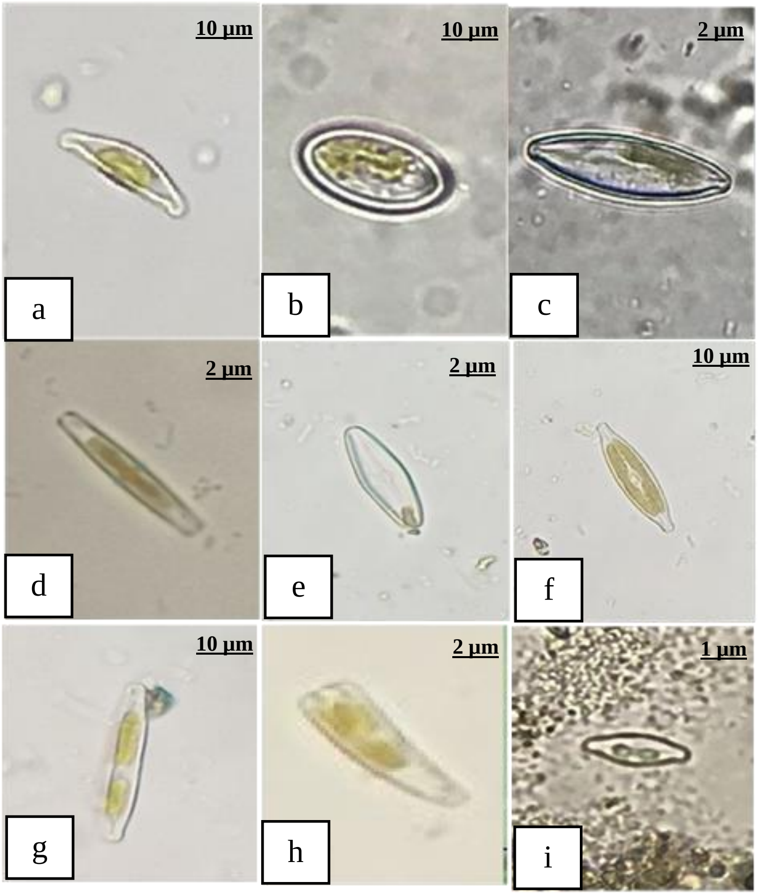

Figure 2. Morphology of epilithic diatoms observed under a microscope at 1000× magnification: *Amphora* (a), *Cocconeis* (b), *Craticula* (c), *Fragilaria* (d), *Frustulia* (e), *Navicula* (f), *Nitzschia* (g), *Rhoicosphenia* (h), and *Hippodonta* (i)

Abundance, Diversity, and Dominance Levels of Epilithic Diatoms in the Waters of the Dem River, Coban Glothak Waterfall

Before analyzing the diversity index, it is necessary to first determine the total number of individuals of all species (abundance). The abundance analysis follows the principles, at station 1, the highest abundance was observed for the genus *Navicula*, which was also the case at stations 2 and 3, while the genus with the lowest abundance at all three observation stations was *Amphora* (Table 1). *Amphora* is a genus of diatoms characterized by their distinct, elongated, and sometimes asymmetrical frustules (silica shells). These diatoms are commonly found in a variety of aquatic environments, including freshwater, brackish, and marine systems. *Amphora* can be sensitive to nutrient levels, particularly nitrogen and phosphorus. An increase in nutrient pollution in water bodies often leads to shifts in diatom communities. A high diversity of Amphora species generally indicates a healthy and stable aquatic environment, while a decline in diversity can signal ecological stress or degradation.

Table 1. Abundance values of genera in each observation area (station)

Genus	Number of individuals	Abundance (ind/cm^2)		
		I	II	III
Amphora	2	9.6	0	3.2
Hippodonta	6	30.4	11.2	9.6
Cocconeis	43	94.4	64	68.8
Craticula	11	41.6	28.8	17.6
Fragilaria	43	86.4	80	68.8
Frustulia	16	43.2	36.8	25.6
Navicula	167	252.8	246.4	267.2
Nitzschia	86	158.4	142.4	137.6
Rhoicosphenia	72	118.4	126.4	115.2
Total		835.2	736	713.6

Another important parameter that needs to be analyzed is the diversity index and dominance value. The diversity index provides information or an overview of the stability of a community. A high diversity index indicates a stable community within the ecosystem, while a low diversity index indicates an unstable community. The diversity index ranges from 1 to 3, which reflects a moderately stable community, meaning the community is prone to change or very sensitive to changes occurring within the ecosystem.

Table 2. Diversity index (H') and dominance (D) value

Parameter	Station			Total
	I	II	III	
Biodiversity (H`)	1.910	1.781	1.724	1.805
Dominance (D)	0.178	0.202	0.224	0.199

If the dominance value approaches 0, it indicates a stable community structure, whereas if the dominance value approaches 1, it indicates an unstable community structure, where a single species dominates the ecosystem. Ecosystems with moderate to high diversity tend to have low dominance values. This is consistent with this study, where the diversity was moderate (1.805) and the dominance was low (0.199) (Table 2).

Analysis of Water Physico-Chemical Parameters

Water quality is influenced by various natural and human factors. The most important natural influences are geological, hydrological, and climatic factors, as they affect both the quantity and quality of available water. Physicochemical and biological factors can indicate water quality in an aquatic environment. Water quality can be explained in terms of the concentration and state (dissolved or particulate) of various organic and inorganic substances present in the water, along with certain physical characteristics of the water, such as temperature, pH, and water flow velocity (Table 3).

Table 3. Results of physico-chemical factor measurements in the sub-dash Dem River

Parameter	Station			Water quality standards PP Number 22 The year of 2021			
	I	II	III	1^{st}	2^{nd}	3^{th}	4^{th}
Temperature (°C)	20.3	22.1	24.7	Dev 3	Dev 3	Dev 3	Dev 3
pH	7.9	8.6	8.7	6–9	6–9	6–9	6–9
TDS	103	123	168	1,000	1,000	1,000	1,000
OD (mg O_2/L)	7.64	6.99	5.98	6	4	3	1
BOD (mg/L)	5.59	5.69	5.71	2	3	6	12
COD (mg/L)	20.59	20.98	21.47	10	25	40	80
NO_3 (mg/L)	11.78	15.88	16.42	10	10	20	20
PO_4 (mg/L)	0.04	0.10	0.22	0.2	0.2	1	-

Based on the analysis of physico-chemical factors at station 1, the water in that area falls under Class 2 water quality standards, but with BOD levels exceeding the Class 2 standard, as is also the case for the waters at stations 2 and 3. Class 2 water, according to the regulation of the Republic of Indonesia Number 22 of 2021, is water that can be used for water recreation, freshwater fish farming, livestock, irrigation, and can be utilized for industrial purposes with certain treatment processes. The BOD levels in these waters fall under Class 3, where the Class 3 water quality standard, as per Government Regulation (PP) No. 22 of 2021 on the Implementation of Environmental Protection and Management, is intended for agricultural irrigation, livestock, and industrial purposes, as well as a raw water source for drinking water with intensive treatment.

DISCUSSION

The genera identified in this study (*Cocconeis*, *Nitzschia*, *Rhoicosphenia*, *Craticula*, *Frustulia*, *Hippodonta*, *Navicula*, *Amphora*, and *Fragilaria*) (Figure 2), primarily consist of epilithic diatoms, a group of benthic microalgae that inhabit hard substrates, such as rocks, in freshwater ecosystems. The term *epilithic* originates from the Greek *epi* ("upon") and *lithos* ("rock"), referring to their preference for colonizing solid surfaces in lotic and lentic environments. Belonging to the class *Bacillariophyceae*, phylum *Bacillariophyta*, epilithic diatoms are widely recognized as bioindicators due to their sensitivity to environmental parameters, including nutrient loading, organic pollution, hydrological fluctuations, and substrate composition.

Epilithic diatoms are encased in silica-based frustules with taxonomically distinct and morphologically intricate designs. Their sessile lifestyle and site fidelity make them reliable indicators of localized and long-term environmental conditions. For instance, *Nitzschia* species are frequently associated with eutrophic and nutrient-enriched waters, and their prevalence may signal organic pollution or anthropogenic disturbance (Bellinger & Sigee, 2010). *Navicula*, the most dominant genus at all stations, is commonly linked to β-mesosaprobic conditions, indicative of moderately polluted waters (Kurbanov et al., 2021). Meanwhile, *Amphora*, which occurred at lower frequencies in this study, is considered sensitive to nitrogen and phosphorus levels; its species richness can reflect ecosystem health, with declines potentially indicating environmental stress (Rott & Skerlep, 2014).

Additional genera such as *Craticula* and *Rhoicosphenia* offer further ecological insights. *Craticula* is often found in habitats subject to fluctuating salinity or periodic desiccation, suggesting environmental variability. *Rhoicosphenia* is frequently reported in freshwater systems impacted by agricultural runoff (Mirzahasanlou et al., 2018), consistent with its highest abundance being observed at station 2, which is surrounded by rice fields.

Quantitative analyses of diatom abundance were performed in accordance with the American Public Health Association (APHA) (2005) protocols. Among the three sampling sites, station 1 (proximal to Coban Glothak), station 2 (agricultural zone), and station 3 (residential zone), *Navicula* consistently showed the highest abundance, while *Amphora* showed the lowest. These patterns suggest spatial variation in nutrient input and land-use influence. As noted by Azis et al. (2020), diatom growth, including epilithic taxa, is strongly driven by nutrient availability, particularly nitrate and phosphate concentrations.

Ecological structure was further assessed through diversity and dominance indices. A moderate Shannon-Wiener diversity index ($H' = 1.805$) and low dominance value ($D = 0.199$) were observed, indicating a relatively balanced and stable community. According to Usman et al. (2013), aquatic systems with moderate to high diversity typically exhibit low dominance, reflecting ecological resilience. Therefore, the epilithic diatom assemblages observed in this study offer valuable insight into benthic ecosystem health and water quality across sites with differing anthropogenic pressures (Isnaningsih & Patria, 2018).

The absence of a dominant epilithic diatom genus at each station, according to Radiarta et al. (2015), is due to the fact that several epilithic diatom genera exhibit a high tolerance to extreme environmental conditions. However, some species were found at station 1 but not at station 2. station 2, which is an agricultural area, lacked the genus *Amphora*, which was present at station 1. The absence of *Amphora* in this area could signal deteriorating water quality, as this genus is considered sensitive to pollution and changes in water chemistry. A decline in the abundance of sensitive epilithic diatom species, such as *Amphora*, may indicate increased pollution, such as higher nutrient concentrations or shifts in pH levels. Differences in the presence or abundance of epilithic diatoms across stations are likely influenced by variations in environmental factors such as nutrient levels, organic matter, and land-use practices, which can significantly impact the composition of epilithic diatom communities within the ecosystem (Lowe, 1974).

Based on the analysis of physic and chemical factors at station 1, the water in that area falls under Class 2 water quality standards, but with BOD levels exceeding the Class 2 standard, as is also the case for the waters at stations 2 and 3. Class 2 water, according to the Regulation of the Republic of Indonesia Number 22 of 2021, is water that can be used for water recreation, freshwater fish farming, livestock, irrigation, and can be utilized for industrial purposes with certain treatment processes. However, the BOD levels in these waters fall under Class 3, where the Class 3 water quality standard, as per Government Regulation (PP) No. 22 of 2021 on the Implementation of Environmental Protection and Management, is intended for agricultural irrigation, livestock, and industrial purposes, as well as a raw water source for drinking water with intensive treatment.

Biochemical Oxygen Demand (BOD) is a parameter commonly used to determine pollution in water, where BOD indicates the amount of dissolved oxygen consumed by microorganisms to decompose organic matter in the water. A low BOD value generally indicates good water quality, while a high BOD value indicates pollution. Aini et al. (2015) highlighted that a high BOD concentration in water reflects pollution in that water body. In addition to BOD, epilithic diatoms are also effective indicators of water quality, providing valuable insights into both short-term and long-term changes in the ecosystem. These diatoms, sensitive to nutrient levels and organic pollution, can reflect water quality in ways that complement physicochemical parameters like BOD (Rimet & Bouchez, 2012; Lobo et al., 2016). Epilithic diatoms respond to changes in water chemistry, including fluctuations in nutrients, pH, and organic matter, offering an ecological perspective to water quality monitoring (Stoermer & Smol, 2004).

Differences in BOD values can occur due to the specificity of the measurements, as each parameter measures different aspects of water quality. For instance, pH measures the acidity or alkalinity of the water, while BOD measures the oxygen required to decompose organic matter. These two parameters may not be directly related, so even if pH is within normal limits, BOD can still be high if there is an increase in decomposed organic matter. Similarly, epilithic diatoms provide a complementary bioindicator of pollution. The diversity and composition of epilithic diatoms reflect not only physical and chemical conditions, but also the longer-term trends in water quality (Kelly et al., 2009).

Based on the above description, it can be concluded that the waters of the Sub-Dem River in the Coban Glothak area still exhibit relatively good water quality according to biological indicators, such as epilithic diatom diversity and dominance indices, alongside physic chemical indicators like BOD. The presence and composition of epilithic diatoms provide additional confirmation that the river maintains its ecological health despite some areas showing signs of pollution.

CONCLUSION

This study investigated the epilithic diatom community in the Dem River at Coban Glothak, assessing its role as a bioindicator of water quality. The results revealed a moderate diversity of diatoms, with the genus *Navicula* being the most abundant across all stations, indicating a balanced aquatic ecosystem. The diversity index, ranging from 1.724 to 1.910, suggests that the diatom community is moderately stable, though still sensitive to environmental changes. The low dominance value (0.199) further supports the conclusion of a relatively stable ecosystem, without any one species overwhelming the community. The physico-chemical analysis of water quality at the study sites indicated that while the water in the Dem River generally meets Class 2 water quality standards, certain parameters, particularly biochemical oxygen demand (BOD), exceeded the standards, suggesting the presence of moderate pollution. These findings highlight that while the river supports a diverse diatom community, it may still be vulnerable to nutrient pollution, as reflected by the abundance of certain genera such as *Nitzschia* and *Rhoicosphenia*, which thrive in nutrient-rich conditions. Overall, the study underscores the potential of epilithic diatoms as bioindicators of water quality in the Dem River, providing valuable insights into the health of the aquatic ecosystem in the

Coban Glothak area. Further monitoring of these diatom communities, along with regular physico-chemical assessments, is recommended to ensure the long-term sustainability of the river's ecosystem amidst increasing tourism and anthropogenic activities.

ACKNOWLEDMENTS

Thank you to all members of the undergraduate ecology team from the Biology Department for their assistance in the research, and to LP2M UIN Malang for providing the funding for the publication of the following scientific article.

REFERENCES

Aini, Z., Mulyadi, A., & Amin, B. (2015). Analysis of epipelic diatom composition as a bioindicator of coastal water pollution in Dumai City, Riau Province. *Kutubkhanah*, *18*(1), 7-18. doi: 10.24014/kutubkhanah.v18i1.1469.

American Public Health Association (APHA). (1992). *Standard methods for the examination of water and wastewater (18th ed.)*. Washington, DC: American Public Health Association.

American Public Health Association (APHA). (2005). *Standard methods for the examination of water and wastewater (21st ed.)*. Washington, DC: American Public Health Association.

Azis, A., Nurgayah, W., & Salwiyah. (2020). The relationship between water quality and phytoplankton abundance in the waters of Koeno, South Palangga District, South Konawe Regency. *Jurnal Sapa Laut*, *5*(3), 221-234. doi: 10.33772/jsl.v5i3.13452.

Bellinger, E. G., & Sigee, D. C. (2010). *Freshwater algae: Identification and use as bioindicators*. Chichester, West Sussex, UK: Wiley-Blackwell.

Castillejo, P., Chamorro, S., Paz, L., Heinrich, C., Carrillo, I., Salazar, J. G., ... & Lobo, E. A. (2018). Response of epilithic diatom communities to environmental gradients along an Ecuadorian Andean river. *Comptes Rendus Biologies*, *341*(4), 256-263. doi: 10.1016/j.crvi.2018.03.008.

Fitria, R., & Wulandari, D. (2020). Water quality and biodiversity in river ecosystems: Insights from recent studies in East Java. *Aquatic Ecosystem Health & Management*, *23*(3), 250-263.

Isnaningsih, N. R., & Patria, M. P. (2018). The role of mollusk communities in supporting the function of mangrove areas in Tanjung Lesung, Pandeglang, Banten. *Biotropika: Journal of Tropical Biology*, *6*(2), 35-44. doi: 10.21776/ub.biotropika.2018.006.02.01.

Junaedi, R., & Sulistiani, N. (2023). Impact of tourism on water quality and ecosystem health: A case study of Coban Glothak, East Java. *Journal of Environmental Management*, *309*, 114543. doi: 10.2166/ws.2023.123.

Kelly, M. G., Cazaubon, A., Coring, E., Dell'Uomo, A., Ector, L., Goldsmith, B., … Vizinet, J. (1998). Use of diatoms for river quality assessment. *Science of the Total Environment, 210-211*, 125-129. doi: 10.1016/S0048-9697(98)00109-4.

Kelly, M. G., Juggins, S., & Guthrie, R. (2009). A comparison of diatom indices used to assess European river water quality. *Aquatic Ecology*, *43*(1), 55-67. doi: 10.1007/s10452-008-9203-5.

Kelly MG, Bennett C, Coste M, Delgado C, Delmas F, Denys L, Ector L, Fauville C, Ferreol M, Golub M, Jarlman A, Kahlert M, Lucey J, ní Chatháin B, Pardo I, Pfister P, Picinska Faltynowicz J, Rosebery J, Schranz C, Schaum-burg J, van Dam H, Vilbaste S. 2009a. A comparison of national approaches to setting ecological status bound-aries in phytobenthos assessment for the European Water Framework Directive: results of an intercalibration exercise. *Hydrobiologia* 629: 169-182.

Krammer, K., & Lange-Bertalot, H. (1988). *Bacillariophyceae* (vols. 2/1-4). In H. Ettl, J. Gerloff, H. Heynig, & D. Mollenhauer (Eds.), *Süßwasserflora von Mitteleuropa (freshwater flora of Central Europe).* Stuttgart: Gustav Fischer Verlag.

Kurbanov, A., Titova, N., Mustaphaeva, Z., & Atabaeva, N. (2021). The role of macrozoobenthos and periphyton in bioindication of water resources quality in Uzbekistan. *E3S Web of Conferences, 265*, 01016. doi: 10.1051/e3sconf/202126501016.

Kurniawan, D. (2021). Assessment of water quality in Indonesian rivers using diatom bioindicators: A case study of the Brantas River Basin. *Water Quality Research Journal, 56*(4), 621-631.

Lowe, R. L. (1974). *Environmental requirements and pollution tolerance of freshwater diatoms (EPA-670/4-74-007)*. Cincinnati, Ohio: National Environmental Research Center, Office of Research and Development, U.S. Environmental Protection Agency

Lobo, E. A., Heinrich, C. G., Schuch, M., Wetzel, C. E., & Ector, L. (2016). Diatoms as bioindicators in rivers: Ecological relevance and methodological considerations. In O. Necchi Jr. (Eds.), *River algae* (pp. 245-271). Cham, Switzerland: Springer International Publishing.

Mann, D. G., & Vanormelingen, P. (2013). An overview of the phylum *Bacillariophyta* (diatoms) in freshwater ecosystems. In J. P. Smol & E. F. Stoermer (Eds.), *The diatoms: Applications for the environmental and earth sciences (2nd ed.)*. Cambridge, UK: Cambridge University Press.

Mirzahasanlou, J. P., Nejadsattari, T., Ramezanpour, Z., Namin, J. I., & Asri, Y. (2018). The epilithic and epipelic diatom flora of the Balikhli River, Northwest Iran. *Turkish Journal of Botany*, *42*(4), 518-532. doi: 10.3906/bot-1711-46.

Odum, E. P. (1996). *Dasar-dasar ekologi edisi ke-iii* (S. Tjahjono, Terjemahan). Yogyakarta: Gadjah Mada University Press.

Patrick, R., & Reimer, C. W. (1966). *The diatoms of the United States exclusive of Alaska and Hawaii (volumes 1 & 2)*. Philadelphia: Academy of Natural Sciences of Philadelphia.

Potapova, M., & Charles, D. F. (2003). Distribution of benthic diatoms in US rivers. *Journal of Phycology*, *39*(4), 659-672.

Prahardika, B. A., & Setyawan, W. M. L. D. (2020). Study of epilithic diatom diversity and their potential as bioindicators of river water quality in Coban Tarzan, Malang Regency. *Biotropika: Journal of Tropical Biology*, *8*(2), 116-124. doi: 10.21776/ub.biotropika.2020.008.02.07.

Prahardika, B. A., & Setyawan, W. M. L. D. (2022). The epilithic diatom community as a bioindicator of water quality in Brangkal Subwatershed in the Mojokerto Area. *Jurnal Biodjati*, *7*(2), 268-279. doi: 10.15575/biodjati.v7i2.20439.

Prygiel, J., & Coste, M. (1993). The assessment of water quality in the Artois–Picardie water basin (France) by the use of diatom indices. *Hydrobiologia*, *269-270*, 343-349.

Radiarta, I. N., Erlania., & Sugama, K. (2015). Spatial and temporal analysis of phytoplankton communities around integrated marine aquaculture in Ekas Bay, West Nusa Tenggara. *Jurnal Riset Akuakultur*, *10*(2), 283-291. doi: 10.15578/jra.10.2.2015.283-291.

Rimet, F., & Bouchez, A. (2012). Life-forms, cell sizes and ecological guilds of diatoms in European rivers. *Hydrobiologia*, *683*(1), 59-76.

Rott, E., & Škerlep, M. (2014). Diatom communities in aquatic systems: A review. *Hydrobiologia*, *721*(1), 1-20. doi: 10.1046/j.1365-2427.2003.01080.x.

Sabri, L., & Hastono, S. P. (2007). *Statistik kesehatan*. Jakarta: Rajawali Pers.

Sari, I. N., & Rahayu, S. (2024). Ecological assessment of river systems using epilithic diatoms: Methods and applications in Indonesia. *Hydrobiologia*, *851*(2), 315-328.

Spaulding, S. A., Lubinski, D. J., & Potapova, M. (2010). Diatoms of the United States. Retrieved from https://diatoms.org

Stoermer, E. F., & Smol, J. P. (2004). *The diatoms: Applications for the environmental and earth sciences (2nd ed.)*. Cambridge, UK: Cambridge University Press

Suhendar, U., Putra, D. F., Soeprobowati, T. R., & Wiryani, E. (2012). Komunitas diatom epilitik pada aliran air sekitar sumber air panas dan sumber gas belerang kawasan Gedongsongo, Kabupaten Semarang. *Bioma: Berkala Ilmiah Biologi*, *14*(1), 33-36. doi: 10.14710/bioma.14.1.33-36.

Taylor, J. C., & Cocquyt, C. (2016). *Diatoms from the Congo and Zambezi Basins – methodologies and identification of the genera (vol. 16)*. Meise, Belgium: ABC Taxa/Botanical Garden Meise.

Usman, M. S., Kusen, J. D., & Rimper, J. R. T. S. (2013). Plankton community structure in the waters of Bangka Island, North Minahasa Regency. *Jurnal Pesisir dan Laut Tropis*, *2*(1), 51-57. doi: 10.35800/jplt.1.2.2013.2149.

Wetzel, R. G. (2001). *Limnology: Lake and river ecosystems (3rd ed.)*. San Diego, CA: Academic Press.

Wibowo, D. S., & Mutaqin, B. W. (2020). Bioindikator kualitas air berdasarkan komunitas diatom epilitik di Sungai Brantas, Jawa Timur. *Jurnal Ilmu Lingkungan*, *18*(2), 321-329. doi: 10.14710/jil.18.2.321-329.