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# Pollution level of Banjaran River, Banyumas District, Indonesia: A study based on the Saprobic Index of periphytic microalgae

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[2]Program of Aquaculture, Faculty of Fisheries and Marine Sciences, Universitas Jenderal Soedirman. Jl. Dr. Soeparno, Purwokerto Utara, Banyumas 53122, Central Java, Indonesia

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**Abstract.** *Samudra SR, Fitriadi R, Baedowi M, Sari LK. 2022. Pollution level of Banjaran River, Banyumas District, Indonesia: A study based on the Saprobic Index of periphytic microalgae. Biodiversitas 23: 1527-1534.* The saprobic index of periphytic microalgae can be used to determine the level of water pollution based on the number and composition of species. Banjaran River is one of the rivers in the Banyumas District, Central Java, Indonesia, which is widely used by the local people for daily activities. The increase of domestic and agricultural activities in the river triggers an increase in the pollutants input into the river. This study aims to determine the status of the waters in the midstream of Banjaran River by using the periphytic microalgae saprobic index as a bioindicator of water quality. Purposive sampling method was used in this study by establishing four stations and five replications at each station. The result showed that the abundance of periphytic microalgae ranged from 7,547-8,733 cells/cm$^2$; the diversity index ranged from 1.64-2.07 (moderately polluted waters); the dominance index ranged from 0.21-0.26 (no particular species of periphytic microalgae dominating the four stations); and saprobic index value of Banjaran River ranged from 1.00 to 1.03 which indicates that Banjaran River belongs to β-meso/oligo saprobic water. In other words, it was water with a light pollution level. An action to reduce organic pollution is necessary, one of which is by reducing the people's activities such as washing and disposing of household waste into the river so that the condition of Banjaran River can be maintained properly and reduce pollution in its subsequent river flows.

**Keywords:** Banjaran River, microalgae, periphyton, saprobic index, water pollution

## INTRODUCTION

Water quality monitoring can be carried out based on three approaches, namely, using biological, physical, and chemical parameters. Among such three approaches, biological parameters using organisms living in the water environment (i.e., biological indicators) have advantages in terms of they can detect changes in the environment quickly. Another advantage of using bio-indicators in water quality monitoring is that they will represent better results compared to those of physical and chemical parameters since the biological community that exists in the water will be greatly influenced by the changes in environmental conditions (Vis et al. 1998; Li et al. 2010; Ovaskainen 2019).

One of the uses of biological indicators in the water environment is to determine the level of water pollution. Biological indicators generally used in monitoring water quality are macroinvertebrates, fish, plankton, and periphyton (Arsad et al. 2021). Periphyton is a community made up of algae, bacteria, heterotrophic microbes, and small animals immersed in the mucilaginous matrix, which lives attached (permanently or freely) to objects submerged in streams and rivers (Wu 2017; McDowell et al. 2020). Periphyton can be an early warning system to detect contamination and reveal pollutant effects in the water (Montuelle et al. 2010). Microalgae are the most dominant community of periphyton when the water has high nutrient or organic matter content. If there is an environmental change, physiological characteristics and distribution of the periphyton will also change (Wu 2017). Periphytic microalgae are often used as a potential biological assessment method for environmental sensitivity characteristics (Peng et al. 2020). The use of periphyton as an indicator of pollution levels is due to its wide distribution in the water, rapid reproduction can be found on various types of substrates and can adapt to heavy water currents (Arsad et al. 2021).

Microalgae can be used to monitor the level of organic matter pollution based on the analysis of community structure and its saprobity index. The saprobic index is a determination of the water pollution level based on the number and species composition of the living organisms in the waters. Saprobic level of the waters shows the pollution degree in the water and is represented by the number of microorganisms as the indicators of pollution (De Pauw and Vanhooren 1983; Salsabila et al. 2021).

Banjaran River is a tributary of Logawa River in Banyumas District, Central Java, Indonesia. The upstream of this river is located in Baturaden Subdistrict and the downstream is in Patikraja Subdistrict. Along the Banjaran River is dominated by residential areas with various activities. Various activities such as washing, bathing, and defecating of local people along this river are likely to produce various pollutants that will affect the water quality. Changes in the river water quality need to be monitored as an effort of conservation to maintain the aquatic ecosystem. This study aimed to assess the pollution of Banjaran River using bioindicator periphytic microalgae based on the saprobic index.

## MATERIALS AND METHODS

### Study period and area

This study was conducted from April to July 2021 in Banjaran River, Banyumas District, Central Java, Indonesia (Figure 1). The purposive sampling method was used based on consideration of certain characteristics present in the study location. Four sampling stations with five replications were established for data collection taken every 2 weeks. The sampling stations were located in the central part of Banjaran River. The station I (7º22'28" S, 109º13'23" E) was the river area close to the headwaters, where the riverbank was dominated by agriculture and several residential areas. Station II (7º23'39" S, 109º13'31" E) was a river area where there were many settlements and a few rice fields. Station III (7º24'28" S, 109º13'42" E) and IV (7º25'16" S, 109º13'26" E) were river areas surrounded by densely populated areas.

### Data collection procedures

*Periphytic microalgae sampling*

Samples of periphytic microalgae were taken by randomly selecting five slippery rock substrates in the river, then scraping the surface of the rock using a brush of 3x3 cm. The materials resulted from scraping were put into a sample bottle filled with 50 mL distilled water, then Lugol's solution was added as a sample preservative. The identification of periphytic microalgae was performed under a binocular microscope with 100x magnification using the Lackey drop microtransect counting method.

*Water sampling*

A sampling of water quality was done by taking water from the river body using a bucket. Measurement of water quality variables was carried out in situ and ex-situ. In situ measurements of temperature, Dissolved Oxygen (DO), Total Dissolved Oxygen (TDS), conductivity used Lutron YK-2001PHA, and measurement of pH used Lutron PH-222. While ex situ measurement was conducted in the laboratory, including TSS (SNI 06-6989.04:2004), nitrate (APHA 1992:4005-NO3.4-87), nitrite (SNI 06-6989.9:2004), and phosphate (Spectrophotometry).

### Data analysis of periphytic microalgae

Calculation of periphyton abundance was performed using a formula from APHA (2017) with modifications, as follows:

$$N = \frac{C \times At \times Vt}{Ac \times Vs \times As \times S}$$

Where: N: abundance of periphytic microalgae (cells/cm$^2$); C: numbers of observed periphytic microalgae (cells); At: cross-sectional width of cover glass (324 mm$^2$); Vt: sample volume in bottle (50 mL); Ac: width of view field (1.11279 mm$^2$); Vs: sample volume under cover glass (0.1 mL); As: width of scrapped substrate (3x3 cm$^2$); S: total of view field (30).

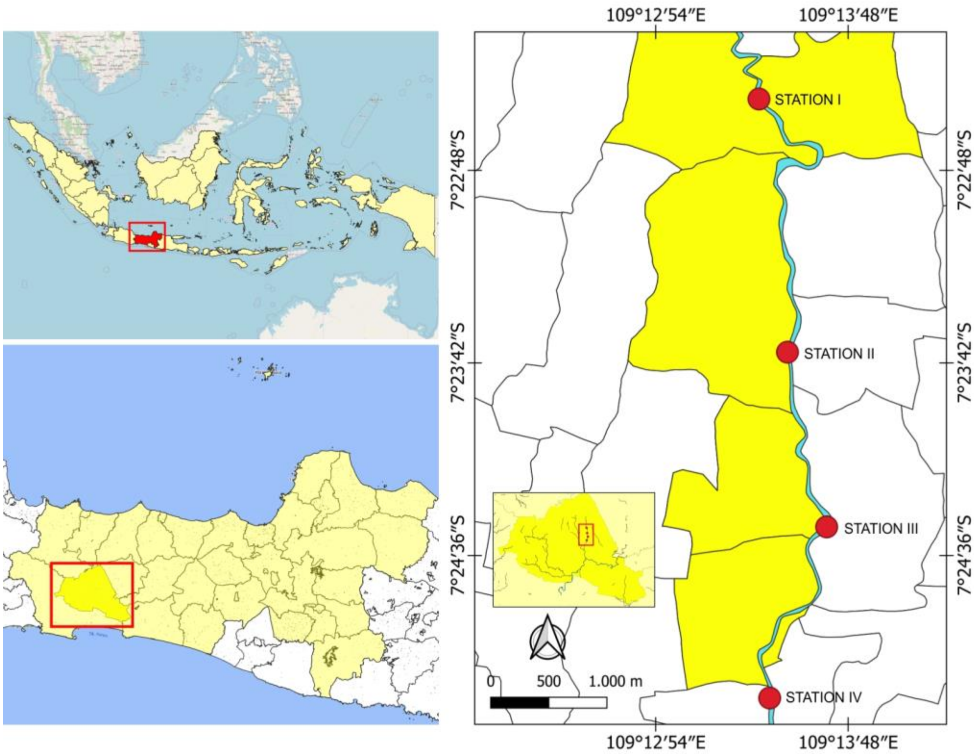


**Figure 1.** Location of the sampling sites of periphytic microalgae in Banjaran River, Banyumas District, Central Java, Indonesia

Periphyton diversity index was calculated based on the Shannon-Weaver formula:

$$H' = -\sum \left(\frac{ni}{N}\right) \ln \left(\frac{ni}{N}\right)$$

Where, H': diversity index of Shannon-Wiener; ni: number of individuals of species i; N: total number of individuals of all species

Value Category:

0-1.0 : very low diversity
1.1-2.0 : low diversity
2.1-3.0 : moderate diversity
3.1-4.0 : high diversity
>4 : very high diversity

Periphyton dominance index was calculated based on Simpson's formula:

$$C = \sum \left(\frac{ni}{N}\right)^2$$

Where, C: Simpson dominance index; ni: number of individuals of species i; N: total number of individuals of all species.

Value Category:

$0<C\leq0.5$ : low dominance
$0.5\leq C\leq0.75$ : moderate dominance
$0.75\leq C\leq1.0$ : high dominance

Saprobic index accorded to Dresscher and Mark (1976), and was calculated by the formula:

$$X = \frac{C + 3D - B - 3A}{A + B + C + D}$$

Where, X: Saprobic Coefficient, between of-3 to +3; A: Number of species groups Ciliates (polysaprobic); B: Number of species groups Euglenophyta (α-mesosaprobic); C: Number of species groups Chlorococcales and Diatoms (β-mesosaprobic); D: Number of species groups Peridinians+Chrysophyceae+Conjugate (oligosaprobic).

## RESULTS AND DISCUSSION

Based on the identification and analysis of periphyton in Banjaran River, Banyumas District, 17 species of periphytic microalgae were found, consisting of 11 species of Bacillariophyta (64.7%), 5 species of Chlorophyta (29.4%), and 1 species of Cyanobacteria (5.9%) (Table 2). Bacillariophyta was the most abundant division in the four stations. Bacillariophyta is the part of periphyton generally found in freshwaters such as rivers, lakes, and reservoirs. Bacillariophyta or diatoms are cosmopolite periphytons; thus, they can be found in waters with extreme conditions or polluted waters. It is due to the fact that Bacillariophyta has high adaptability in waters with extreme conditions by multiplying mucus on its body surface (Heramza et al. 2021; Saxena et al. 2021). Furthermore, Bacillariophyta has the ability to survive in slow to fast currents waters since they have gelatin stalk that functions to attach themselves to the substrate, and thus they are not carried away by fast water currents (Safitri et al. 2019). According to the study results of Godillot et al. (2001), diatoms species are more adaptable to attach to the substrate as periphyton in waters. Therefore, diatoms will be more commonly found as periphyton in various aquatic environments because they have a better ability to attach to the substrate (Guan et al. 2021).

The average abundance of periphyton at the station I (8,266 cells/cm$^2$) was higher than that of stations II and IV but lower than that of station III. The high abundance of periphytic microalgae at the station I could be caused by the relatively good condition of water quality, indicated by a low TSS value (Table 4). The average abundance of periphyton at station II was the lowest compared to the other three stations. Presumably, it was due to the lowest nitrate content of 0.215 mg/L than the other stations. At station III, the average abundance of periphyton was 8,733 cells/cm$^2$, the abundance value was the highest compared to the other three stations. It was likely due to the slower current than the previous station, which was 0.3 m/s, leading to the planktonic microalgae to move slowly in the river flow. It is supported by Gulin et al. (2021), stating that the abundance of periphyton tends to be higher in slow current waters since faster currents will decrease nutrients because these substances are carried by currents to other parts of the river. This can be seen from the average phosphate value at station III, which was higher than other stations.

**Table 1.** Categories of water pollution levels based on saprobic index

| Pollutant source | Pollution level | Saprobic phase | Saprobic index value |
|---|---|---|---|
| Organic matter | Very heavy | polysaprobic | -3 to-2 |
| | | Poly/α-mesosaprobic | -2 to-1.5 |
| | Heavy | α-meso/polysaprobic | -1.5 to-1 |
| | | α-mesosaprobic | -1 to-0.5 |
| Organic and inorganic substances | Medium | α/β-mesosaprobic | -0.5 to 0 |
| | | β/α-mesosaprobic | 0 to 0.5 |
| | Light | β-mesosaprobic | 0.5 to 1 |
| | | β-meso/oligosaprobic | 1 to 1.5 |
| Few organic and inorganic substances | Very light | Oligo/β-mesosaprobic | 1.5 to 2 |
| | | Oligosaprobic | 2 to 3 |

Source: Dresscher and Mark (1976)

**Table 2.** Abundance of periphytic microalgae in Banjaran Banjaran River, Banyumas District, Central Java, Indonesia

| Species | Station I (cells/cm$^2$) | | | | | | Station II (cells/cm$^2$) | | | | | | Station III (cells/cm$^2$) | | | | | | Station IV (cells/cm$^2$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | U1 | U2 | U3 | U4 | U5 | Average | U1 | U2 | U3 | U4 | U5 | Average | U1 | U2 | U3 | U4 | U5 | Average | U1 | U2 | U3 | U4 | U5 | Average |
| **Bacillariophyta** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cymbella* sp. | 2,336 | 3,235 | 899 | 2,336 | 0 | 1761 | 899 | 3,594 | 3,055 | 719 | 719 | 1,797 | 1,617 | 3,235 | 1,078 | 2,516 | 539 | 1,797 | 719 | 2,875 | 539 | 899 | 1,617 | 1,330 |
| *Eucocconeis flexella* | 0 | 180 | 0 | 180 | 0 | 72 | 180 | 0 | 180 | 0 | 0 | 72 | 359 | 0 | 0 | 0 | 180 | 108 | 0 | 0 | 0 | 0 | 719 | 144 |
| *Fragilaria* sp. | 0 | 0 | 0 | 0 | 180 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 180 | 0 | 0 | 36 | 0 | 0 | 0 | 0 | 180 | 36 |
| *Melosira varians* | 359 | 0 | 0 | 180 | 899 | 288 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 359 | 0 | 72 | 0 | 180 | 359 | 180 | 539 | 252 |
| *Navicula* sp. | 1,797 | 2,875 | 1,078 | 3,414 | 4,493 | 2731 | 0 | 4,493 | 5,750 | 1,617 | 3,414 | 3,055 | 1,977 | 4,133 | 3,414 | 3,414 | 5,391 | 3,666 | 2,696 | 1977 | 2,516 | 5,032 | 5,571 | 3,558 |
| *Nitzschia* sp. | 1,797 | 1,078 | 1,258 | 1,797 | 1,258 | 1,438 | 0 | 719 | 719 | 1,258 | 1,438 | 827 | 719 | 1,438 | 359 | 899 | 539 | 791 | 0 | 1,797 | 0 | 1,438 | 1,078 | 863 |
| *Pleurosigma* sp. | 0 | 0 | 0 | 180 | 0 | 36 | 359 | 0 | 0 | 180 | 359 | 180 | 0 | 180 | 0 | 180 | 180 | 108 | 0 | 0 | 0 | 180 | 359 | 108 |
| *Surirella* sp. | 0 | 359 | 180 | 0 | 0 | 108 | 0 | 180 | 0 | 180 | 539 | 180 | 180 | 0 | 0 | 539 | 1,438 | 431 | 0 | 180 | 0 | 1,078 | 719 | 395 |
| *Synedra acus* | 1977 | 0 | 0 | 0 | 0 | 395 | 0 | 0 | 0 | 0 | 0 | 0 | 180 | 0 | 0 | 0 | 2,156 | 467 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Synedra ulna* | 359 | 899 | 0 | 1,258 | 1,258 | 755 | 0 | 899 | 0 | 899 | 3,774 | 1,114 | 1,078 | 539 | 0 | 719 | 2,156 | 899 | 899 | 180 | 0 | 1,258 | 1977 | 863 |
| *Tablelaria* sp. | 0 | 0 | 0 | 1617 | 359 | 395 | 0 | 0 | 0 | 0 | 899 | 180 | 0 | 0 | 0 | 0 | 539 | 108 | 0 | 0 | 0 | 359 | 899 | 252 |
| **Chlorophyta** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cladophora* sp. | 719 | 0 | 0 | 0 | 0 | 144 | 0 | 0 | 0 | 0 | 0 | 0 | 359 | 0 | 0 | 0 | 0 | 72 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Closterium acerosum* | 359 | 0 | 0 | 0 | 0 | 72 | 0 | 180 | 0 | 0 | 0 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Closterium moniliferum* | 0 | 0 | 0 | 0 | 180 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 180 | 0 | 0 | 36 |
| *Coelastrum microporum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 899 | 0 | 0 | 0 | 0 | 180 | 0 | 0 | 0 | 180 | 0 | 36 |
| *Scenedesmus opoliensis* var. disparShen | 0 | 0 | 0 | 0 | 0 | 0 | 180 | 0 | 0 | 0 | 180 | 72 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Cyanobacteria** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Oscillatoria limosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 180 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Average Total Abundance | 8,266 | | | | | | 7,547 | | | | | | 8,733 | | | | | | 7,871 | | | | | |
| Diversity Index | 2.07 | | | | | | 1.64 | | | | | | 1.79 | | | | | | 1.72 | | | | | |
| Dominance Index | 0.21 | | | | | | 0.26 | | | | | | 0.24 | | | | | | 0.26 | | | | | |

**Table 4.** Physical and chemical parameters of waters in Banjaran River Banjaran River, Banyumas District, Central Java, Indonesia

| Parameters | Unit | Station I | | Station II | | Station III | | Station IV | |
|---|---|---|---|---|---|---|---|---|---|
| | | Range | Average | Range | Average | Range | Average | Range | Average |
| Current speed | m/s | 0.2-0.5 | 0.4 | 0.3-0.4 | 0.34 | 0.3-0.4 | 0.3 | 0.1-0.2 | 0.2 |
| Temperature | ℃ | 23.0-24.4 | 23.9 | 25.4-27.0 | 26.02 | 26.7-28.7 | 27.4 | 27.5-29.7 | 28.5 |
| pH | - | 7.9-8.5 | 8.1 | 7.5-8.2 | 7.9 | 7.9-8.3 | 8.1 | 7.7-8.4 | 8.0 |
| TDS | mg/L | 92.7-115.7 | 98.0 | 94.3-117.0 | 102.0 | 97.7-127.0 | 107.8 | 101.7-141.7 | 112.1 |
| Conductivity | µs/cm | 127.0-169.3 | 146.0 | 141.7-173.0 | 151.14 | 145.9-200.7 | 158.4 | 147.0-209.7 | 166.3 |
| DO | mg/L | 7.8-8.6 | 8.2 | 6.5-8.2 | 7.34 | 7.3-8.0 | 7.6 | 7.3-8.1 | 7.7 |
| TSS | mg/L | 0.17-5.50 | 2.6 | 2.50-7.17 | 4.32 | 5.33-10.33 | 7.5 | 3.20-9.17 | 6.5 |
| Nitrate | mg/L | 0.050-0.350 | 0.264 | 0.124-0.452 | 0.215 | 0.158-0.400 | 0.220 | 0.173-0.492 | 0.255 |
| Phosphate | mg/L | 0.165-0.385 | 0.274 | 0.215-0.366 | 0.245 | 0.207-0.540 | 0.300 | 0.070-0.324 | 0.177 |

**Table 3.** Saprobic Index of periphytic microalgae in Banjaran River Banjaran River, Banyumas District, Central Java, Indonesia

| Species | Station I | Station II | Station III | Station IV |
|---|---|---|---|---|
| GROUP A | | | | |
| - | | | | |
| GROUP B | | | | |
| - | | | | |
| GROUP C | | | | |
| *Achnanthes flexella* | 72 | 72 | 108 | 144 |
| *Coelastrum microporum* | 0 | 0 | 180 | 36 |
| *Cymbella* sp. | 1761 | 1797 | 1797 | 1330 |
| *Fragilaria* sp. | 36 | 0 | 36 | 36 |
| *Melosira varians* | 288 | 0 | 72 | 252 |
| *Navicula* sp. | 2731 | 3055 | 3666 | 3558 |
| *Nitzschia* sp. | 1438 | 827 | 791 | 863 |
| *Pleurosigma* sp. | 36 | 180 | 108 | 108 |
| *Scenedesmus opoliensis* | 0 | 72 | 0 | 0 |
| *Surirella* sp. | 108 | 180 | 431 | 395 |
| *Synedra acus* | 395 | 0 | 467 | 0 |
| *Synedra ulna* | 755 | 1114 | 899 | 863 |
| *Tabellaria* sp. | 395 | 180 | 108 | 252 |
| Total | 8015 | 7476 | 8662 | 7835 |
| GROUP D | | | | |
| *Closterium acerosum* | 72 | 36 | 0 | 0 |
| *Closterium moniliferum* | 36 | 0 | 0 | 36 |
| Total | 108 | 36 | 0 | 36 |
| Saprobic index | 1.03 | 1.01 | 1.00 | 1.01 |

The species having the highest average abundance in the four stations were *Navicula* sp. and followed by *Cymbella* sp. (Table 2). The two genera are part of the division Bacillariophyta. Bacillariophyta is a division of microalgae that has the ability to adapt to its environment, has a high tolerance for water pollution, especially organic pollution, and is resistant to extreme conditions (Odum 1993; Safitri et al. 2019). In addition to the Bacillariophyta division, Chlorophyta and Cyanobacteria divisions were also identified at the four study stations. The presence of Chlorophyta and Cyanobacteria found at the four stations indicates that the source of pollution in the Banjaran River was organic waste. It is in line with the statement of Anago et al. (2013) that the activities of local people dominated by domestic and agricultural activities will support the growth of Chlorophyta and Cyanobacteria as a result of organic matter input of these activities.

The results of the diversity index at the four stations showed that station I had the highest diversity index value and the lowest diversity index was at station II (Table 2). Fluctuation in the diversity index of the four stations was due to physical and chemical factors in the waters that affected the number of periphyton found during the sampling process. Based on its diversity index, Banjaran River is categorized as water with moderate pollution levels. It is in accordance with Wilhm and Dorris (1986) statements that if the diversity index of water is H' <1, it is categorized as heavily polluted waters; if the diversity index is 1<H'<3, it is categorized as moderately polluted waters; and if the value of diversity index is H'> 3, it belongs to clean waters. Furthermore, the value of the diversity index at the four stations indicated that the biota community in the waters belongs to moderate stability.

The dominance index shows the level of a species in dominating other species in the water. If the dominance index value of waters tends to be close to 0, it means that there are no certain dominant species, the periphyton is distributed more evenly and the water environment tends to be stable. Meanwhile, if the dominance index value is close to 1, it means that there are certain species dominating the water (Odum 1993). The value of the periphyton dominance index obtained in this study ranged from 0.21-0.26 (Table 2), meaning that there were no particular species of periphytic microalgae dominating the four stations. The most periphyton found in this study belonged to the Bacillariophyta division. Bacillariophyta adapts to a fast currents environment by producing Extracellular Polymeric Substance (EPS) (Burliga and Kociolek 2016). Bacillariophyta or diatoms are easily found in various ecosystems and in almost all types of seasons (Cordeiro et al. 2017). The dominance of diatoms is related to their morphological and physiological characteristics. Diatoms have mucus secretions that enable the adhesion to the substrate (Murakami et al. 2009). Periphytic diatoms are types of microalgae that can describe anthropogenic influences because diatoms are the most abundant group in periphyton (Zelnik and Sušin 2020).

Periphyton has been used as a water indicator for decades using the saprobic index (Hill et al. 2000). The range of the saprobic index value of Banjaran River was 1.00-1.03 (Table 3), which means that Banjaran River belongs to the light level of β-meso/oligosaprobic pollution (Table 1). The highest saprobic index value was at station I, which means that the organic and inorganic pollution loads at the station were relatively less than the other three stations. It can be found visually that the water at a station I was quite clear. Station III, with the lowest saprobic index, indicates that the incoming pollutant is relatively higher than the other stations. The incoming pollutant is supposed to be dominated by community activities such as bathing, washing, and toileting, as well as a few people throwing household waste directly into the river.

Bacillariophyta was periphyton mostly found in the four stations. The presence of Bacillariophyta indicates that these waters are β-mesosaprobic waters. It is supported by Kurbanov et al. (2021) stated that if diatoms of genus *Fragilaria, Cymbella, Navicula, Nitzschia, Pinnularia, Synedra,* and *Surirella* are found in water, it indicates that the waters belong to β-mesosaprobic waters.

Speed of the water current will determine the distribution and deposition of the periphyton. Colonization or deposition of microalgae will be influenced by the substrate nature and texture and the current speed (Godillot et al. 2001). Current speed also affects the type of periphyton algae attached to the substrate. McIntire (1966) conducted a study on the effect of current speed on the periphyton community at a laboratory and the results obtained were at a faster current speed (0.38 m/s), the periphyton community dominating gravel and rubble substrates is diatoms, which appears dark green or brown in color. Meanwhile, at slow current speed (0.09 m/s), periphyton was dominated by microalgae of *Stigeoclonium, Oedogonium,* and *Tribonema* species. The data of the current speed of the Banjaran River obtained in this study was at an average range of 0.2-0.4 m/s. It shows that the current speed of Banjaran River at the sampling station was moderate to fast, and the results obtained were in accordance with McIntire (1966) research that the predominant periphytic microalgae community is from the Bacillariophyta division, followed by the discovery of several species from Chlorophyta (Table 2).

Based on the study results, it was found that the water temperature from the station I to station IV had an increasing trend (Table 4). The increase in temperature was likely caused by the decreasing canopy or plant cover along with the river flow. The average temperature range at the four stations (23.9-28.5°C) is considered a normal range. The optimal water temperature for periphyton growth is 25-30°C (Wu 2017). According to research conducted by Guðmundsdóttir et al. (2011), the increasing temperature from the range of 7.1°C to 21.6°C will help microalgae in responding to nutrient enrichment. The most responding microalgae to the nutrient enrichment with increasing temperature were diatoms (Bacillariophyta), followed by green algae (Chlorophyta).

The average range of pH values from the four stations was 7.9-8.1. The pH value in waters is influenced by anthropogenic activities. Based on the Government Regulation of Republic Indonesia No. 22 of 2021 on Environmental Protection and Management, the pH value quality standard for rivers is 6-9. The increase in periphyton biomass at high pH was caused by the nutrient increase (Wu 2017). It is consistent with this study results that at stations I and III, with an average pH value of 8.0, the abundance value of periphytic microalgae and the average content of nitrate and phosphate were higher than stations II and IV.

TDS measured at the four stations ranged from 98.0-112.1 mg/L. The highest TDS value was at station IV, which was likely caused by the accumulation of dissolved solids from the previous water flow. TDS is a dissolved and colloidal material whose source might result from the use of materials containing cations and anions used in household activities (Suoth and Nazir 2016; Hansen et al. 2018). The number of household activities such as washing clothes and bathing along the river will increase TDS value. TDS value is related to conductivity. The higher the TDS value, the higher the conductivity value, and vice versa. Conductivity values in Banjaran River ranged from 146.0-166.3 µs/cm. The range of conductivity values is considered suitable for natural waters. Zhang et al. (2019) stated that if the stream conductivity exceeds 500 µs/cm, it will lead the health conditions to change from normal grade to poor grade. The water conductivity is influenced by the content of water ions, such as nitrate, phosphate, sulfate, calcium, and aluminum.

The value of Dissolved Oxygen (DO) at the four stations is optimal for the waters. The DO content at station II was the lowest (7.34 mg/L) compared to the other stations. The main factor affecting the low DO value included domestic waste input from the local people's activities. The river flow at station II was widely used by the people for washing, bathing, and disposing of garbage. In addition, the people's livestock cages were also found on the river banks allowing for the input of organic waste. The decrease of water DO was triggered by the input of domestic waste into the waters as well as the activity of microorganisms to decompose organic matter into inorganic materials, both biologically and chemically (Arum et al. 2019).

TSS or Total Suspended Solid in Banjaran River ranged from 2.6-7.5 mg/L. The highest TSS was found at station III, which was 7.75 mg/L which was likely due to anthropogenic activities in rivers such as washing, bathing, and defecating. This is supported by the result of Chatanga et al. (2019) study, which states that the high value of total suspended solids, total dissolved solids, nitrate, phosphate, conductivity, turbidity in Mohokare River was caused by anthropogenic activities.

The average range of nitrate content from stations I to IV was 0.215-0.264 mg/L (Table 4). The highest average content is found at station I, which was 0.264 mg/L. It was likely due to the fact that there were agricultural lands along the river at station I; hence, most of the sources of pollutants were originated from agricultural land activities such as fertilizer residue. While the source of nitrate at other stations mostly came from the domestic activities of the people living on the river banks. Results of the abundance values of periphytic microalgae at stations I and III were the highest, which could be influenced by the concentration of nitrate and phosphate, which was higher and above the saturation concentration. According to Schmidt et al. (2019), nitrogen saturation concentrations for periphytic microalgae ranged from 0.0085 mg/L to 0.06 mg/L. This shows that the nitrogen concentration in Banjaran River is above the saturation value, which means it can stimulate the growth of periphyton.

The average value range of phosphate content at the four stations was 0.177-0.300 mg/L. The high phosphate content at station III can be caused by the use of river flows for washing and bathing activities. The people's activities such as washing and bathing provide input of organic materials in the form of residual detergent and bath soap which can increase the phosphate content in these waters (Amadi and Omokhyeke 2020). According to Schmidt et al. (2019), phosphorus saturation concentrations for benthic microalgae ranged from 0.012 mg/L to 0.029 mg/L based on chlorophyll-a and 0.0025 to 0.0061 mg/L based on AFDM. Based on the results, it can be seen that the concentration of phosphate in the Banjaran River exceeded the saturation concentration for the growth of benthic microalgae. Therefore, the growth rate of microalgae in rivers will be high when the nutrient concentration is above the saturation concentration. Diatoms are microalgae that mostly respond to nutrient enrichment, and this response will increase with increasing temperature (Gudmundsdottir et al. 2011). This is in accordance with the results of this study, in which the division of periphytic microalgae that dominated was Bacillariophyta or diatoms, with the highest abundance at station III.

In conclusion, the pollution level of Banjaran River based on the periphyton saprobic index was in β-meso/oligosaprobic phase or β-mesosaprobic phase to oligosaprobic, which means that the waters belong to the slight pollution level supported by the nitrate and phosphate content in the river. An action to reduce organic pollution is necessary, one of which is by reducing the people's activities such as washing and disposing of household waste so that the condition of the Banjaran River can be maintained properly and reduce pollution in its subsequent river flows.

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