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Abundance of Perifiton as Natural Fish Food in The Banjaran River, Banyumas Indonesia

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Abstract

Fresh waters in Indonesia are strongly broad and play a role for aquaculture as well as human activities, thus impacting water quality and river ecosystems. Periphyton acts as a natural food source. This study aimed to determine the abundance of periphyton species as natural food for fish in the Banjaran River, and the quality of river water. Survey method and purposive sampling were used and conducted at four stations. This research was conducted in situ and ex situ and the test results were analyzed descriptively quantitatively. The percentage of periphyton abundance the Banjaran River is 28% from the class Bacillariophyceae (25 species), 21% Chlorophyceae (9 species), 21% Cyanophyceae (3 species), 16% Eugelenophyceae (2 species), and 16% Rhizopoda class (1 species). The abundance of periphyton at each station was 3,275–5,574 individuals/cm² with species abundance values of 26–22,904 individuals/cm², while the percentage values for the abundance of each class were Bacillariophycae (82%), Chlorophyceae (9%), Eugelenophyceae (6%), Cyanophyceae (2%), and Rhizopoda (1%). The water quality that greatly influences the value of periphyton abundance is TDS (Total Dissolved Solid). The influence of TDS content on the abundance of periphyton was 0.8 and the influence was negative.

Keywords: Banjaran river, fish natural food, periphyton

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Introduction

Indonesia has a vast amount of fresh water, and it can be used for aquaculture (Henriksson *et al*., 2019). The total area of all rivers, reservoirs, and swamps in Indonesia combined can reach up to 141.690 hectares (Trianto & Marisa, 2020). Rivers are tracks of water that flow from upstream to downstream (Agustin *et al*., 2019). A river has abiotic and biotic components that interact with one another (Isti'anah *et al*., 2015) One of microscopic organisms that thrive in rivers is periphyton.

Periphyton live on the surface of an object such as stones, woods, and plants (Ameilda *et al*., 2016). They act as producer as well as bioindicator since they are sensitive to changes in water quality and can serve as a reference to the existence of corresponding biodiversity (Suryono & Sudarso, 2019). Periphyton also act as food source for some invertebrates and fishes due to its abundance on many objects found in the river (Pratiwi *et al*., 2017). Ecological relationships with other aquatic organisms can be analyzed to find out the feeding habit of a fish (Effendie, 2002 *in* Dirham & Trianto, 2020) . Rivers serve not only as habitats for many organisms (Nangin *et al*., 2015), but also support human lives and activities (Pasisingi *et al*., 2014). Research related to periphyton in rivers has also been carried out by Rahayu & Piranti, 2021; Kono et al., 2021; Lestari et al., 2021; Agustin et al., 2019.

Banjaran river is one of the rivers that flows within Banyumas regency and is widely used by people in the area. Banjaran river is a tributary of Logawa river that flows north to south, from Baturraden district where it starts to Sidabowa village in Patikraja district where it ends (Setiyawan, 2006 *in* Prayitno & Rukayah, 2019). Banjaran river watershed is utilized by local communities as residential areas and yards,

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recreational areas, sanitation facilities, as well as drop off sites for various wastes (Samudra *et al.*, 2022). Research in the Banjaran River, namely microplastic content (Yuliana, et al., 2024); Reproduction and Histological Structure of Fish (Samudra *et al.*, 2022); Phytoplankton Community Structure (Candra et al., 2022). All of which contribute to degrading water quality and river ecosystems. Therefore, a study on periphyton abundance in Banjaran river is necessary as it acts as an important natural food source for fishes in there.

Research Methods

Research Time and Location

This research was conducted from November 2022 to February 2023. Sediment sampling was carried out at Banjaran River, Banyumas Regency and sample analysis was carried out at the Integrated Science Laboratory, Faculty of Science and Technology, Nahdlatul Ulama University Purwokerto.

This research was conducted from October 2022 to July 2023. The methodology used was survey with purposive sampling technique. The samples were taken from 4 different stations with 3 repetitions, once every two weeks, for each station. The stations were determined by accounting for the effect of watershed land-use on Banjaran river. Observation of the samples were carried out at natural science laboratory of Science and Technology Faculty, Universitas Nahdlatul Ulama Purwokerto.

Variable of interest in this research were total abundance and relative abundance of periphyton in Banjaran river while their supporting variables were pH, temperature, stream current's speed, TSS, TDS, and brightness. These variables were then analyzed using descriptive-quantitative method to find out possible explanation of periphyton abundance based on water physical properties in Banjaran river.

Table 1. Sampling locations

St.	Coordinate	Village	Land-use
1	7°36'87.09"S, 109°22'13.46"E	Kebumen, Kec. Baturraden	Paddy field, farm, low density residential area
2	7°39'17.72"S, 109°22'61.84"E	Beji, Kec. Kedung Banteng	Paddy field, farm, mild density residential area
3	7°42'38.62"S, 109°22'42.08"E	Kober, Kec. Purwokerto Barat	High density residential area
4	7°45'77.81"S, 109°21'38.97"E	Sidabowa, Kec. Patikraja	Paddy field and low density residential area

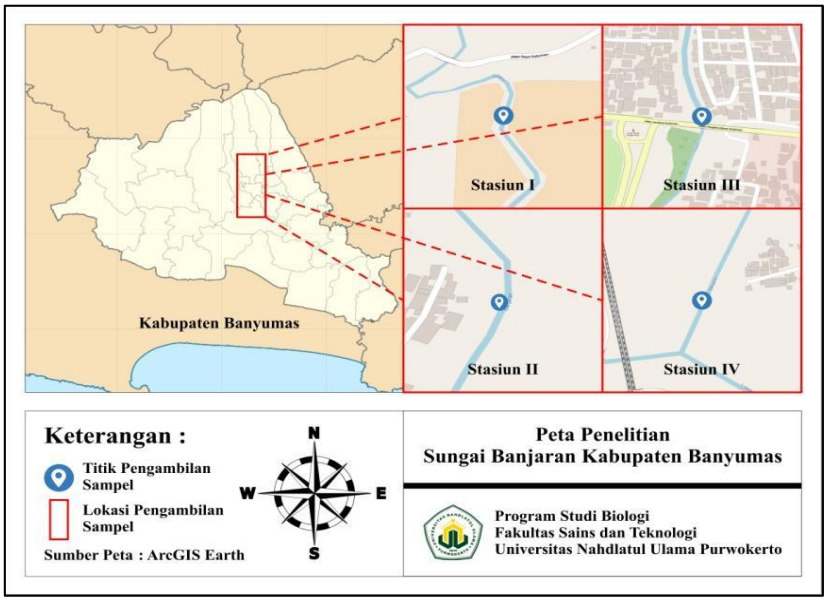

Figure 1. The Sampling location

Calculating Periphyton's Abundance

According to APHA (2017), here is the formula to calculate periphyton's abundance:

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

Explanation:
N = Total abundance (Individual/cm²)
C = Number of observed individuals
As = Area of substrate taken as sample (3x3 cm²)
At = Area of *cover glass* (22 x 22 mm²)
Ac = Area of smearing (2,405 mm²)
Vt = Volume of sampling bottle (50 ml)
Vs = Volume of observed sample under microscope (0.3 ml)
S = Number of observation field per sample (12)

Relative Abundance (RA)

According to Presscot (1970) *in* Rahayu *et al* (2017), in order to estimate how many organisms there are in an observation site/station we can use the following formula :

$$RA=\frac{ni}{N} \times 100\%$$

Explanation:
RA= Relative abundance
ni = number of individuals from species *i*
N = number of individuals from all observed species

The results will be interpreted in a table with a description of the signs, these signs will describe the number of large and small samples obtained.

Physical and Chemical Parameters

Some of physical and chemical properties analyzed in for this research were temperature, brightness, stream current's speed, TSS, TDS, and pH.

Data Analysis

The data of periphyton's abundance was analyzed with descriptive method, while the data of water quality which acts as supportive variables to periphyton's abundance were analyzed using PCA (Principal Component Analysis).

Result and Discussion

Specifics of the locations used in this research were determined based on the land-use of Banjaran river watershed by local communities. Station 1 was in Baturraden district lying at -7.391765 ˚E and 109.22621 ˚S. The area around this station was characterized by sparse housing and many gardens along the river. Station 2 was in Kedungbanteng district at -7.367759 ˚E dan 109.220233 ˚S. It's an area with a lot more housing and decent spaces for yards and gardens. Station 3 was in Purwokerto Barat district at -7.423856 ˚E dan 109.22419 ˚S. The area around station 3 was densely populated with many houses had little to no private space thus producing high volume of domestic waste. Station 4 was in Patikraja district at -7.457774 ˚E dan 109.213903 ˚S. The area was mainly dedicated for paddy field, but it also had few houses. It also had sandy and grainy substrate typical of downstream area.

Periphyton's Abundance as a Natural Food Source for Fishes in Banjaran River

Sampling and identification processes were carried out through December 2022 to January 2023 both i*n-situ* and *ex-situ*. The results for periphyton's abundance analysis can be found in Table 2.

The abundance value of periphyton in Banjaran river ranged from 26 to 22.904 individuals/cm² comprised of 5 classes and 40 species. The observed classes were Bacillariophyceae (25 species), Chlorophyceae (9 species), Cyanophyceae (3 species), Euglenophyta (2 species), and Rhizopods (1 species). Each accounted for 82%, 9%, 6%, 2%, and 1% from the total abundance respectively. Figure 2 presents these values in a pie chart.

Table 2. The Abundance of Periphyton Species in Banjaran River

Class	Species	Periphyton Abundance Values (Individual/cm²)			
		Station 1	**Station 2**	**Station 3**	**Station 4**
Bacillariophycae	*Amphipleura pellucida*	+++	+++	+++	++++
	Fragilaria sp.	+++++	+++++	+++++	++++
	Thalassionema sp.	+++	+++	+	+++
	Gomphonema sp.	+++	+++	+	+
	Tabellaria flocculosa	+++	+++	+++	+++
	Cymbella helvetica	+++++	+++++	++++	+++++
	Cymbella sp.	+++	+++	+	+
	Epithemia sorex	+	+++	+	+
	Melosira sp.	+	+++	+++	+++
	Nitzschia sp.	++++	+	+++	+++
	Meridion circulare	+	+	+	+++
	Meridion sp.	+++++	+++++	++++	++++
	Navicula radiosa	+++++	+++++	++++	++++
	Navicula sp.	+++++	+++++	+++++	+++++
	Navicula lanceolata	+++++	+++++	++++	++++
	Navicula protractoides	+++++	+++++	+++++	+++++
	Cocconeis pediculus	+++++	+++++	++++	++++
	Synedra acus	++++	++++	+++	++++
	Synedra elegans	++++	+	+	+++
	Synedra ulna	+++++	+++++	+++++	+++++
	Surirella sp.	+++	+++	+	+
	Pinnularia sp.	++++	+++	+++	+++
	Frustulia rhomboids	+	+++	+	+
	Gyrosigma sp.	++++	++++	++++	++++
	Cyclotella sp.	+++	+++	+++	+++
Chlorophyceae	*Closterium* sp.	+	+++	+++	++++
	Scenedesmus acuminatus	+++	+	+++	+++
	Scenedesmus quadricauda	+++	+++	+++	++++
	Scenedesmus sp.	+	+++	+	+
	Treubaria sp.	++++	+++	+	+
	Stigeoclonium sp.	++++	++++	++++	+++++
	Cosmarium sp.	+++	+++	++++	++++
	Pediastrum sp.	+++	+	+++	+++
	Chlorococcum sp.	++++	++++	++++	++++
Cyanophyceae	*Merismopedia elegans*	+++	+	+	+++
	Lyngbya sp.	+	+	+	++++
	Anabaena sp.	++++	++++	++++	+
Euglenophyceae	*Euglena spirogyra*	+++	+++	+	+
	Euglena sp.	+++++	++++	++++	++++
Rhizopoda	*Arcella crenulata*	+++	+	+++	+

Explanation:

+++++ = Abundance > 10.000
++++ = Abundance 1.000 - 10.000
+++ = Abundance 100 - 1.000
++ = Abundance 1 - 100
\+ = Abundance < 1

Bacillariophycae had the highest relative abundance at 82%. This might be because Bacillariophycae could adapt very well in any kind of environment since their cells contained mucopolysaccharide, and they had the ability to secrete sticky fluid made of gelatin that they used to attach themselves to any of substrate (Arsad *et al*., 2019). The smallest relative abundance was contributed by Rhizopods at 1 %. This might be due to Rhizopods' natural tendencies to live in sandy or muddy substrate and polluted water (Bellinger, 2010). This research revealed that all four stations in Banjaran river had rocky substrate and was slightly polluted.

The average value of periphyton's abundance in Banjaran river from all four stations were 3.275 – 5.574 individuals/cm^2. *Navicula* sp. was the dominating species with an abundance value of 22.904 individuals/cm^2. In contrast, *Scenedesmus* sp., *Frustulia rhomboids*, and *Epithemia sorex* had the lowest count at only 26 individuals/cm^2. Station 1 had the highest count of total abundance at 5.574 individuals/cm^2. This might be due to its upstream location where interference from human activities were minimum. Station 1 had rocky substrate that is suitable for periphyton to live on against stream current (Ruttner, 1974 *in* Dharmaji *et al*., 2020). Station 4 had low count of total abundance at 3.275 individuals/cm^2. It could be attributed due to its location at downstream where many locals lived creating more pressure to environment from human activities such as bathing, washing, waste dumping, etc. There were also farms and gardens which means Station 4 could potentially be polluted by agricultural wastes, in addition to domestic wastes, which affected the overall river ecosystem and periphyton habitat specifically. The same conclusion was also made by Sugianto (2010) starting that human activities and pollution to rivers caused water quality to deteriorate.

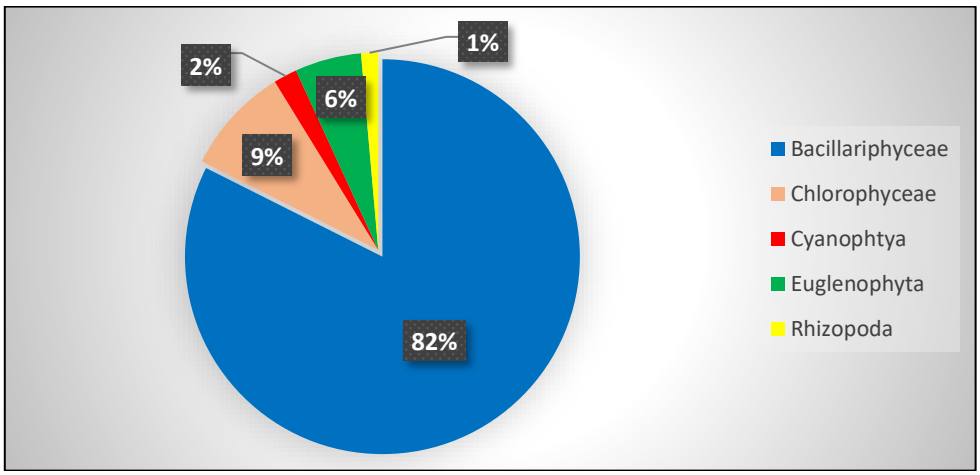

Figure 2. Relative Abundance of Periphyton in Banjaran River

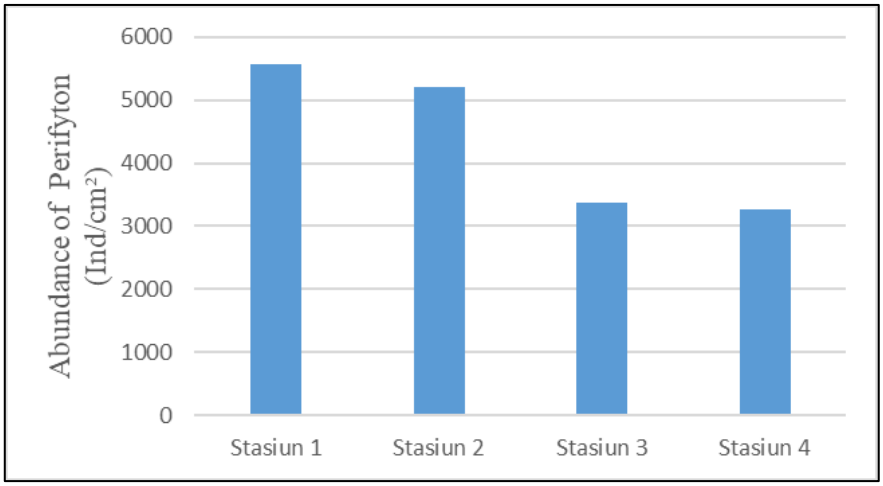

Figure 3. Periphyton's abundance in Banjaran River

Table 3. Periphytons fed on by fishes in Banjaran river

Class	Station 1	Station 2	Station 3	Station 4
Bacillariophyceae	++++	++++	++++	++++
Euglenophyceae	+++	+++	+++	+++
Chlorophycea	+++	+++	+++	+++
Cyanophyceae	++	+++	++	++
Rhizopoda	++	+++	++	++

Explanation:
++++ = Natural fed on with KR value > 10
+++ = Natural fed on with KR value < 10
++ = Natural fed on with KR value < 1
- = Not found

Table 4. Water quality of Banjaran Rivers

Parameters	Station 1	Station 2	Station 3	Station 4
	Range	Range	Range	Range
pH	7	7	7	7
Temperature (˚C)	22 – 25	23 – 25	24 – 27	24 – 28
Current speed (m/s)	0,32 - 0,74	0,30 - 0,43	0,30 - 0,38	0,25 - 0,33
Brightnees (%)	100 %	100 %	100 %	100 %
TSS (mg/L)	1,13 - 7,85	1,07 - 9,20	1,33 - 11,54	1,5 - 10,54
TDS (mg/L)	662 - 828	582 – 860	618 – 868	607 – 800

Fish's gut analysis revealed which periphytons were fed on by fishes in Banjaran river. Table 3 summarized the result of such analysis. Based on Table 3, all periphyton classes found in this research were natural food sources for fishes in Banjaran river. From most common to less common ones there are Bacillariophyceae at 28%, both Euglenophyceae and Chlorophyceae at 21% respectively, as well as Cyanophyceae and Rhizopods at 16% respectively. The abundance of these periphytons provided fishes in Banjaran river with plenty of food and optimum aquatic ecosystem since they also acted as a main driver of primary productivity which produced oxygen and organic matter (Fatmawati *et al*., 2016). Periphytons were essential in food chain or trophic level (Ameilda & Irma, 2016). Periphytons can be used as bioindicator of water quality owing to their sensitivity to changes in environmental conditions (Ditya, 2015).

Analysis of Banjaran river's water quality had been carried out through December 2022 to January 2023. Water samples were collected from 4 stations with 3 repetitions each, once every two weeks. The result is displayed in Table 4.

The analysis of some parameters such as pH, temperature, stream current, and brightness was performed directly at sampling locations in Banjaran river while the analysis of other parameters such as TSS and TDS was performed at Natural Science Laboratory of Science and Technology Faculty, Universitas Nahdlatul Ulama Purwokerto. As displayed in Table 4, water quality in Banjaran river can be summarized as follows: pH value was around 7, water temperature varied between 22 – 28^{o}C, stream current's speed ranged from 0,25 to 0,74 m/s, water brightness was at 100%, TSS value ranged from 1,07 – 11,54 mg/L, and TDS value ranged from582 – 868 mg/L.

Based on the results above, water pH of Banjaran river was said to be optimum for supporting periphyton's growth and development. According to Saputra *et al.* (2018), periphyton lived well in water with pH between 7 to 9. The same thing can be said for water temperature. Optimum living conditions for periphytons according to (Siregar *et al*., 2015)was between 25 – 35^{o}C. Stream current's speed also showed good result for periphyton's growth and development that is between 0,5 – 1 m/s (Xiao et al., 2023). Water brightness also proven to be good for periphyton. According to Carles et al. (2021), the better water brightness value that allowed sunlight to reach the bottom of a water body (100%) would provide enough light for periphyton to photosynthesize. TSS value of Banjaran river was optimum for periphyton's growth and development since the overall value of TSS can be considered as low, which is below 50 mg/L. According to a

research by Dwirastina & Wibowo (2015), TSS value between 5 – 13,5 mg/L allowed good sunlight penetration to water that enable photosynthesis by periphyton to support their growth and development.

TDS value of all four stations in Banjaran river was optimum for periphyton's growth and development. According to Wijaya (2009), TDS value below quality standard of 1.000 mg/L can be considered as low. All parameters of water quality were then incorporated in Principal Component Analysis (PCA). The result showed that TDS was the parameter that affecting periphyton's abundance. Figure 4 displayed PCA result in a plot. The plot made it clear that the TDS value was inversely proportional to the value of periphyton's abundance implying that higher TDS value would result in lower periphyton's abundance. TDS value of water in Banjaran river in general was 582 – 868 mg/L with the average value between 688 – 718 mg/L.

Station 3 had the highest TDS value at 868 mg/L while station 2 had the lowest TDS value at 582 mg/L. High TDS value at station 3 affect periphyton's abundance in a way that resulted in a relatively lower count compared to other stations, at 3.376 individuals/cm^2. On the other hand, low TDS value at station 2 resulted in high periphyton's abundance count at 5.206 individuals/cm^2. According to Dwirastina & Wibowo (2015), TDS value in Banjaran river could be considered low in general following recommeded quality standard.

The result of PCA showed that TDS had stronger effect on periphyton's abundance compared to the rest of the parameters. Even though the dissolved substances in a water were not toxic, they could increase water turbidity and hindered light penetration if the amount were excessive or beyond recommended quality standard of < 1000 mg/L (Wibowo & Rachman, 2020). According to Effendi (2003), TDS came from inorganic matters in the form of ions dissolved in water such as Sodium (Na), Calsium (Ca), and Magnesium (Mg). Excessive amount of these dissolved substances could increase turbidity and hinder light penetration which is needed in photosynthesis (Abdelfattah, 2023). A study by Wisha *et al.* (2016) concluded that periphyton's abundance was inversely proportional to the content of solid substance in the water of Porong river, Sidoarjo Regency.

TDS content has been shown to have an effect on the abundance of periphyton. The magnitude of the recorded effect is 0.8. The relationship is negative, meaning that increasing TDS content tends to decrease the abundance of periphyton. This shows that environmental conditions influenced by TDS can affect the presence of periphyton in aquatic ecosystems.

Discussion

Periphyton were essential in supporting river ecosystem. For one, they were natural food sources for fishes and other aquatic organisms while also being producers. Water physical properties such as TDS and TSS had direct effects on periphyton's abundance. This research revealed that both TDS and TSS value in Banjaran river were in accordance with Government Regulation No. 22 of 2021. Although, it's not unlikely to change with the massive land-use conversion in Banjaran river watershed.

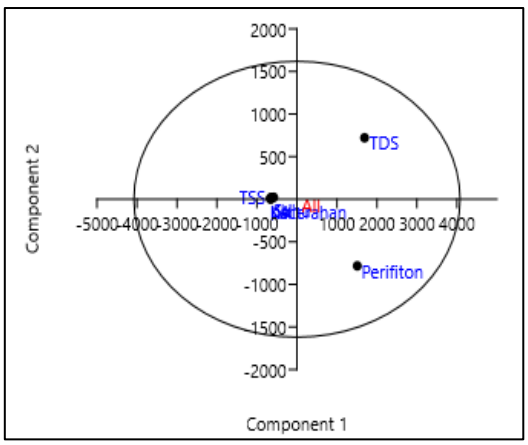

Figure 4. PCA Plot of Water Quality Parameters and Periphyton's Abundance in Banjaran River

Conclusion

The composition of periphyton, which act as natural food sources for fishes, in Banjaran river were 28% of Bacillariophyceae, 21% of Chlorophyceae, another 21% of Cyanophyceae, 16% of Euglenophyceae, and 16% of Rhizopods. All of which made up for an abundance count of 26 to 22.904 individuals/cm^2.

There were several water properties that affected the abundance of periphyton such as pH, temperature, brightness, stream current, TSS, and TDS. The prominent one being TDS with an average value of 688 to 718 mg/L. High TDS value increased water turbidity and reduced sunlight penetration that in turn reduced periphyton's overall ability to photosynthesize.

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