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Water Quality Analysis Based on Diversity and Abundance of Plankton in the Way Besai River, North Lampung

Analisis Kualitas Air Berdasarkan Keanekaragaman dan Kelimpahan Plankton di Sungai Way Besai Lampung Utara

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Abstrak

Plankton merupakan salah satu biota aquatik yang dapat berperan sebagai menjadi bioindikator perairan karena sangat peka terhadap perubahan kualitas air tempat hidupnya. Sungai Way Besai terletak di Desa Dwikora, Kecamatan Bukit Kemuning, Kabupaten Lampung Utara. Tujuan penelitian ini untuk mengetahui kualitas air Sungai Way Besai berdasarkan keanekaragaman dan kelimpahan plankton sebagai bioindikator suatu perairan dan untuk mengetahui hubungan antara struktur komunitas plankton dengan parameter kualitas air. Penelitian ini dilakukan pada bulan November-Desember 2024. Pengambilan sampel dilakukan menggunakan metode survey dengan 6 (enam) spot kemudian diidentifikasi dan dihitung menggunakan metode Sedgewick-Rafter. Berdasarkan analisis kelimpahan dan keanekaragaman plankton diketahui bahwa Sungai Way Besai dalam kondisi tercemar sedang dan terdapat hubungan yang signifikan antara struktur komunitas plankton dengan parameter kualitas air.

Kata kunci: *Kualitas air, Plankton, Sungai Way Besai, Sedgewick Rafter*

Abstract

Plankton is one of the aquatic biota that can act as a bioindicator of Water because it is susceptible to changes in the quality of the Water where it lives. The Way Besai River is in Dwikora Village, Bukit Kemuning District, North Lampung Regency. This study aimed to determine the water quality of the Way Besai River based on the diversity and abundance of plankton as a bioindicator of Water and to determine the relationship between the plankton community structure and water quality parameters. This study was conducted in November-December 2024. Sampling was performed using a survey method with 6 (six) spots, which were then identified and calculated using the Sedgewick-Rafter method. Based on the analysis of plankton abundance and diversity, it is known that the Way Besai River is moderately polluted, and there is a significant relationship between the plankton community structure and water quality parameters.

Keywords: *Water quality, Plankton, Way Besai River, Sedgewick Rafter*

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INTRODUCTION

As a water resource, rivers have life benefits for the surrounding community. In addition, rivers are essential ecosystems for living things and are a significant part of the water hydrological cycle. Rivers are a dynamic system, where human activities in the river basin can affect water quality from upstream to downstream. Activities in the river basin, as a place of residence, agriculture, and industry, cause pollution to the river flow, thus affecting the quality of river water [1,2].

Way Besai River in the Dwikora Segment is a part of the river located in Dwikora Village, Bukit Kemuning District, North Lampung Regency. Way Besai River in this segment is located between coffee plantations and far from residential areas, and there are no factories around the Way Besai River, which allows the river water not to be polluted. However, to be sure whether the Way Besai River water is polluted or not, research needs to be conducted to determine the condition of the Way Besai River water.

Based on Law Number 6 of 2023 concerning Environmental Protection and Management, environmental pollution is the entry or introduction of living things, substances, energy, and/or other components into the environment by human activities so that they exceed the established environmental quality standards. The presence of biotic components can provide a picture of physical conditions, including temperature, total suspended solids, water clarity, and color; chemical parameters such as biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), and pH; and biological parameters such as plankton.

Biologically, river water quality can be known from the presence or absence of various living things as bioindicators. Bioindicators are living organisms that assess ecosystem health, environmental changes, and water quality. One of the biota that has a vital role in waters that can be used as a biological indicator is plankton [3].

Plankton is very sensitive to changes in the quality of the Water where it lives, thus affecting the composition and abundance of the organism. Its abundance and composition depend on tolerance to changes in the surrounding environment. Plankton consists of zooplankton and phytoplankton. If the diversity and abundance of plankton in a body of Water is high, then the condition of the Water is not polluted. Still, conversely, if the diversity and abundance of plankton found is low, then the Water has been polluted [4].

METHODS

Sampling technique

This research was conducted in the Way Besai River, Bukit Kemuning, North Lampung, Lampung. Sampling was conducted in November 2024 using a survey method at six sampling stations representing the river's upstream, middle, and downstream.

Samples were taken using a 10 L bucket dipped into the river but not touching the riverbed. At each station, samples were taken from 3 spots, namely, the right bank, left bank, and middle bank, and then composited. Plankton was filtered using a plankton net with a mesh size of 25. The filtered plankton was collected in a 30 ml flask fixed with 4% formalin.

Water samples were taken directly at the research station with the UPTD team from the Lampung Province Environmental Service and the Laboratory System to find out the physical and chemical parameters. Water samples on the riverbank were taken using a 10 L Biology Education Laboratory, UIN Raden Intan Lampung. The research was conducted using the following procedures: bucket. The chemical parameters observed in the field were pH and DO, while TSS, COD, BOD, nitrate, and phosphate were measured in the laboratory.

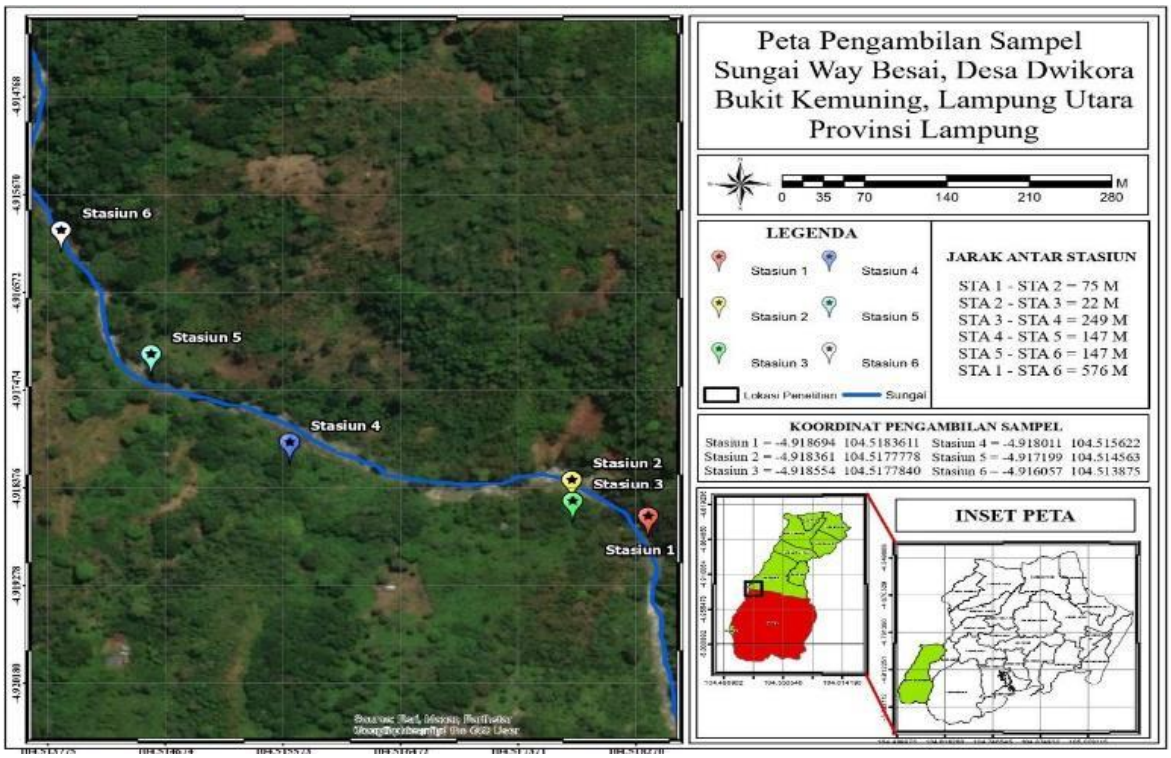

Figure 1. Map of sampling station

Plankton identification

Plankton samples were identified at the Zoology Laboratory, Department of Biology, University of Lampung, in November 2024. Plankton was identified by determining morphology, such as shape, color, locomotory organs, and type of plankton. Identification was carried out following the book The Marine and Fresh-Water Plankton. Plankton calculations were carried out using the direct counting method using the Sedgwick-Rafter.

Data Analysis

The plankton data that have been obtained are then analyzed to determine abundance, diversity index, uniformity index, and dominance index using standard equation formulas.

An abundance of plankton

Plankton abundance is expressed in the Number of cells/liters with the following equation [5]:

$$N = \frac{(a\ x\ 1000)b}{L}$$

N = Number of plankton individuals per liter of river water

a = Mean of plankton individual plankton in 1 cc of filtered water

b = Water of filtered Water (ml)

L = Volume of river water filtered (l)

Diversity index

Diversity index analysis determines the Number of species in a group. The equation used to calculate the diversity index is the Shannon-Wiener equation [6].

$$H' = -\sum_{i=1}^{a} Pi.\,In\,Pi$$

H' = Diversity Index of Shanon Wiener

S = number of species

Pi = ni/N

Ni = Number of individual types i

N = total Number of individuals

The range of diversity index (H') is classified as follows [7]:

0 < H' < 1 = low diversity

1 < H' < 3 = middle diversity

H' > 3 = high diversity

Evenness index

The *Shannon-Wiener* evenness index was used to find the uniformity of plankton.

$$E = \frac{H'}{Hmaks}$$

E = uniformity index

H' = *Shannon-Wiener* diversity index

H_{maks} = In S

S = number of species

E value ranges from 0 to 1. If the E value approaches 0, species uniformity in the

plankton community is low. In contrast, if E approaches 1, species uniformity in the plankton community is high.

Dominance index

The dominance index is helpful in identifying the dominant group in a community and is calculated using the following Simpson formula. [8].

$$C = \sum_{i=1}^{\alpha} \left(\frac{ni}{N}\right) 2$$

C = Simpson dominance index

ni = Number of individual type i (ind/l)

N = total Number of plankton in sampling spot (ind/l)

Relationship of plankton community structure based on water quality parameters

Pearson Correlation analysis was used to determine the relationship and impact of pH, COD, BOD, DO, Nitrate, Phosphate, and TSS parameters on bioindicators in aquatic environments. The relationship between the plankton community structure (abundance, diversity, uniformity, and dominance) and the physical and chemical parameters in waters using Pearson correlation is available in IBM SPSS Statistics 26 software [9].

RESULTS AND DISCUSSION

Plankton analysis

Plankton found at six research stations consisted of 12 classes, five classes of phytoplankton (Table 1) and seven classes of zooplankton (Table 2), respectively. The classes of phytoplankton found were Bacillariaophyceace, Chlorophyceae, Cynophyceae, Clostericeae, and Chaetophoraceae. At the same time, the classes of zooplankton obtained were Dinoflagellata, Zooplankton, Protozoan, Nematoda, Cladocera, Capepoda, and Rotifer.

The calculation results showed that at all observation stations, the dominant plankton was the Bacillariophyceae class, and the most common species found were *Diatoma* sp. The Bacillariophyceae class is known to better adapt to the surrounding environmental conditions.

The Bacillariophyceae class plankton consists of 7 species, namely *Cyclotella* sp., *Diatoma* sp., *Achnanthes* sp., *Grammatophora* sp., *Fragillaria* sp., *Nitzchia* sp. and *Cymbella* sp. In the Chlorophyceae class one, species, namely *Pentium* sp. Cynophyceae class has two types, namely *Arthospira* sp. and *Planktothrix* sp. Clostericeae class has one type of plankton, namely *Closterium* sp. At the same time, the Chaetophoraceae class consists of one type, namely *Stigeoclonium* sp.

From the zooplankton group, the Dinoflagellata class has one type, namely Phascus sp. The Zooplankton class consists of two types, namely *Cyclops* sp. and Paramecium sp. The Protozoa class consists of three types: *Pernema* sp, *Vorticella* sp., and *Urotricha* sp. In the Nematoda Class, one type of plankton was found, namely *Nematoda*. Cladocera class has one type, namely *Daphnia* sp. Capepoda class has one type, namely *Caenis* sp. At the same time, the Rotifer class consists of one type of plankton, namely *Trichocerca* sp.

Table 1. Number of phytoplankton in Way Besai River (ind/L)

Class	Species	ST1	ST2	ST3	ST4	ST5	ST6
Bacillariaophyceace	*Cyclotella* sp.				20	40	40
	Diatoma sp.	100	90	60	40	50	50
	Achnanthes sp.			60			
	Grammatophora sp.	250	230				
	Fragillaria sp.	150	120				
	Nitzchia sp.	30	20				
	Cymbella sp.		30				
Chlorophyceae	*Penium* sp.			120	60	60	80
Cynophyceae	*Arthospira* sp.	20					
	Planktothrix sp.		110				
Clostericeae	*Closterium* sp.		30				
Chaetophoraceae	*Stigeoclonium* sp.	40					

Table 2. Number of Zooplankton in Way Besai River (ind/L)

Class	Species	ST1	ST2	ST3	ST4	ST5	ST6
Dinoflagellata	*Phacus* sp.			240	180	120	120
Zooplankton	*Cyclops* sp.						180
	Paramecium sp.			720	240	480	660
Protozoan	*Pernema* sp.	710	590				
	Vorticella sp.	350					
	Urotricha sp.	590	590				
Nematoda	*Nematoda*	120	240				
Cladocera	*Daphnia* sp.	350	470				
Capepoda	*Caenis* sp.		240				
Rotifer	*Trichocerca* sp.	590	590				

The abundance of plankton in the Way Besai River, North Lampung Regency, from 6 diverse research stations is presented in Figure 2. The highest total plankton abundance was at Station 2 with a value of 2800 ind/L, with the most common species being Grammatophora sp and *Pernema* sp, and the lowest was at Station 4 with a value of 540 ind/L, with the most common species being Paramecium sp. Based on the total plankton abundance in the Way Besai River, it is 540-2800 ind/L.

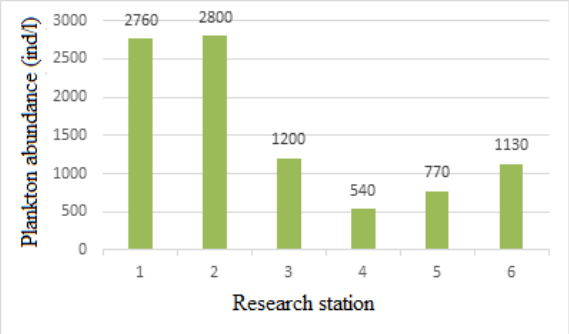

Figure 2. Abundance of plankton in 6 research stations

Table 3 Diversity index of Plankton in Way Besai River

Research Station	Diversity Index (H')
1	2,111
2	2,036
3	1,158
4	1,293
5	1,117
6	1,288

The results of the diversity index calculation from the 6 research stations presented in Table 3 produced the following values. At Stations 1, 2, 3, 4, 5, and 6 (ST 1-6), the diversity index values were 2.111, 2.036, 1.158, 1.293, 1.117, and 1.288, respectively. The diversity index from all stations ranged from 1.117 to 2.111, which indicates that the diversity and stability of plankton are classified as moderate. Sutrisna et al. (2018) stated that the assessment criteria based on species diversity are low if H' <1, moderate if 1< H'<3, and high if H'>3 [7].

Table 4. Evenness index of plankton in Way Besai River

Research Station	Uniformity Index (E)
1	0,849
2	0,794
3	0,719
4	0,803
5	0,694
6	0,719

Plankton dominance index data in the Wai Besai River are presented in Table 5. The dominance index at Stations 1, 2, 3, 4, 5, and 6 was 0.143, 0.130. 0.415, 0.270, 0.438, and 0.386, respectively. The range of the plankton dominance index at all stations was 0.130-0.438.

Table 5. Dominance index of Plankton in Way Besai River

Research Station	Dominance Index (D)
1	0,143
2	0,130
3	0,415
4	0,270
5	0,438
6	0,386

Water Quality Parameter

The diversity and abundance of plankton in Water correlate with the environment's physical and chemical parameter. The physical and chemical parameters of Wai Besai waters, including TSS, pH, BOD, COD, DO, phosphate, and nitrate, are presented in Table 6.

Table 6. Physical and chemical quality parameters of water in Wai Besai river

No	Water quality parameters	Research Station						Quality standard *
		ST1	ST2	ST3	ST4	ST5	ST6	
1	TSS (mg/L)	2	2	2	2	2	2	50
2	pH	7,89	8,11	7,79	7,89	8,58	8,40	6-9
3	BOD (mg/L)	2	3	3	2,5	2,2	2	3
4	COD (mg/L)	7,8	10,6	9,8	8,9	10,5	10,1	25
5	DO (mg/L)	6,7	6,8	6,6	6,6	6,5	6,5	4
6	Nitrate (mg/L)	4,294	3,570	3,983	0,635	1,748	2,027	10
7	Phosphate	0,10	0,10	0,10	0,10	0,01	0,02	0,2

*Baku Mutu Menurut PP No 22 Tahun 2021

Correlation of Community Structure and Water Quality Parameter

The relationship between the impact of Water physicochemical parameters such as pH, COD, BOD, DO, nitrate, phosphate, and TSS on the structure of the plankton community as a bioindicator of the aquatic environment was calculated using Pearson correlation analysis. The community structure parameters used were abundance, diversity, uniformity, and dominance of plankton. The results are presented in Table 7.

Table 7. Correlation of community structure and water quality

		TSS	pH	BOD	COD	DO	Nitrate	Phosphate
K	Pearson Correlation	.199	**.847***	-.742	.274	**-.827***	-.492	**-.908***
	Sig. (2-tailed)	.706	.033	.091	.599	.042	.321	.012
	N	6	6	6	6	6	6	6
H	Pearson Correlation	.231	**.963****	-.551	.535	-.724	-.526	-.766
	Sig. (2-tailed)	.659	.002	.257	.275	.104	.283	.076
	N	6	6	6	6	6	6	6
E	Pearson Correlation	-.418	-.544	**.914***	.196	.520	.023	.759
	Sig. (2-tailed)	.409	.264	.011	.710	.290	.965	.080
	N	6	6	6	6	6	6	6
D	Pearson Correlation	-.318	**-.975****	.402	-.669	.480	.422	.520
	Sig. (2-tailed)	.539	.001	.430	.146	.335	.405	.291
	N	6	6	6	6	6	6	6

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Plankton abundance in the Way Besai River, North Lampung Regency, at six research stations varied. The highest total plankton abundance was found at Station 2 with a value of 2800 ind/L, with the most common species being Grammatophora sp and Pernema sp. The lowest was found at Station 4 with a value of 540 ind/L, where the most common species was Paramecium sp. The total plankton abundance in the Way Besai River ranged from 540-2800 ind/L, so the Way Besai River can be categorized as oligotrophic.

According to Megarani (2016), the trophic status of waters can be determined if the plankton abundance value is >15000 ind/L; such waters are categorized as eutrophic or fertile. Plankton abundance between 2000-15000 ind/L is called mesotrophic or moderately fertile. Meanwhile, if the plankton abundance is <2000 ind/L, the waters are categorized as oligotrophic waters [11].

The diversity index is one of the parameters for determining the diversity of species in a particular community. The diversity level is

considered high if the H' value approaches 3; such waters are called good waters. The diversity index (H') describes the population of organisms mathematically, including the Number of individuals of each type in a community, which shows the richness of plankton species in water [12].

The evenness index describes the level of balance of species composition based on the similarity of the Number of individuals between species in a community. The more similar the Number of individuals between species (the more evenly distributed), the greater the degree of balance. The evenness index used is based on the Shannon-Wiener formula to determine the distribution of each type [13]. Based on the results of the evenness index calculation, it can be seen in Table 3 that the range from 0.694-0.849 ind/L indicates a high evenness index value.

If the uniformity index E <0.4, then the species uniformity is low; if 0.4 <E <0.6, the species uniformity is moderate; while if E >0.6, then the species uniformity is high. A high uniformity index value indicates an even distribution of individuals; each genus has the same opportunity to utilize nutrients such as nitrate and phosphate, which are available even though the amount is limited [10]. The closer the uniformity is to a value of 1, the more the plankton population shows an even number of individuals [14].

The dominance index is a parameter that shows species dominance in a community. The dominance index describes the presence or absence of a type or group of plankton that dominates. If the Dominance Index value is high, dominance (control) is centered on one species. However, if the dominance index value is low, dominance is centered on several species. If the dominance index is $0 < C < 0.5$, it means that there is no species that dominates; if $0.5 < C < 1$, then there is a species that dominates [15].

Based on the data in Table 4, the dominance index value is in the range of 0.130-0.438 ind/L. Thus, there is no dominant species. If the species dominance index value approaches 0, then there are no dominant organisms in the community; conversely, if the dominance index value approaches 1, then there are dominant organisms in the community [16].

The TSS value at all stations is the same, which is 2 mg/L. The TSS value of 2 mg/L in river waters is relatively low. It does not hurt plankton and aquatic ecosystems because it does not experience turbidity but is relatively bright. Although the TSS concentration is low, it reduces light penetration, which is important for the phytoplankton photosynthesis process. Low TSS values will trigger plankton abundance because water clarity can help phytoplankton

photosynthesis. Thus, water conditions can potentially increase the diversity and evenness index and reduce the dominance of particular species [17].

The results of pH value measurements show that the pH value at the six stations ranges from 7.9 to 8.58, which means that the pH value in the Way Besai River has met the water quality standards according to Government Regulation No. 22 of 2021 concerning Water Quality Standards. According to Soliha et al. (2016), the optimal pH value for phytoplankton growth is 6.0-8.0, while for zooplankton, it ranges from 5.0-8.0 [18].

The BOD value at all stations ranged from 2.0-3 mg/L, indicating that the BOD value of the waters did not exceed the water quality standard limit, so it was categorized as good (Water was not polluted). Based on the Water Quality Standards in Government Regulation No. 22 of 2021, the minimum BOD value standard is >3 mg/L. A low BOD value indicates that not much organic material is degraded, which means the waters are not affected by excessive organic waste [19].

Chemical oxygen demand (COD) is the amount of oxygen used to degrade organic matter contained in Water through chemical processes and is one of the parameters of water quality [20]. Based on the results of COD value measurements at each station, the values obtained were 10.5, 10.1, 7.8, 10.1, 9.8, and 8.9 mg/L. This indicates that the waters are not too polluted by organic matter. This means that a little organic matter is degraded in the Water, but it does not affect the abundance of plankton because the COD value does not exceed the established quality standard limit.

Dissolved oxygen (DO) is an important water chemistry parameter for aquatic biota. Decreased dissolved oxygen concentration can reduce oxygen uptake efficiency for aquatic biota, reducing their ability to live normally. The DO value at the six research stations ranged from 6.6-6.8 mg/L, making it categorized as low pollution. The waters are sufficient to support plankton life if the dissolved oxygen level is above 5 mg/L. At this level, most plankton species can function well, respire, and participate in photosynthesis (for phytoplankton) [21].

The results of nitrate measurements at each station were 1,748, 2,027, 4,294, 3,570, 3,983, and 0.635 mg/L. The highest nitrate levels were at station 3, with a value of 4,294 mg/L; the nitrate levels can be considered high and potentially cause eutrophication.

Eutrophication is the process of increasing nutrients, especially nitrogen and phosphate, which can encourage excessive plankton

growth. The high nitrate levels may be caused by agricultural waste because there are plantations around the Way Besai River. The optimum nitrate levels for phytoplankton range from 0.9-3.5 mg/l. Nitrate content is still good for plankton growth. The lowest nitrate levels were at station 6, with a value of 0.635 mg/L, which is a relatively low value.

Phosphate levels at each station were 0.01, 0.02, 0.10, 0.2, 0.10, and 0.10 mg/L. The highest phosphate values were at stations 3, 5, and 6 because they exceeded the quality standards according to government regulation No. 21 of 202, namely 0.2 mg/L. The high phosphate levels in river ecosystems are thought to be due to agricultural activities around the river [22]. Phosphate significantly affects the high and low abundance of phytoplankton in waters. Phosphate compounds can also naturally come from the waters themselves.

Community structure and water quality parameter correlation

The basis for making decisions from Pearson correlation is as follows: 1) if the Significance value <0.05, then it is correlated; 2) if the Significance value >0.05, then it is not correlated. If the significance value is exactly 0.05, then we can compare the Pearson Correlation Test with the r table with the following provisions: 1) if the Pearson Correlation Test > r table, then it is related; 2) if the Pearson Correlation Test <r table, then it is not related. Several provisions of the form of the Pearson correlation relationship are interpreted in the following table.

Table 8. Interpretation of Pearson correlation coefficient

Coefficient interval	Level of correlation
0,00 – 0,199	Very weak
0,20 – 0,399	Weak
0,40 – 0,599	Moderate
0,60 – 0,799	Strong
0,80 – 1,000	Very strong

Sources: Jabnabillah & Margina, 2022.

Based on the results of the Pearson correlation analysis, it is known that there is a correlation between the structure of the plankton community and the parameters of Water's physical and chemical quality. The correlation between pH and plankton abundance is r = 0.847 and p = 0.033. This value shows a powerful relationship based on the interpretation of the correlation (0.80-1,000) and is significantly related because the p-value <0.05. This means that when the pH value increases, the abundance of plankton tends to increase. This relationship shows that pH plays an important role in influencing the abundance of plankton.

The same thing also happens in the pH and diversity index relationship. pH and the diversity index are very strongly related, namely r = 0.963 with a p-value = 0.002; this means that pH and the diversity index have a significant relationship. The relationship

between pH and the dominance index is r = -0.975 and p = 0.001, which indicates a powerful and significant relationship between pH and the dominance index.

The correlation between BOD and the evenness index is also robust, marked by r = 0.914 and p = 0.011, indicating a significant relationship between BOD and the evenness index. The results of the correlation between DO and plankton abundance are r = -0.827 and p = 0.042, meaning that the relationship between DO and plankton abundance is powerful and significant at a fundamental level of 95%. This is in line with research conducted by Ainalyaqin and Abida (2024) that dissolved oxygen does not affect plankton diversity because the significance value is 0.103> 0.05 [23].

The correlation between phosphate and plankton abundance is r = -0.908 and p = 0.012; there is a robust but inverse relationship, meaning that the higher the phosphate level, the lower the plankton abundance. The phosphate values obtained at all research stations ranged from 0.01-0.10 mg/L.

CONCLUSION

Based on the results of the Analysis of Plankton Diversity and Abundance in the Way Besai River, it was concluded that (1) 12 plankton classes consist of 5 phytoplankton classes and seven zooplankton classes with abundance values ranging from 540-2800 ind/L; (2). The diversity index value ranges from 1.117-2.111, which indicates that the water quality of the Way Besai River is in a moderately polluted condition; (3) there is a significant relationship between the structure of the plankton community and water quality parameters such as pH, BOD, DO and phosphate.

CONFLICT OF INTEREST

I hereby declare that there is no conflict of interest in writing this scientific work.

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