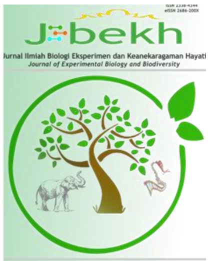
Jurnal Ilmiah Biologi Eksperimen dan Keanekaragaman Hayati (J-BEKH)

Volume 10, Issue 2, November 2023



Plankton Community Structure as a Bioindicator of Water Quality in the Way Sekampung River- the Segment of Rulung Helok

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Article History
Received: January 17, 2023
Accepted: November 15, 2023
Published: November 1, 2023

Abstract

Planktons are microorganisms that live in aquatic habitats. Plankton is used as a quality bioindicator of a water body. Way Sekampung flows to several areas in Lampung Province. The existence of activities around the watershed such as settlements, agriculture, and industrial waste disposal is thought to affect the water quality of the Way Sekampung River. The purpose of this study was to determine the water quality of Way Sekampung River based on plankton community structure consisting of abundance index, diversity index, uniformity index, and dominance index. Water sample data were analyzed using chemical parameters namely pH, BOD, DO, Phosphate, Nitrate, and physical parameters namely temperature and *Total Suspended Solid* (TSS) which are used to determine the status of water quality standards. This research was conducted at the beginning of the dry season (April) and the beginning of the rainy season (October). Sampling used a survey method based on the Way Sekampung River segment. Sampling points were carried out before and after the Argoguruh Dam. The results showed that the water quality of Way Sekampung River at the beginning of the dry season (April) and the beginning of the rainy season (October) were moderately polluted based on the analysis of plankton community structure such as abundance index, diversity, uniformity, and dominance.

Keywords: community structure plankton, way sekampung river

How to Cite: Tugiyono, U. J. Ayuni, Priyambodo, and G.N. Susanto, "Plankton Community Structure as a Bioindicator of Water Quality in the Way Sekampung River- the Segment of Rulung Helok," *Jurnal Ilmiah Biologi Eksperimen Dan Keanekaragaman Hayati (J-BEKH)*, vol. 10, no. 2. pp 69-79, 2023, doi:

INTRODUCTION

The river is a water area with an elongated shape that has an important role in human activities. One of the main problems that often occurs is river water pollution due to disposing of household waste to industrial waste on a large scale. Way Sekampung River is a river with the largest waterhed in Lampung Province. Way Sekampung River is utilized by the community along the upstream of the river as a place of settlement, a source of water in agriculture, disposal of household waste, and an *outlet for* industrial waste disposal. Various activities around the waterhed are thought to have a major influence on the water quality of the Way Sekampung River. A decrease in water quality can result in a decrease in its function and capacity so that natural resources cannot be used properly [1]. Decreased water quality can be identified by changes in physical, chemical, and biological conditions.

The decline in river water quality can be identified by utilizing bioindicators of plankton to identify water pollution. Plankton are microscopic organisms that live in line with the water current [2]. Plankton are distinguished as phytoplankton and zooplankton. Phytoplankton act as *primary producers* in aquatic ecosystems. In addition, phytoplankton acts as a parameter of fertility in water [3].

As well as using bioindicators, the decline in river water quality can be recognized by physical and chemical parameters. Changes in physical conditions such as an increase of watercolor levels to brownish black as an indication of the presence of chemical substances [4]. The physical parameters used are temperature and *Total Suspended Solid* (TSS). The chemical parameters used are pH, BOD, DO, Phosphate, and Nitrate. The level of pollution in a water body can be analyzed by observing the structure of the plankton community. This study used plankton community structure analysis such as abundance index, diversity, uniformity, and dominance.

METHODS

This research was conducted in Way Sekampung River located in Rulunghelok Village, Tegineneng, Jalintim (East Cross Road), Jembatan Dua, Natar, South Lampung, Lampung. The research was conducted by sampling at two stations, namely before and after the Argoguruh Dam. The research was conducted at the beginning of the dry season (April) and the beginning of the rainy season (October). Physical and chemical parameter measurements were analyzed at SEAMEO BIOTROP. Plankton observations were conducted at the Zoology Laboratory 2, Department of Biology, Faculty of Mathematics and Natural Sciences, University of Lampung.

The tools used in this study are *plankton net* number 25, 30 ml sample bottle, 10-liter plastic bucket, *ice box,* Olympus CX21 light microscope, object glass, cover glass, dropper pipette, OPPO A15 mobile camera, *hand counter,* DO meter AZ-8403, pH meter, *thermometer,* analytical balance, titration equipment, 1-liter jerry can, and plankton identification book with the title *The Marine and Fresh-Water Pl*ankton.

The materials used in this study were plankton samples, 4% formalin, water samples, and label paper. This study used a survey method to determine sampling points based on upstream and downstream rivers. Plankton samples were taken from the Way Sekampung River water at the designated station. Water samples were taken using a 10 L bucket that was inserted into the river water before touching the riverbed. The samples were then filtered with plankton net Number 25 for 10 repetitions. The water sample is collected in a 30 ml bottle transferred to a sample bottle and dripped with 4% formalin as much as 2 drops so that the plankton body tissue is not damaged and durable. After the preparation is complete, the sample bottle is labeled and put into an ice box to be brought and identified at the Zoology Laboratory 2, Department of Biology, Faculty of Mathematics and Natural Sciences, University of Lampung.

The research location was carried out in the upstream and downstream of the Way Sekampung River with the determination of coordinate points using GPS. The coordinate points of the upstream and downstream stations are presented in Figure 5. Upstream Station was S:05°11'57.2" E: 105°10'45,2" and Downstream Station was S: 05°12' 04.0 "E: 105°10'53.0").

Figure 1. Location Map of the Research Station.

Measurement of Physical and Chemical Parameters *in situ* and *ex-situ*

Water sampling for physical and chemical parameters was taken directly at the research station with the BIOTROP team. Water samples were taken at the edge of the river directly using a 15 L bucket. The physical parameters were temperature and TSS while the chemical parameters were pH, DO, BOD, Phosphate, and Nitrate.

Sample Identification

Sample identification was carried out at the Zoology Laboratory 2, Department of Biology FMIPA, University of Lampung. Identification was carried out with the guidance of a plankton identification book entitled *The Marine and Fresh-Water Plankton*. Identification aims to determine the morphology of plankton such as shape, color and movement, plankton diversity, plankton uniformity, abundance index, and dominance index. Counting of individual plankton used a *handcounter.*

Data Analysis

The data is then analyzed to measure several index values such as the abundance index, diversity index, uniformity index, and dominance index with the formula used as follows:

a. Plankton Abundance

Plankton abundance was calculated usingthe formula:

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

Description:

N = Number of individual plankton per liter of river water

a = The average number of individual plankton counted in 1 cc of filtered sample water

b = Volume of filtered sample water (ml)

L = The volume of filtered river water (l)

b. Diversity Index

Diversity index analysis is used to determine the number of species in a group. The equation used to calculate this index is the Shanon-Wiener equation [6].

$$H' = \sum_{t=1}^{a} Pi. \ln Pi$$

Description:

H´ = Shanon-Wiener diversity index

S = Number of species

Pi = ni/N

Ni = Number of individuals of species

N = Total number of individuals

The diversity index value (H') is categorizedas follows [7].

$0 < H' < 1$ = Low diversity and heavily polluted

$1 \leq H' \leq 3$ = Medium diversity and moderately polluted

$H' > 3$ = High diversity and stable community

c. Uniformity Index

The uniformity index is used to determine the distribution of biota. If the number of uniformity is high, the distribution of biota in the water is thorough [7]. The Shannon-Winner formula can be used to determine the value of uniformity [8].

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

Description:

E = Uniformity index
H' = Shannon-Wiener diversity index
Hmaks = In S
S = Number of species

If the uniformity index (E) < 0.4, the species uniformity is low. Meanwhile, if the value of 0.6 ≥ E ≥ 0.4, the species diversity is moderate. Moreover, E> 0.6 indicates the species diversity is high [9] A uniformity index close to 0 is interpreted as an unstable community while if it is close to 1 then the community is classified as a good community and a stable state.

d. Dominance Index

The dominance index serves to determine the dominant group in a community and is calculated by Simpson's formula [8].

$$C = \sum_{i=1}^{a} [\frac{ni}{N}]2$$

Description:

C = Simpson's dominance index
ni = Number of individuals of type I (Ind/l)
N = Total number of plankters per samplingpoint (Ind/l)

Determination of the dominance index value (C) is carried out through Simpson's dominance index formula calculation method. If the dominance indexvalue is 0 < C ≤ 0.5 then there is no dominating genus and if the dominance index value is 0.5 < C < 1 then there is a dominating genus.

RESULTS AND DISCUSSION

Plankton Abundance

Plankton abundance is the total number of individuals of plankton species in liter units. Plankton abundance at each depth can be used as a measure of water productivity.

Based on the observation data, the abundance of plankton in the Way Sekampung River at the beginning of the dry season at the upstream station was 4230/L while at the downstream station, it was 3160/L. At the beginning of the rainy season, there was an increase in planktonabundance at both upstream and downstream stations. At the upstream station, the abundance of plankton reached 12250/Liter, and at the downstream station reached 12950/Liter. The abundance of plankton in both seasons indicates that the water of the Way Sekampung River is classified as mesotrophic or medium fertility.

The most abundant phytoplankton found atthe beginning of the dry season and the beginning of the rainy season is the Baccilariophyceae Family.

The Baccilariophyceae Family is a diatom that dominates a body of water because it has properties that easily adapt to the environment. Zooplankton most commonly found at the beginning of the dry season is the Tubulinea class. Tubulinea class is known to be more adaptable to environmental change conditions than other zooplankton. The most zooplankton found at the beginning of the rainy season is the Crustacea class. Crustacea is one of the zooplankton that has about 68000 speciesworldwide.

Table 1. Plankton Abundance in April (Early Dry Season)

Class	Genus	Upstream (Ind/L)	Downstream (Ind/L)
Bacillariophyceae	Achnantes	10	10
	Bacillaria	2610	1475
	Cocconeis	15	-
	Cymbella	35	20
	Fragilaria	220	240
	Frustulia	15	55
	Gomphonema	5	-
	Navicula	70	85
	Nitzschia.	90	35
	Pinnularia	20	20
	Pleurosigma	15	-
	Surirelia	195	90
	Sydnedra	245	435
Chlorophyceae	Pediastrum	40	35
	Scenedesmus	80	40
Coscinodiscophyceae	Coscinodiscus	-	10
	Melasira	140	-
Cyanophyceae	Chroococcus	55	180
	Oscillataria	15	5
	Spirulina	30	-
Euglenophyceae	Euglena	75	30
	Phacus	60	100
Zygnematophyceae	Closterium	55	20
	Cosmarium	5	15
	Eustrum	5	5
	Staurastrum	10	5
Copepoda	Cyclops	5	10
Eurotatoria	Monostyla	-	10
	Aspianchna	-	5
	Brachionus	5	-
	Nothoica	5	15
	Trichocerca	10	10
Tubulinea	Arcella	70	180
	Diffugia	20	20
Total		4230	3160

Table 2. Plankton Abundance in October (Early Rainy Season)

Class	Genus	Upper River (Ind/L)	Downstream (Ind/L)
Bacillariophyceae	Asterionella	1400	1050
	Gyrisigna	1050	700
	Nitzschia	2100	2800
	Fragilaria	700	1050
	Surirella	1050	1400
Chlorophyceae	Closterium	1400	1050
	Pediastrum	1050	1050
Crustaceae	Nauplius	1750	2450
Rotifera	Brachionus	700	700
	Keratella	1050	700
Total		12250	12950

Diversity Index

The diversity index is one of the analyses used to measure the diversity (biodiversity) of species in a particular community. Based on the calculation of the Shannon-Wiener diversity index (H'), the value of plankton diversity in the water of the Way Sekampung River is classified as moderately polluted water with moderate stability of the biota community. At the beginning of the dry season, the total value of H' upstream was 1.749 while at the beginning of the dry season, the downstream station had a total value of H' of 2.039. The plankton diversity index at the beginning of the rainy season upstream was 2.246 while the downstream was 2.175.

If the value H' < 1 then a community is said to be heavily polluted with low biota stability. whereas if 1≤ H'≤3 then it is categorized as a moderately polluted community with moderate biota stability. If the value of H' > 3, it is classified as a stable community and can support the life of the biota in it.

Uniformity Index

The uniformity index is an index used to determine the similarity or balance of the number of individuals between species in a particular community. The more similar the number of individuals between species found, the higher the uniformity index value [9].

Based on the uniformity index calculation data, the level of plankton uniformity at the beginning of the dry season is lower than at the beginning of the rainy season. It can be seen that the plankton uniformity index at the beginning of the dry season upstream was 0.496 and at the downstream station was 0.578. At the beginning of the rainy season, the upstream plankton uniformity index value was 0.975 and the downstream was 0.944.

If the uniformity index (E) < 0.4, the species uniformity is low. Meanwhile, if the value of 0.6 ≥ E ≥ 0.4, the species diversity is moderate. And if E> 0.6 then the species diversity is high [9]. A uniformity index close to 0 is interpreted as an unstable community while if it is close to 1 then the community is classified as a good community and a stable state [11].

Dominance Index

The dominance index is an index used to measure the pattern of concentration or dominance of a species in a particular community [12]. Based on the results obtained, the plankton dominance index at the beginning of the dry season upstream was 0.393 while downstream showed a dominance index value of 0.252. At the beginning of the rainy season, the plankton dominance index of the upstream station was 0.122 while in the downstream section, it was 0.129.

Based on the results of these data, it can be interpreted that the water of the Way Sekampung River in both seasons are in the category of no dominating genus. Determination of the dominance index value (C) is done through the calculation method of Simpson's dominance index formula. If the dominance index value is 0 < C ≤ 0.5 then there is no dominating genus and if the dominance index value is 0.5 < C < 1 then there is a dominating genus. This is reinforced by Basmi et al [13] in Pirzan et al [14] if the dominance value is close to the value of 1, it means that in the community there is a genus that dominates another genus, otherwise if it is close to the value of 0, it means that in the community structure, there is no genus that extreme dominates another genus.

Water Quality Parameters

Water quality conditions can be determined by physical parameters and chemical parameters. The structure of the plankton community is closely related to changes in water quality.

Physical Parameters

This study uses temperature and TSS

parameters to determine the condition of Way Sekampung River water related to plankton. Based on the data obtained, the measurement results of physical parameters, namely temperature, and TSS at the beginning of the dry season and the beginning of the rainy season, experienced differences. The temperature at the beginning of the dry season reached 31°C while at the beginning of the rainy season, the temperature upstream and downstream was around 28-29°C. The optimum temperature for phytoplankton growth is around 20-30°C. This is in line with the explanation of [15] that states that the optimal temperature for phytoplankton growth ranges from 20-30°C.

In the TSS measurement, there was a drastic change between the beginning of the dry season and the beginning of the rainy season. At the beginning of the dry season, the TSS value was only around 18 and 12 mg/L, while at the beginning of the rainy season, the TSS increased, namely in the upstream section around 55.2 mg/L and downstream 59.8 mg/L. Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management states that the TSS quality standard according to class 2 is 40 mg/L. The increase in TSS in the early rainy season is thought to be due to high community activity in the agricultural sector increasing solids (organic or inorganic matter) suspended in water.

Chemical Parameters

Measurement of water quality in Way Sekampung River uses chemical parameters namely Ph, BOD, DO, phosphate, and nitrate. Measurement of water quality can be done by measuring chemical parameters. Based on these data, the pH value obtained at the beginning of the dry season and the beginning of the rainy season shows similarities, namely the pH value in the range of 7. Following the quality standard value that has been determined, the optimal pH for plankton growth ranges from 5-9. It can be interpreted that the upstream and downstream stations have a pH value that is classified as good forplankton growth.

Based on the data obtained, BOD levels at the beginning of the dry season showed that BOD was following the predetermined quality standard of 2 mg/L. The increase in BOD levels at the beginning of the rainy season is due to the high pollution load that enters the water. At the beginning of the rainy season, substances on land accumulate in the water, causing polluted water. In addition, activities around the waterhed also have a major influence on increasing BOD levels.

The DO value shows the amount of oxygen available in a water body. According to PP No. 22 of 2021 concerning the Implementation of Environmental Protection and Management in class 2, the quality standard of river water and the like is 3 mg/L. The higher DO value, it can indicate that the water are in a fertile condition. Conversely, if the DO value is low, it means that the water are polluted. Based on the measurements of the research results, and the data obtained at the beginning of the dry season, the DO value reached a range of 6-7 mg/L. This means that the water conditions at the beginning of the dry season are relatively good to show plankton life. Meanwhile, at the beginning of the rainy season, there was a decrease in DO values, which ranged from 2 mg/L. This condition can be interpreted as the water being polluted.

Phosphate comes from soil erosion, industrial waste, animal waste, and rock weathering. Most of the pollution caused by phosphorus comes from the presence of detergent compounds in the water [13]. The results show that phosphate (PO4) levels at the beginning of the dry season and the beginning of the rainy season were higher than those determined.

Based on the data, it shows that nitrate levels at the beginning of the dry season were 1 mg/L. At the beginning of therainy season, nitrate levels were around 3,34 mg/L (upstream) and 3.26 mg/L downstream. According to Basmi et al. [14], nitrogen in water comes from several human activities that result in waste such as industrial wastewater, animal waste, agricultural waste, and vehicle emissions, all of which can affect the formation of nitrates. So, it can be seen that differences in nitrate content can also be caused by an increase in different human activities or activities around the Way Sekampung River.

Correlation of Plankton Abundance with Water Quality Parameters

Pearson correlation is a form of the formula used to find the relationship between two variables, namely the independent variable (X) and the dependent variable (Y). The relationship between plankton structure and several supporting parameters such as temperature, TSS, pH, BOD, DO, Phosphate, and Nitrate can be known using the Pearson correlation method. Based on the results of the Pearson correlation analysis (Table 3), it was found that there was a relationship between the structure of the plankton community and the water quality parameter

Table 3. Results of person correlation analysis

		Temp	TSS	pH	BOD	DO	Phosphate	Nitrate
K	Pearson Corr	**-.967***	**1.000****	.492	.934	**-.996****	**.987***	**.933****
	Sig. (2-tailed)	.033	.000	.508	.066	.004	.013	.007
	N	4	4	4	4	4	4	4
H’	Pearson Corr	-.884	.762	-.021	.701	-.829	.691	.835
	Sig. (2-tailed)	.116	.238	.979	.299	.171	.309	.165
	N	4	4	4	4	4	4	4
E	Pearson Corr	**-.995****	**-.964***	.300	.883	**-.987***	.925	**.990****
	Sig. (2-tailed)	.005	.036	.700	.117	.013	.075	.010
	N	4	4	4	4	4	4	4
D	Pearson Corr	.921	-.839	-.130	.894	.894	.785	-.892
	Sig. (2-tailed)	.079	.161	.870	.106	.106	.215	.108
	N	4	4	4	4	4	4	4

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

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

Based on the results of Pearson correlation analysis, it was found that there is a relationship between plankton community structure and water quality parameters. The relationship obtained between temperature and plankton abundance is r = -0.967 with a probability of 0.033 This value states a very strong relationship based on correlation interpretation (0.80-1.000) and is significantly related at the 95% level. However, the relationship has a negative correlation direction (-). This means that the higher the temperature, the lower the plankton diversity index. The same thing also occurs in the relationship between temperature and uniformity index. It was found that the relationship between temperature and the uniformity index was very strong at -0.995 with a probability of 0.005 at the 95% level. This value states that the relationship is negative, that is, the higher the temperature, the lower the uniformity index.

The relationship between TSS and plankton abundance shows that there is a very strong relationship of 1000 with a probability of 0.000. This value states a very strong and real relationship based on the interpretation of correlation (0.80-1.000). The same thing also happened to the relationship between the plankton uniformity index and TSS. The relationship is 0.964 with a probability of 0.036. This value indicates a very strong and significant relationship at the 95% level. TSS is the total solids that do not dissolve in water, these solids will settle to the bottom of the water. Substances suspended in water consist of organic and inorganic materials. Organic material consists of compounds such as cellulose, fat, protein, and some aquatic microorganisms such as plankton, bacteria, algae, and so on. Organic matter, apart from coming from natural materials, can also come from industrial, agricultural, mining, and household activities. The high TSS value in the water of the Way Sekampung River is thought to be influenced by community activities around the waterhed. The high TSS value that exceeds the threshold will obstruct sunlight penetration into the water so that the phytoplankton photosynthesis process will be disrupted [15]. Reduced sunlight entering the water also reduces the amount of oxygen produced so that the zooplankton respiration process will be disrupted and can lead to death.

In this study, it was found that the relationship between DO and plankton abundance was -0.996 with a probability of 0.004. This means that there is a very strong and significant relationship at the 95% level between DO and the diversity index. The same thing also happened to the relationship between DO and uniformity index. The correlation value obtained was -0.987 with a probability of 0.013. This value indicates a strong and significant relationship at the 95% level between DO and the uniformity index. The high abundance of plankton DO value is influenced by several factors such as temperature, salinity, water turbulence, and atmospheric pressure.

The decrease in oxygen levels in water is caused by the process of eutrophication or pollution of organic matter in the form of nutrients. The high level of organic matter entering the water causes the decay process to reduce oxygen levels. The decay of organic matter into nutrients can increase the fertility of water so that it can cause high numbers of plankton abundance in water. Plankton abundance that cannot be controlled can cause blooming so that the aquatic biota in it will die because of the struggle for oxygen in the water [19]

The relationship between phosphate and plankton abundance is 0.987 with a probability of 0.013. The relationship is strong and positive at the 95% real level. This means that higher phosphate levels will lead to higher plankton abundance. The high value of phosphate can be caused by the accumulation of sedimentation due to high rainfall and also the influx of nutrients from river flow. Phosphate comes from soil erosion, industrial waste disposal, animal waste, and rock weathering. Phosphate is an important nutrient in phytoplankton growth and metabolism. The main source of phosphate comes from the decomposition process of weathering, decomposition of plants, the remains of dead organisms, and land waste discharges (domestic, industrial, agricultural, livestock, and feed residues) which will be decomposed by bacteria into nutrients [20]

When phosphate in water bodies is in excessive amounts, it will be re-deposited into the sediment pores through sedimentation, adsorption, and precipitation processes. Thus, sediment in a water body has an important role in the eutrophication process because it acts as a source and sink for phosphate [21]

The relationship between nitrate and diversity index was 0.995 with a probability of 0.007. It shows that there is a strong and positive relationship at a 95% real level between nitrate and diversity index. The higher the nitrate level, the higher the diversity index. The relationship between nitrate and uniformity index was 0.990 with a probability of 0.010. This value is interpreted as a strong relationship with a positive direction. The higher the nitrate level, the higher the plankton uniformity index. Different things happen to the relationship between nitrate and dominance index. Nitrate is a nutrient that supports water fertility. Nitrate is the main form of nitrogen in water and is the main nutrient needed for plant and algae growth. Nitrate is very soluble in water and is stable [17]. The nitrate content of a water body has positive and negative impacts.

The positive impact is the increased production of phytoplankton. The negative impact caused is the decrease in oxygen content in the water and a decrease in phytoplankton diversity or *biodiversity* due to the development of harmful phytoplankton. High levels of nitrate in water can lead to eutrophication(enrichment) resulting in harmful phytoplankton *blooms* known as *Harmful Algae Blooms* (HAB) [22], [23]. According to Casali [24] cited in Hamuna et al [25], community activities such as the agricultural sector, plantations, industry, and household waste disposal also have a major role in nitrate sediment in water.

CONCLUSION

The conclusion obtained is based on the structure of the plankton community, the condition of the water of the Way Sekampung River Relung Relok Segment at the beginning of the dry season (April) and the beginning of the rainy season (October) is moderately polluted.

ACKNOWLEDGMENTS

Thanks to PT Adhya Tirta Lampung (ATL) for allowing the research process and also to BIOTROP for helping in the sampling process until analysis.

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