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STUDY OF PHYTOPLANKTON AS BIOINDICATORS OF ORGANIC MATTER POLLUTION LEVELS IN THE ESTUARY OF KENDARI BAY WATERS

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ABSTRACT

The study aims to find out the structure of the phytoplankton community including abundance, dominance and to know the pollution of organic material in the Gulf of Kendari river stream using the sapropic index based on the phytoplankton as its indicator. The study was conducted from August to September 2022. The determination of the sampling station is carried out purposively by the sampler or sampler that has been planned by the researcher taking into account various considerations of conditions in the research area that may represent the conditions of the waters. The sampling technique was vertically carried out by tapping 150 L of seawater and then filtered using net plankton as many as 1 repetition at each station, then the sample filtered is inserted into a sample bottle and added preservatives. The samples are preserved using 3% formalin. The abundance calculation results of phytoplankton at each observation station during the study range between 269-2733 ind / l. The result of the calculation of the dominant index of each station during the study ranged from 0.17-0.96. The highest value was obtained at 0.17 and the lowest at 0.96. Measurement results of chemical physics parameters of water obtained temperature range 30-31 ^{o}C, current rate 0.09-0.37 m/second, TSS 0.3670-1.3395 mg/l, DO 5-6 mg/L, nitrate 0.134-0.163 mg / l, phosphate 0.60-0.285 mg /L.

Keywords: organic materials, bioindicators, phytoplankton, pollution

INTRODUCTION

Phytoplankton is a microscopic organism that generally lives on a floating stream of water. Phytoplankton is an important organism in water because it is the basis of the food chain in an ecosystem. Phytoplankton lives mainly in water layers that receive the sunlight needed to carry out the photosynthesis process. (Safnowandi, 2021).
A bioindicator is a group or community of organisms whose presence or behavior in nature correlates with environmental conditions, so that it can be used as an indicator of environmental quality. (Purwati, 2015).

Changes in water quality can be known from changes in the physical, chemical and biological conditions of the waters. As a biondikator, phytoplankton can provide instructions to monitor the occurrence of pollution. In addition, the presence of phytoplankton in a water can provide information about the condition of the water. (Rasyid *et al*., 2018).

Kendari Bay is one of the coastal areas that has potential water resources and supporting life in it. various kinds of activities such as maritime services such as ports for navigation, fishing and other activities that are around the Gulf such as residential settlements, industrial, residential, tourism and so on as supporting human life.

Organic pollutants carried from the stream of the river to end in the muara will affect the waters around it, one of which is the Gulf waters. Bays that are exposed to excess organic material will trigger the occurrence of eutrophication characterized by the appearance of blooming or a surge in the growth of phytoplankton (Pratiwi *et* al., 2013). Based on the description, it is necessary to conduct this research on the level of pollution of organic materials in the Gulf of Kendari, so that it can be used as an additional consideration material in the management of water resources in the City of kendari with the hope that the Gulp of Kenderi can be managed optimally, effectively and efficiently.

MATERIALS AND METHODS

The study was conducted from August to September 2022. The sampling location for this study was carried out in the Gulf of Kendari waters, Kendari City, South East Sulawesi Province. The analysis of the sample was conducted at the Fisheries Laboratory, Faculty of Fisheries and Marine Sciences of Halu Oleo University.

Figure 1. Map of research locations

Phytoplankton Sampling Method

Sampling was done using 50 μm net plankton taken vertically with a boat. Sampling was carried out at 10.00-13.00 WITA located in the Gulf of Kendari, Southeast Sulawesi. The sampling technique is vertically carried out by tapping 150 L of seawater and then filtered using net plankton as many as 1 repetition at each station, then the sample filtered is inserted into a sample bottle and added preservatives. Conservation of the sample using 3% formalin (Hecky & Kling, 1981) of 1 ml, then stored in a container that contains ice. Total phytoplankton samples were taken as many as 20 samples with 1 sample per station during the study. Next, the sample that has been obtained below goes to the laboratory for observation using a 10x10 magnification microscope in the Sedgwick-Rafter Cell container. Identification books used in observations are Botes (2001), Yamaji (1996), Sachlan (1982), Davis (1955). Chemical physical parameters of water measured insitu and exsitu. insitu measurements take place while in the field. All measurements and sampling of water physico-chemical parameters are carried out simultaneously with samples of phytoplankton. The exsitu measurement was carried out in the Laboratory of the Faculty of Fisheries and Marine Sciences of the University of Halu Oleo in the form of analysis of water samples.

Measurement of Aquatic Physics-Chemical Parameters

Chemical physical parameters of water measured in insitu and exsitu. Measurement takes place on the field. All measurements and sampling of water physico-chemical parameters are carried out simultaneously with samples of phytoplankton. The exsitu measurement was carried out in the Laboratory of the Faculty of Fisheries and Marine Sciences of the University of Halu Oleo in the form of analysis of water samples.

Data Analysis

Phytoplankton abundance was calculated using the sensing method using Sedwick-Rafter Cell (SRC) as follows (Arninardi et al., (1997) in Nurhatika et al. (2018):

$$N = ni\ x\ 1/Vd\ x\ Vt/Vs$$

N is Total number of individuals or plankton cells per m3 (cells/m), ni is number of individuals or cells of the i-th species that were counted, Vd is Filtered water volume (liters), Vt is Filtered water volume (ml), Vs is Sample volume under cover glass (ml)

Dominance Index was calculated using the dominance index formula from Simpson (Sirait et al., 2018):

$$D = \Sigma (ni/N)^2$$

D is Simpson's Dominance Index, ni is the number of individuals of each species, N is the number of individuals of all species. The index of dominance ranges from 0 to 1, the smaller the value of the dominant index, then indicates that no species is dominant instead the greater the index value, then shows that there is a particular species that is dominating.

Calculating the probability of water used analysis whose values are determined from the Saprobik Index (SI) to determine the level of pollution with the following equation (Rasyid et al., 2018):

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

X is Saprobic Coefficient, A is Number of Genus of Polysaprobic Organisms (Cyanophyta), B is Number of Genus of α-Mesosaprobic Organisms (Dinophyta), C is Number of Genus of β-Mesosaprobic Organisms (Chlorophyta), D is Number of Genus/Species of Oligosaprobic Organisms (Chrysophyta)

Table 1. The relationship between the saprobic coefficient (X), the rate of sapropic phase pollution and pollutants (Dresscher dan Van Der Mark, 1976 dalam Soewignoyo et al., 1986).

Polluted Substances	Pollutant Level	Saprobic Phase	Saprobic Coefficient
Organic Materials	Very heavy	Polisaprobik	(-3)-(-2)
		Poli/α-mesosaprobik	(-2)-(-1,5)
	Quite heavy	α-meso/Polisaprobik	(-1,5)-(-1)
		α-mesosaprobik	(-1)-(-0,5)
Organic and Inorganic Materials	Medium	α/ β-mesosaprobik	(-0,5)-(0)
		β/α- mesosaprobik	(0)-(0,5)
	Light	β-mesosaprobik	(0,5)-(1)
		β-meso/Oligosaprobik	(1)-(1,5)
Organic and Inorganic Materials	Very light	Oligo/ β-mesosaprobik	(1,5)-(2)
		Oligosaprobik	(2)-(3)

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PCA or Principal Component Analysis is a descriptive statistical method that aims to present the maximum information contained in a data matrix in the form of a graph. PCA analysis results can show correlations between important parameters or variables. PCA analysis using XLSTAT software (Rahmawati et al., 2021).

RESULTS AND DISCUSSION

Phytoplankton Abundance

The results of the calculation of the abundance of phytoplankton at each observation station during the study range between 269-2733 ind/L. The highest abundance of phytoplankton was 2733 ind / l. The lowest phytoplankton abundance was calculated at 269 indes/L.

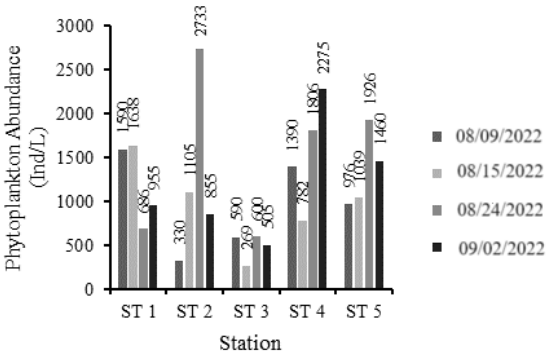

Figure 2. Phytoplankton abundance by station

The result of the calculation of the dominant index of each station during the study ranged from 0.17-

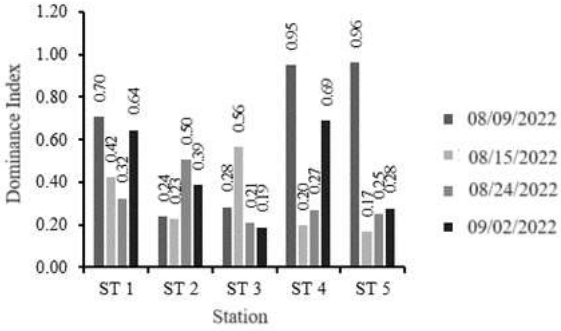

Figure 3. Dominance index by station

Saprobic Index

Based on the results of the calculation of the saprobic index on the entire station obtained a value of 0.5. This indicates that the river stream of the Gulf of Kendari waters is included in the β-mesosaprobic saprobity level

Table 2. The value of the Saprobic index at the mouth of the Kendari Bay waters

Phylum	Genus Number	Saprobity Value
Cynophyta	3	
Dinophyta	2	0.5
Chlorophyta		
Chrysophyta	3	(β-mesosaprobic group)

Water Chemical Physics Parameters

Measurement of chemical physics parameters of waters in the Gulf, River, Riverside during the study

Table 3. value of the physical and chemical parameters of the waters during the study

No.	Parameters	Range	Observation Station				
			I	II	III	IV	V
1	**Physical**						
	Temprature(°C)	20-30	31	30	30	31	31
	Current (m/s)	-	0.09	0.15	0.27	0.37	0.14
	TSS (mg/L)	50	0.4515	0.5808	0.367	0.7043	1.3395
2	**Chemical**						
	DO (mg/L)	>5	6	5	5	6	6
	Nitrat (mg/L)	0.008	0.163	0.145	0.159	0.15	0.134
	Fospat (mg/L)	0.015	0.074	0.285	0.075	0.06	0.061

*Source: Kep.No 51/MENLH/2004 = nitrat, fosfat and DO; Irawati, (2014) = temprature; PP No. 82 TH 2001= TSS

Principal Component Analysis (PCA)

The results of the PCA (Principal Component Analysis) analysis obtained a total of 74.81% of information that showed a correlation between the physico-chemical parameters at the research station and the abundance of the phytoplankton observed.

DISCUSSION

The resulting abundance of phytoplankton ranges from 269 to 2733 indes/L. The highest abundance is 2733 Indes /L. The location of the research is a part of the river that leads to the sea, so it is possible along the flow of rivers there is organic material that

can be used by the phytoplankton in making development. Therefore, the river stream has a high productivity with the presence of organic material input from river and sea streams that can support the growth and abundance of phytoplankton as a source of food and water biota. (Fitriyah *et al*., 2022).

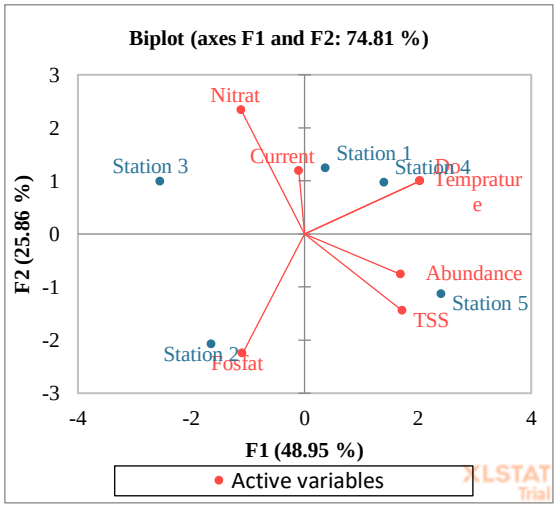

Figure 4. Principal Component Analysis (PCA)

The flow of water from the rivers plays an important role in the entry of organic matter into the ocean. (Li *et al*., 2019). The number of genes obtained during the research on the Cyanophyta filum was 3 genes, Dinophytas 2 genes and Chrysophyts 3 Genes and Chlorophyte 12 genes.

Based on the results of the abundance of phytoplankton, the lowest abundance value of 269 indes/L. the abundantity of phytoplankton of <1,000 cells/L is low, abundance between 1,000–40,000 cells / L is moderate and abundance <40,000 cell / l is high. (Samudera et al., 2021). The high low abundance is influenced by the location of stations that are on the river stream with high nutrients. The high amounts of nutrients in the river stream come from the land through the rivers to the sea and the downstream water. The high low abundance of phytoplankton due to the location of the station that is in the river, is the place where it meets fresh water and sea water so that it becomes the meeting place between nutrients carried by river water and nutrients taken from sea water (Aryawati *et al*,. 2021) The nutrients will be relatively high at the stations in the bay (front of the river) and undergo a decline towards the sea, this is due to the station that is in front of a river much get the supply of charges from the activities on land, whether it is agriculture, fishing or the activity of the population, which enters through the rivers and goes to the bay. (Irawati, 2014). Thus, the abundance of phytoplankton is influenced by the availability of nutrients and the ability of fitoplancton to utilize it. (Rasyid et al., 2018). Nutrient content can boost the growth of phytoplankton, high rate of growth can increase the abundance of fitoplancton in the waters (Diana et al., 2021). Supply of nutrients necessary for the growth of phytoplankton (Trombetta *et al*., 2019).

Correlation between phytoplankton abundance to water physico-chemical parameters can be supported using PCA analysis (Hamidah *et al*., 2017). Use of PCA analysis to analyze the relationship between water physico-chemical parameters to the abundance of phytoplankton (Kutlu *et al*., 2020). Based on the results of the PCA analysis showed that the combination of two axes F1 and F2 can explain as much as 74.81% or more than 70% as required in the use of PCA. (Ridho *et al*., 2020). The results of PCA analysis showed the parameters that influence the abundance of phytoplankton among them DO, temperature and TSS because of the formation of an angle <90o and the less influential parameters nitrates, flow speed and phosphate because of forming an angle >90o (Samudera *et al*., 2021). This is because the longer the arrow, the more the parameters are influential.(Sari *et al*., 2016).

Based on the results of the dominant index of phytoplankton ranges between 0.17-0.96. The highest dominance value was 0.96 and the lowest was 0.17. The value of the dominant index ranges from 0 to 1, the value that is closer to 1 indicates that there is a dominance of the phytoplankton species over other species (Sirait *et al*., 2018). Based on the values of these indicators, there is a gene of phytoplankton that tends to dominate. The overall value of the dominant index obtained indicates that at the site of the study there is a particular gene that tends to dominate, namely, Cyclotella sp. of the class Bacillariophyceae. Phytoplanktons of the Bacillariophyceae class can be easily found in a variety of water conditions (Dahlan *et al*., 2020). The phytoplankton of the class Bacillariophyceae is able to maintain its life and develop itself to become abundant despite changes in the environment. (Rasyid *et al*., 2018). The class Bacillariophyceae can regenerate and have a stronger and greater rate of reproduction in extreme and low conditions than other classes. (Bone *et al*., 2023). Phytoplanktons of the class Bacillariophyceae have a very broad tolerance to nutrients in water (Al-Shandah et al., 2022). The class of Bacillariophyceae has quite a number of genus that spreads widely in open sea waters, beaches and estuary areas. (Fitrianti *et al*., 2022). The genus that belongs to the class of Bacillariophyceae rapidly develops in payau waters. (Fitriyah *et al*., 2022)

The saprobic index is an index used to know the status of pollution of organic materials in water

using the presence of phytoplankton as an indicator. (Supriyanti *et al*., 2020). The sapropic status can be determined by the indicator of phytoplankton (Kamberović *et al*., 2023). Based on the saprobic index value of 0.5, this value includes the β-mesosaprobic saprobity level. The ratio of values and levels of probability results in the picture that the Gulf of Kendari river stream belongs to the category of light organic and inorganic matter pollution. The β-mesosaprobic probity level indicates that a water has a mild to moderate level of pollution. Although belonging to the level of β-mesosaprobic probability indicated slightly (Basmi, 2000). Pollution of organic materials is closely linked to nitrate and phosphate content as nutrients. (Rasyid *et al*., 2018). The values of nitrates and phosphates that are necessary nutrients in the growth and development of phytoplankton have values that are above the raw quality limits according to KepMen LH No. 51 in 2004. The high nitrate and phosphate values in the Gulf of Kendari river streams come from residues of settlement activities and industrial activities carried by river flows that then go to the sea. The phosphate and nitrate compounds in the waters are affected by residential and industrial waste that enters the water (Haninuna *et al*., 2015).

The results of the temperature calculation range between 30-31 ^{o}C. The temperature range obtained indicates that the temperature during the study is still within the tolerance limits for the phytoplankton to grow and develop. The optimal temperature for the growth of phytoplankton ranges between 20-30 ^{o}C and the temperature tolerance limit for plankton is 35 ^{o}C, so that the temperature range can still be tolerated by the fitoplancton. High or low water temperatures can affect the state of phytoplankton in the waters both physiologically and ecologically. Temperature influence on the phytoplankton can cause differences in the composition and abundance of the plant (Zainuri et al., 2023). Increased water temperature in the tolerance range will increase the rate of metabolism and photosynthesis activity against phytoplankton (Mustofa, 2015). The adaptation of the phytoplankton to warmer temperatures increases the metabolism of the fitoplancton to adjust to certain temperatures (Kottuparambil *et al*., 2019).

The results of the calculation of the current speed were obtained ranging from 0.09-0.37 m/sec. Nilai kecepatan arus tertinggi sebesar 0.37 m/det, nilai ini termasuk kategori berarus sedang dan nilai kecepatan arus terendah sebesar 0.09 m/det, nilai ini termasuk kategori berarus lambat Kecepatan arus terdiri dari empat kategori yaitu kategori arus lambat berkisar pada kecepatan 0-0.25 m/det, kategori arus sedang berkisar pada kecepatan 0.25-0.50 m/det, kategori arus cepat berkisar pada kecepatan 0.5-1 m/det dan kategori arus sangat cepat berkisar pada kecepatan di atas 1 m/det. kecepatan arus pada permukaan air dipengaruhi oleh angin yang membangkitkan arus permukaan, pengaruh angin sebagai pembangkit arus di permukaan akan berkurang sering bertambahnya kedalaman (Gunawan *et al*., (2022). The flow speed plays a role in the process of spread or migration of the phytoplankton as a passive organism or following the flow movement so that generally the movement of the fitoplancton is influenced by the flow, which indicates the flow speed will affect the abundance of the plant (Putri *et al*., 2019). The current speed is an important factor in predicting the abundance of phytopankton (Kim *et al*., 2019).

TSS calculation results range between 0.36-0.58 mg/L. TSS values are included under the quality standards that have been established by government regulations No. 2005 for water of 50 mg/l. High TSS will make it difficult for phytoplankton to photosynthesize, affecting the primary productivity of the fitoplancton, because TSS restricts sunlight to enter the body of water. TSS can cause stiffness in the waters thus preventing sunlight from entering the water columns necessary for the phytoplankton's photosynthesis process. This process of photosynthesis will result in the presence of dissolved oxygen in water. If oxygen is dissolved in low water, it can kill aerobic microorganisms or even if the oxyge levels are very low can kill aquatic animals in the waters. (Alfatihah *et al*., 2022). Increased TSS concentration leads to a decrease in water transparency and limits primary productivity (Wei *et al*., 2022). The TSS value in Wanggu's mouthpiece was 4,8080 mg/L, the Al-Alam hotel and mosque area was 4,3400 mg / L and the area around Tracking Mangrove Lahundape was 4,1520 mg /L. (Alfiani *et al*., 2019).

The results of DO calculation range between 5-6 mg/l. The DO value obtained still includes meeting the standards of baku quality set by KepMen LH No. 51 in 2004 at >5 mg/L. Dissolved oxygen (DO) is one of the life supporters in estimates and is an indicator of water fertility. The level of oxygen dissolved in the water has an impact on the life of organisms in water (Yang *et al*., 2021). Low oxygen levels may indicate that organic waste in a water is increasing. This is due to the oxygen available in the water, used by microorganisms to break down organic matter into inorganic matter. The more abundant the dissolved oxygen (DO) in a water, it will help water organisms to carry out metabolic processes. Therefore, the lower the level of dissolved oxygen, the more organic material in the water will increase. It is caused by bacteria that use

oxygen to degrade organic matter into inorganic matter (Megawati *et al*., 2014).

The result of the nitrate calculation ranges between 0.134-0.163 mg/L. This value exceeds the standards set by KepMen LH No. 51 in 2004 at 0.008 mg/L. The value of nitrates that exceeds baku mutu due to the location of the station is in the river river that is close to the lantern with residential housing. The main source of nitrates comes from household and agricultural waste including animal and human dirt. (Simbolon, 2016). In addition, the high nitrate value of station one indicates that there is a waste of organic waste originating from the settlements of citizens that is then converted into anorganic substance in the form of nitrates by microorganisms. Microorganisms use oxygen to degrade organic matter into inorganic matter (Megawati *et al*., 2014). excess nitrate content can trigger the occurrence of eutrophication(Ménesguen *et al*., 2019).

The results of the phosphate calculation range between 0.060-0.285 mg/L. The phosphate value obtained is a value that exceeds the water quality standard based on KepMen LH No. 51 in 2004 at 0.015 mg/L. Phosphate is a nutrient used by the phytoplankton to grow and develop. (Mishbach *et al*., 2021 & Wijaya *et al*., 2022). Phosphate can not be found in free form in water, but in the form of inorganic compounds and organic particulate compound derived from animal waste and plant absorption as well as the destruction of organic material and mineral-mineral phosphates. In marine waters, phosphates are in anorganic and dissolved organic forms as well as the phosphate particles necessary for the growth and metabolism processes of phytoplankton and other marine organisms. Furthermore, the phosphate compounds in the waters are derived from soil erosion, animal waste and plant degradation as well as the destruction of organic material and mineral-phosphates. (Hamuna *et al*., 2018)

CONCLUSION

The abundance of phytoplankton ranges from 269 to 2733 ind / l, the highest of 2733 in / l belongs to the medium and the lowest of 269 in / L belong to the low. The dominance index ranging from 0.17 to 0.96 indicates that in the Gulf of Kendari river stream there are species that dominate other species. The

sapropic index obtained at 0.5 indicates that the river stream of the Gulf of Kendari includes mild organic and inorganic pollution in the β-mesosaprobic phase. Water quality based on phytoplankton indicators in the Gulf of Kendari river waters are mild.

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