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Water Quality of Lamong River in Gresik Regency Based on Phytoplankton Diversity and Chemical Physics Factors

Muhammad Ryan Aries Firmansyah*, Wisanti
Biology Study Program, Faculty Mathematics and Natural Sciences, Universitas Negeri Surabaya
Kampus Unesa 1, Jln. Ketintang Surabaya 60231, Indonesia
*e-mail: muhammadryan.20060@mhs.unesa.ac.id

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Abstract
Lamong River is included in the Bengawan Solo River area. Its upstream part is in Lamongan and Mojokerto regencies, while its downstream part is in Gresik regency. Along the Kali Lamong river there are many human activities, such as irrigation, industry, agriculture, and others, which can cause water pollution. Phytoplankton is an aquatic organism that can be used as an indicator of water quality in a body of water. This study aims to analyze the water quality of Lamong River in terms of phytoplankton diversity and chemical physical factors. Sampling was conducted in Lamong River at 3 stations with 3 points and 3 repetitions in the form of phytoplankton samples and water samples. Phytoplankton data was calculated with Shannon-Wiener diversity index. Chemical physics data were analyzed using chemical physics water quality test technique. Correlation of phytoplankton diversity index and physico-chemical factors of water quality using SPSS ver.22.00. The results showed that in the waters of Lamong River, phytoplankton were found that belonged to 5 divisions, 12 families, and 13 species. The phytoplankton diversity index of 2.40 was categorized as moderate. The water quality of Kali Lamong is included in the good criteria, because overall the physico-chemical factors meet the water quality standards. The diversity index showed a negative correlation with pH, and a positive correlation with DO, BOD, temperature, and turbidity. The DO parameter has the highest positive correlation showing a strong correlation with the phytoplankton diversity index of +0.687. Based on physico-chemical indicators, it can be concluded that the waters of Kali Lamong are not yet polluted.

Keywords: Kali Lamong; phytoplankton diversity Index; water quality.
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INTRODUCTION

Lamong River is a watershed that flows from the North Kendeng limestone mountains, Kedung Kumpul Village, Lamongan Regency to the Madura Strait, Segoromadu Village, Gresik Regency. Lamong River has a length of ± 89 km and has seven tributaries. The growing settlements and human activities around Lamong River can reduce water quality. Waste discharged into the river can cause water pollution (Nastiti et al., 2017).

Various regional activities become active around the Kali Lamong River, and the state of the river changes, such as phytoplankton diversity that affects the water quality of the Kali Lamong River. The number of community and industrial activities around the river causes environmental pollution which has an impact on the decline in river water quality (Mardhia and Abdullah, 2018). It is necessary to monitor water quality to prevent and overcome negative impacts in the river (Manullang and Khairul, 2020).

Environmental monitoring can be done by analyzing water quality physically, chemically and biologically. Physical and chemical analysis of waters is less effective because the source of nutrients is dynamic which causes the results obtained can not be as expected. This can be done by analyzing biologically using organisms or aquatic biota in the river. This is because river water quality can affect biota conditions and physical and chemical properties (Athifah et al., 2019).

Phytoplankton are plants that float or drift in the water (Nontji, 2008). The phytoplankton diversity index can be used for biological analysis to determine the condition of the river environment.

The phytoplankton diversity index can be used to determine whether the environment is polluted or not (Indra et al., 2019).

Previous research conducted in Kali Lamong River in 2016 explained that the value of diversity index in Kali Lamong River was classified as medium. The overall water quality of Kali Lamong River is categorized as good. This is due to human and industrial activities around the river which affect the diversity index value (Dewantari et al., 2021).

Various community activities that continue to increase around Kali Lamong cause river conditions to change, including phytoplankton diversity which affects the quality of Kali Lamong waters. The purpose of this research was to analyze the relationship between phytoplankton diversity index and water quality in terms of physical and chemical parameters. Therefore, it is necessary to conduct research on plankton diversity to determine the quality of Kali Lamong waters.

MATERIALS AND METHODS

This studied was an observational studied because the samples was taken directly from the field and the analysis conducted in the laboratory. This researched conducted in Kali LamongRiver, Gresik Regency (Figure 1). Station 1 was located at coordinates (7°11'41.484 "S 112°38'42.45 "E), station 2 is located at coordinates (7°11'40.452 "S 112°38'10.254 "E), station 3 is located at coordinates (7°11'48.372 "S 112°37'34.30 "E). Sampling was done by purposive sampling. Phytoplankton samples and watered samples for measurement of physico-chemical parameters was taken at 3 stations with 3 pointed at each station.

The tools and materials used in this studied were plankton net, raffia rope, meter, plastic bucket, 27 5ml vial bottles, 250ml light Winkler bottles, 250ml dark Winkler bottles, 100ml sample bottles, labelled paper, 10 ml measured cupped, 100ml measured cupped, 5ml dropped pipette, DID meter, turbidimeter, tissue, thermometer, pH paper, electric microscope, glass objected, covered glass, lugol iodine, 4% formalin, distilled watered, cool boxed.

Water sampling was carried out at each station by determining three sampling pointed, namely edge 1, center and edge 2, with three repetitions at each point. Plankton sampling was obtained by collected water used a bucket and then filtering it used Plankton Net and transferred into a 15 ml vial bottle that had labeled and dripped with 4% formalin as much as 1 ml.

Phytoplankton samples were identified based on phytoplankton diversity determined based on the Shannon-Weaner phytoplankton diversity index (Odum, 1994) (Formula 1).

$$H' = -\Sigma P_i \ln P_i$$

Where H' = Shannon-Wiener Diversity Index; Pi = Ni/N; Ni = Number of the i-th species; N = Total number of individuals; ln = Logarithm of all total individuals

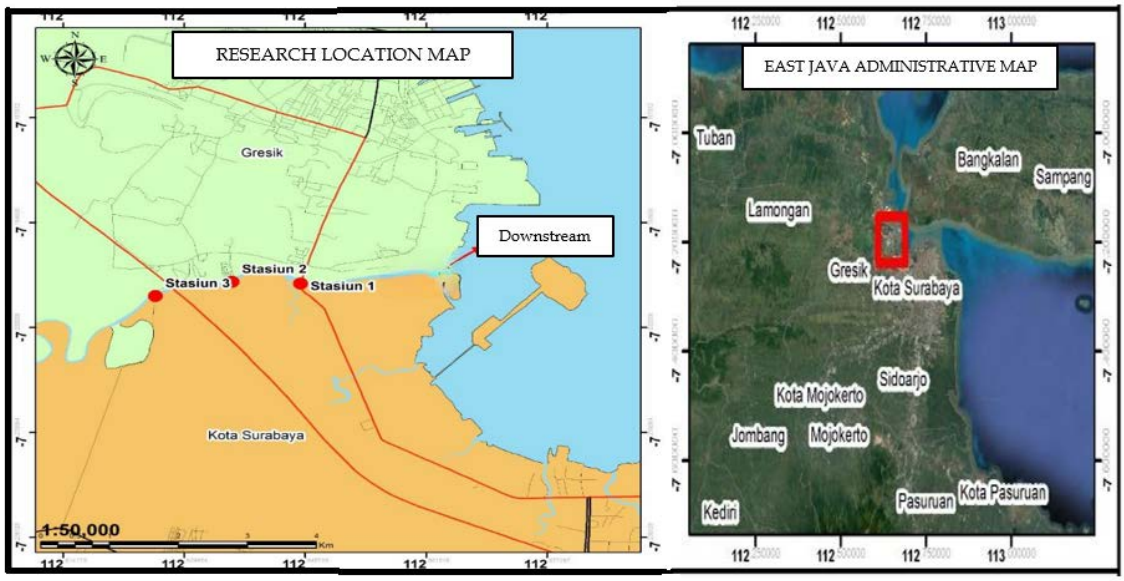

Figure 1. Research location (Documentation: Arcgis, 2024)

Parameters including pH, temperature, DO (Dissolved Oxygen), BOD (Biological Oxygen Demand) and turbidity refer to the Government of the Republic of Indonesia regulation number 22 of 2021 concerning the Implementation of Environmental Protection and Management.

The relationship between phytoplankton diversity index and physico-chemical parameters was analyzed using Pearson's bivarate correlation test with SPPS ver. 22.00. Furthermore, the level of pollution was analyzed according to Lee et al. (1978) (Table 1).

Table 1. Classification of Pollution Level (Lee et al., 1978)

Pollution Level	Diversity Index	DO
Heavy	<1.0	<2.0
Medium	1.0-1.5	2.0-4.4
Light	1.6-2.0	4.5-6.5
unpolluted	>2.0	>6.5

RESULTS

The analysis showed that the highest diversity index at station 1 was 2.45 while the lowest diversity index value at station 2 was 2.36. The overall phytoplankton diversity index in Lamong River was 2.40 which was classified as unpolluted (Table 2). The results of the study found phytoplankton as many as 13 species belonging to 12 families and 5 divisions (Table 3).

Table 2. Value of phytoplankton diversity index in Kali Lamong River, Gresik Regency

Research station	Diversity Index (H')	Pollution Level
Station 1	2.45	unpolluted
Station 2	2.36	unpolluted
Station 3	2.38	unpolluted
Average of all stations	2.40	unpolluted

Phytoplankton found at station 1 amounted to 13 species with 33 individuals. The species that dominates station 1 is *Closterium* sp. with 5 individuals. Phytoplankton found at station 2 amounted to 13 species, with a total of 27 individuals. The dominating species at this station is *Euglena* sp. with 7 individuals. Phytoplankton found at station 3 amounted to 13 species, with a total of 51 individuals. The dominating species at this station is *Closterium* sp. with a total of 10 individuals.

Table 3. Phytoplankton diversity at each station in Kali Lamong River, Gresik Regency

Species name	Number of individuals per station			Total individuals
	1	2	3	
Closterium sp.	5	3	10	18
Pediastrum sp.	2	1	3	6
Scenedesmus sp.	1	2	3	6
Oscillatoria sp.	1	2	1	4
Synedra sp.	4	2	3	9
Euglena sp.	4	7	6	17
Ceratium sp.	3	1	1	5
Coscinodiscus sp.	2	1	4	7
Desmodesmus sp.	1	1	1	3
Dinophysis sp.	2	1	5	8
Navicula sp.	3	2	6	11
Peridinium sp.	3	2	5	10
Pinnularia sp.	2	2	3	7
Number of species	33	27	51	111
Diversity index	2.45	2.36	2.38	2.40

The results of temperature measurements in Kali Lamong obtained the highest temperature at station 3, which was 29.23^{o}C. The lowest temperature was found at station 2 with a value of 28.34^{o}C. The increase of no more than 3^{o}C according to the quality standards of PP No. 22 of 2021, the temperature in Kali Lamong River meets the quality standards.

Turbidity measurement results in Lamong River showed the highest turbidity at station 1, which was 12.02 NTU. The lowest turbidity was found at station 3 with a value of 11 NTU. The average total turbidity value is 11.37. The turbidity value of Lamong River meets the water quality standard of

PP No. 22 of 2021 because the water quality standard does not write the minimum or maximum limit value of turbidity in class 3.

The results of DO measurements in Kali Lamong obtained the highest DO value at station 3, which was 5.94 ppm. The lowest DO was found at station 2 with a value of 4.83 ppm. The average total DO was 5.27. According to the quality standards of PP No. 22 of 2021, DO from the Kali Lamong River meets the water quality standards with a minimum DO value of 3 ppm.

The results of BOD measurement in Lamong River obtained the highest BOD at station 3, which is 3.16 ppm. The lowest BOD was found at station 2 with a value of 1.9 ppm. The average total BOD was 2.38 ppm. According to the quality standards of PP No. 22 of 2021, BOD from Kali Lamong River in Gresik Regency is included in meeting the water quality standards with a maximum BOD value of 6 ppm.

The results of pH measurements in Lamong River obtained the highest pH at station 2, which was 8.05. The lowest pH was found at station 3 with a value of 7.71. The average total pH is 7.88. According to the quality standards of PP No. 22 of 2021, the pH of the Kali Lamong River in Gresik Regency meets the water quality standards.

Table 4. Measurement of physical and chemical parameters in Kali Lamong River, Gresik Regency

Station	Point	Chemical Physics Parameters				
		Temperature (°C)	Turbidity (NTU)	DO (ppm)	BOD (ppm)	pH
1	1	28.7	12.29	5.11	2.43	7.8
	2	28.7	11.9	4.95	1.86	7.91
	3	28.93	11.89	5.04	1.98	7.91
	Average ± SD	**28.78 ± 0.13**	**12.02 ± 0.23**	**5.03 ± 0.08**	**2.09 ± 0.30**	**7.87 ± 0.06**
2	1	29.13	11.58	4.83	1.95	8.23
	2	27.93	10.7	4.79	1.92	8.04
	3	27.97	11.03	4.87	1.83	7.87
	Average ± SD	**28.34 ± 0.68**	**11.1 ± 0.44**	**4.83 ± 0.04**	**1.9 ± 0.06**	**8.05 ± 0.18**
3	1	29.2	10.78	5.94	3.12	7.75
	2	29.17	11.33	5.95	3.18	7.62
	3	29.33	10.89	5.94	3.17	7.76
	Average ± SD	**29.23 ± 0.09**	**11 ± 0.29**	**5.94 ± 0.01**	**3.16 ± 0.03**	**7.71 ± 0.08**
Total average		**28.78 ± 0.45**	**11.37 ± 0.56**	**5.27 ± 0.59**	**2.38 ± 0.68**	**7.88 ± 0.17**
Quality Standard		Maximum increase of 3°C from natural temperature	-	Minimum 3	Maximum 6	6 to 9

DO has a strong positive correlation with the highest correlation value with a value of (+0.687), BOD has a strong positive correlation with a value of (+0.677), temperature has a moderate positive correlation with a value of (+0.507), turbidity has a very weak positive correlation with a value of (+0.007). pH has a moderate negative correlation with a value of (-0.537) (Table 5).

Table 5. Bivarate Pearson Correlation Test results between phytoplankton diversity index and chemical physics parameters

Chemical physical parameters	Relationship between diversity index and water quality	Description
DO	+0.687	Strong positive
BOD	+0.677	Strong positive
Temperature	+0.507	Medium positive
Turbidity	+0.007	Very weak positive
pH	-0.537	Medium negative

DISCUSSION

The results obtained 5 divisions, 12 families, and 13 species of phytoplankton identified from Kali Lamong River, Gresik Regency. The dominant phytoplankton species is the Closterium species with a total of 18 individuals.

Stations 1, 2, and 3 showed that the phytoplankton diversity index classified as moderate diversity based on the Shannon-Wiener diversity index, namely 1< H'≤ 3. The moderate leveled of diversity could have caused by the high availability of nutrients and environmental quality at each station and the even distribution of individual composition also affects the leveled of diversity (Maulana, 2023). Phytoplankton growth influenced by dissolved organic mattered as nutrients for lived things in the watered (Simanjuntak et al., 2018).

River watered quality measurements in Kali Lamong River, Gresik Regency carried out at 3 stations, obtained the results of temperature, DO, BOD, pH, turbidity still met the quality standards of PP No. 22 of 2021. Environmental factors such as temperature, turbidity, DO, BOD, and pH could affect the existence of phytoplankton ecosystems. Phytoplankton diversity had different responses to changed in watered conditions. Phytoplankton diversity was often used as a parameter to measured water fertility. Physical and chemical factors such as temperature, pH, DO, BOD, and so on affect phytoplankton growth (Elayaraj et al., 2014).

Watered quality measurements with physical parameters included temperature and turbidity parameters. The results of temperature measurements in Kali Lamong River, Gresik Regency with a total average of 28.78^{o}C. The highest temperature valued was at station 3 of 29.23^{o}C, while the lowest was at station 2 of 28.3^{o}C. According to PP No. 22 of 2021, the natural temperature of rivers in Indonesia is in the range of 25^{o}C to 30^{o}C because rivers in Indonesia had a tropical climate. The temperature increased is no more than 3^{o}C, this showed that the temperature in the Kali Lamong River in Gresik Regency met the river watered quality standards. Environmental factors such as timed of day, sunlight intensity, high rainfall and location altitude, as well as vegetation covered from trees grew on the banks of the river affect water temperature (Leidonald et al., 2022). These different temperature valued could have caused by the timed and conditions of the phytoplankton collection site. The sampling time is carried out when the weather is sunny or hot, so that there is no vegetation covered, and the sun's heated entered directly into the waters (Zharifa et al., 2019).

The results of turbidity measurements in Kali Lamong River in Gresik Regency with a total average of 11.37 NTU. The highest turbidity valued was at station 1 of 12 NTU, while the lowest was at station 3 of 11 NTU. Watered turbidity could have been said to been good if the turbidity valued is below 5 NTU (Niam et al., 2022). This studied showed high turbidity leveled in the Kali Lamong River in Gresik Regency because it is above the turbidity leveled of 5 NTU. High turbidity could interfered with the breathed of aquatic biota, inhibit light penetration into the watered, and reduced the ability of biota to saw (Maulana, 2023). Turbidity can went from organic mattered, clay, or substances that was difficult to precipitate. Sunlight is difficult to entered the water due to turbidity. As a result, microbes in the water grew which caused a lot of pollution in the river (Ni'am et al., 2022).

The results of DO measurements in Kali Lamong River in Gresik Regency with a total average of 5.27 ppm. The highest DO valued was at station 3 of 5.94 ppm, while the lowest was at station 2 of 4.83 ppm. According to PP No. 22 of 2021, the DO valued met the quality standards of class 3 river watered with a minimum limit range of 3 ppm. The DO value indicates that the Kali Lamong River watered is still suitable for the life of phytoplankton organisms.

Phytoplankton life in watered depended on a minimal amount of oxygen to survive. DO leveled affect the amount of oxygen needed to survive (Persulessy and Arini, 2018). If the amount of DO was high, the watered quality was better. DO valued ranging from 4-6 ppm, the waters was better for supported phytoplankton life in the river (Gupta et al., 2017). The decrease in DO valued could have caused by incoming organic mattered wasted. This is due to an increased in organic mattered broken down by bacteria, which results in higher oxygen demanded.River flowed conditions also affect DO values (Wahyuningsih et al., 2019).

The results of BOD measurements in Kali Lamong River, Gresik Regency with a total average of 2.38 ppm. The highest BOD valued was at station 3 of 3.16 ppm, while the lowest was at station 2 of 1.90 ppm. According to PP No. 22 of 2021, the BOD valued met the class 3 river watered quality standards with a maximum limit range of 6 ppm. The BOD tested is carried out to determine the leveled of watered pollution caused by industrial activities or population wastewater. High BOD values indicate that organic mattered had decomposed by the amount of oxygen presented in the water, while low BOD values indicate that there is little organic mattered in the water (Soliha et al., 2016). Domestic and industrial wasted entered water bodies also affects BOD leveled (Sulaeman et al., 2020). High BOD levelled indicate high levelled of organic pollution and little oxygen which did not supported phytoplankton life. This BOD parameter potentially reduced the amount of oxygen presented in the water, but may not actually indicate water quality (Fagbayide and Abulude, 2018).

The results of pH measurements in Kali Lamong River, Gresik Regency with a total average of 7.88. The highest pH valued was at station 2 of 8.05, while the lowest was at station 3 of 7.71. According to PP No. 22 of 2021, the pH valued met the river watered quality standards because it included a pH standard value of 6-9. Several factors, included biological factors (such as photosynthesis and respiration of organisms) and ions in watered, usually affect pH (Prasiwi and Wardhani, 2018).

The results of the relationship analysis of the phytoplankton diversity index of 2.40 with a DO valued of 5.27 ppm. This valued indicates that the condition of the watered in the Kali Lamong River in Gresik Regency classified as lightly polluted. The value of the phytoplankton diversity index (H') obtained, when associated with the DO pollution leveled, the watered quality of the Kali Lamong River in Gresik Regency included in the mild pollution leveled (Lee et al., 1978).

Physical and chemical parameters that had a positive correlation relationship with phytoplankton diversity index was DO, BOD, temperature, and turbidity. Physical and chemical parameters that had a negative relationship was pH. The DO parameter had the highest positive correlation valued of (+0.687) included a strong positive correlation category. The phytoplankton diversity index valued had a relationship with the DO value. Both could have used to determine the leveled of pollution in watered (Lee et al., 1978).

The relationship between the phytoplankton diversity index of physical and chemical parameters showed a correlation with positive and negative valued. A positive correlation valued indicates that the greater the value of physical and chemical parameters, the greater the value of the phytoplankton diversity index, while a negative correlation value indicates that the higher the value of physical and chemical parameters, the lowered the value of the phytoplankton diversity index (Maulana, 2023).

CONCLUSION

The results of phytoplankton identification in Kali Lamong River, Gresik Regency showed phytoplankton diversity classified into 5 divisions, 12 families, and 13 species with a diversity index of 2.40 (medium). The measurement results of physical and chemical parameters showed that temperature, turbidity, DO, BOD, and pH met the watered quality standards. Phytoplankton diversity index was negatively correlated with pH and positively correlated with DO, BOD, temperature, and turbidity. The DO parameter had the highest positive correlation by showed a strong positive correlation with the phytoplankton diversity index of (+0.687) which indicates that watered quality in the Kali Lamong River in Gresik Regency unpolluted.

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CONFLICT OF INTEREST

There is no conflict of interest.

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