Analysis of Water Pollutant Distribution In Lake Tempe Using Pollution Index Method

Muh. Rafi Aryawardhana[1], Roslinda Ibrahim[2], Mary Selintung[2]

[1]Student the Department of Environmental Engineering Masters Program, Faculty Engineering, Hasanuddin University, Gowa, South Sulawesi, Indonesia
[2]Lecturer the Department of Environmental Engineering Masters Program, Faculty of Engineering, Hasanuddin University, Gowa, South Sulawesi, Indonesia

muhrafi.aryawardhana@gmail.com

ABSTRACT

Lake Tempe is currently grappling with worrisome pollution, primarily due to various activities producing wastewater nearby. These activities encompass domestic tasks, agricultural practices, and local industries. In this research, we employed a robust methodology, including lake water sampling, followed by a comprehensive analysis of the pollution index in line with the Quality Standards and Criteria for Environmental Damage, Attachment I Letter B Method for Determining Water Quality Status, as stipulated in South Sulawesi Governor Regulation No. 68 (2010). Additionally, we used the Independent Sample t-Test method for statistical analysis through S.P.S.S.

Our findings reveal a concerning state of water quality in Lake Tempe, with a strong correlation observed between the concentration of wastewater from the silk industry and the deteriorating water conditions in the lake. Based on these results, we recommend proactive government intervention. Such intervention should ideally include two significant measures. First, an extensive campaign to encourage the return to natural dyes within the silk industry, reducing the harmful effluents currently being released. Second, the introduction of a dedicated program to establish a wastewater treatment plant specifically for the silk industry. These efforts are essential to sustain Lake Tempe's environmental health and ensure the survival of its delicate ecosystem.

Keywords: pollution index, statistic method, wastewater, Lake Tempe

INTRODUCTION

According to Law no. 32/2009 concerning Protection and Management of the Environment Article 1 Paragraph (14) as amended by Article 22 paragraph 1 number 14 of Law no. 11/2020 concerning Job Creation and P.P. No. 22/2021 concerning Implementation of Environmental Protection and Management Chapter I General Provisions Ps. 1 (28), states that environmental pollution is the entry or inclusion 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 largest area of Lake Tempe is in Wajo Regency, about 7 km from Sengkang City, the capital of Wajo Regency. Lake Tempe is the second-largest lake on the island of Sulawesi. The level of pollution in Lake Tempe is in a state of concern. It is due to the increasing activity of the people around Lake Tempe, namely agriculture, industry, and domestic waste from households and fisheries.

The development of the silk industry around Lake Tempe is one of the causes of increasing

pollution in Lake Tempe. The cause is the result of the community's colouring process producing liquid waste without going through the wastewater treatment process, which is then disposed of through a carrier canal connected to Lake Tempe.

In this study, the quality status in the lake using the pollution index method and analysis of the influence of wastewater on the quality of the water in the silk industry based on water quality parameters on the water quality in Lake Tempe in terms of T.S.S., B.O.D., C.O.D., and Phenol parameters by using statistical analysis. This situation seems to be per the opinion of Ghaly et al. (2014), which stated that most of the dyes are absorbed into the textile fabric during the dyeing process. The remaining dyes that are not absorbed will become liquid waste and create a highly toxic colour solution, T.S.S., Very high B.O.D., C.O.D. and Phenol, resulting in a distribution pattern of silk dyeing wastewater pollution in Lake Tempe.

METHODS

Study Design

This research was conducted to determine the relationship of water quality parameters from liquid waste produced by the silk industry to the water quality of Tempe Lake in terms of the water quality parameters T.S.S., B.O.D., C.O.D. and Phenol. The research was conducted in July – December 2022.

Population, Sample and Sampling

The population in this study were in 3 (three) locations for the silk industry in Tanasitolo District in Lake Tempe Inlet Canal Rady A. Gani 2 (two) locations, Community Raw Water Pumps in Tanasitolo District, Lake Tempe Catchment Area, Lake Tempe Oulet (Cenrana River) and in the central part of Lake Tempe, as shown in Figure 1. The samples in this study were water from the dyeing/dyeing of silk threads, carrier water, and lake water. Water Sampling was carried out in

three periods with 2 (two) repetitions for each water sampling point.

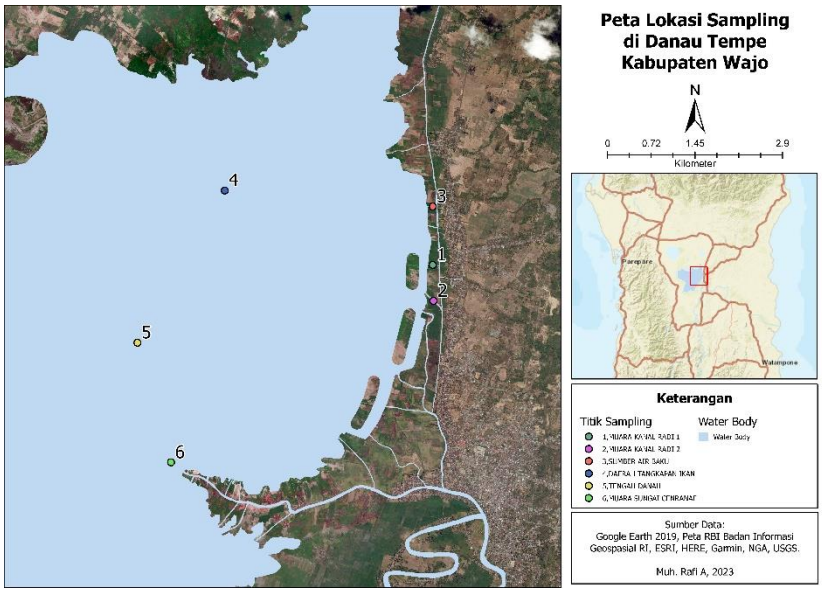

Figure 1. Map of water sampling points
(Data source : Google Earth 2019, Topographic Map of Indonesia Geospatial Information Agency of the Republic of Indonesia, ESRI, HERE, Garmin, NGA, USGS.

Instrument

Water sampling results are entered into the laboratory for water quality testing based on the parameters T.S.S., B.O.D., C.O.D. and Phenol. Data from laboratory testing will be processed to determine the water quality status of Tempe Lake using the pollution index method. They will be analyzed through statistical methods to determine the relationship between water quality in the Silk Industry and water quality in Tempe Lake.

Procedure

This research was carried out by taking water samples using 2 (two) methods, namely Lake Water Sampling. Referring to Indonesian National Standard No. 6989.57:2008 concerning the Method of Sampling Surface Water, using a water sampler, utilizing 2 (two) points, namely on the surface and the bottom of the lake, then mixed (depth composite) because the depth of Lake Tempe is > 10 m and Sampling of Silk Industry Wastewater taken from the container where the silk industrial wastewater is collected by homogenizing first and then taken and put into a bottle.

Then to find out the value of the water quality parameters, the water samples were tested for parameters in the laboratory using the parameter testing method according to the Indonesian National Standard. After testing, the data will be analyzed to determine the water quality status of Tempe Lake using the pollution index method and also analyzed to determine the relationship between water quality in the Silk Industry and water quality in Tempe Lake.

Data analysis

Analysis of determining the status of water quality

In this study, we determine the status of water quality based on South Sulawesi Governor Regulation No. 69/2010 concerning Quality Standards and Criteria for Environmental Damage, Appendix I, Letter B Methods for Determining Water Quality Status. The type of method to be used is the Pollution Index Method. I.P. covers a wide range of independent and influential groups of water quality parameters.

The calculation of the pollution index is carried out using the formula:

$$PL_j = \frac{\sqrt{\left(C_i/L_{ij}\right)_M^2 + \left(C_i/L_{ij}\right)_R^2}}{2}$$

Where :

P.I.: pollution index

Ci: parameter concentration measurement results

Lij: quality standards

M: maximum

R: average

Based on the calculation of the pollution index, water quality can be classified as,

1) $0 \leq PI_j \leq 1{,}0$ meet quality standards
2) $1{,}0 < PI_j \leq 5{,}0$ light polluted
3) $5{,}0 < PI_j \leq 10$ medium polluted
4) $PI_j > PI_j$ heavily polluted

Value calculation (New Ci/Li)

1) If the value (Ci or Li) is below 1.0, then the value entered in (New Ci or Li) is the value (Ci or Li).
   (New Ci or Li) < 1.0
   (New Ci or Li) = (Ci or Li)
2) If the value (Ci or Li) is above 1.0, then use the formula:
   (New Ci or Li) > 1.0
   (New Ci or Li) = 1.0 + P.log(Ci or Lij)
   = 1.0 + 5 (Ci or Lij)

Analysis of Statistical Package for Social Science Software (S.P.S.S.)

One of the statistical packages used in quantitative data analysis is the Statistical Package for Social Science Software (S.P.S.S.). The method used in statistical testing is *the Independent Sample t-Test*, a procedure used to find the difference between the average of two populations or independent data groups. This independent t-Test has assumptions and conditions that must be met, namely:

1) The data is typically distributed.
2) The data group is independent.
3) The data variables to be connected are numbers and grouping results (only for two groups).

Levene's test is used to test the variance of several populations. By using a significance level of 5% (0.05), the basis for decision-making on the homogeneity test is:

1) If the Asymp. Sig (2-tailed) > 0.05, then the data is homogeneous.

If the Asymp. Sig (2-tailed) < 0.05, the data is not homogeneous.

Ethical Clearance

The researcher obtained a research/survey permit from the Investment and One-Stop Service Office of Wajo Regency with Number: 1780 / IP / DPMPTSP / 2022 dated August 2, 2022. The data collected is used only for research purposes.

RESULT AND DISCUSSION

The results of testing water samples in the laboratory for the parameters T.S.S., B.O.D., C.O.D., and Phenol were conducted at the silk industry at Point Sample 1 (Silk Industry 1), Point Sample 2 (Silk Industry 2), and Point Sample 3 (Silk Industry Exhaust Channel), Point Sample 4 at Rady A. Gani 1 Canal Inlet, Sample 5 Point at Rady A. Gani 2 Canal Inlet, Sample 6 Point at Tanasitolo Sub-District Community Raw Water Pump, Sample 7 Point at Lake Tempe Catchment Area, Sample 8 Point at Central Lake Tempe, and Point Sample 9 Lake Tempe Outlet (Cenrana Estuary) Parameter test results are presented in Table 1.

Table 1. Results of water quality testing at the Silk Industry and Lake Tempe

Parameters	Unit	Point Sample									Info.
		PS 1	PS 2	PS 3	PS 4	PS 5	PS 6	PS 7	PS 8	PS 9	
PSS	mg/l	369,33	102,33	68,67	16,50	15,50	14,00	16,00	16,50	16,00	
BOD	mg/l	437,84	463,16	73,86	26,32	31,52	11,99	10,43	11,39	9,37	
COD	mg/l	1.150,14	1.104,72	164,23	39,55	47,18	23,46	28,06	28,06	21,10	
Fenol	mg/l	0,04	0,05	0,02	0,02	0,02	0,01	0,02	0,01	0,01	

The high values of the water quality parameters B.O.D., C.O.D., and phenol are thought to have come from dyeing silk yarn in the silk industry located in Pakanna Village, Tanasitolo District, around Lake Tempe, according to Azanaw et al. (2022), which states that the textile industry is included in a global environmental problem related to the value of water pollution caused by the disposal of liquid waste that is not treated first. It is a critical environmental problem because it reduces oxygen concentration, blocks light into the water and also causes an increase in the values of the water quality parameters B.O.D., C.O.D., and T.D.S., which significantly impact the environment.

This situation also seems to be per the opinion of Sarawati et al. (2014), which states that in the dyeing process, the fabric or yarn has undergone a boiling process, which produces a high phenol value.

The pollution index calculation method is used To determine the value of the water quality status of Lake Tempe. This situation seems to be per the opinion of Prasetia and Walukow (2021), which states that calculations using the pollution index method can be used to determine the value of the pollution level.

Table 2. Lake Tempe's pollution index

No.	Parameters	Average Value or Field Value (Ci)	Quality Standards (LiX)	Ci / Lix	New Ci / Lix	Pollution Index
1	PSS	15,750	80	0,197	0,197	**5,441**
2	BOD	25,253	2	12,626	6,506	
3	COD	45,807	10	4,581	4,305	
4	Fenol	0,015	0,002	7,656	5,420	
		Average Ci / LiX			4,107	
		Maximum Ci / LiX			6,506	

IP calculation results based on parameter values indicate the water quality status in Lake Tempe.

Medium Polluted.

To determine the effect of parameters in the silk industry on water quality parameters in Lake Tempe, a statistical analysis of the Statistical Package for Social Science (S.P.S.S.) software was performed using the Independent Sample t Test method, which is a procedure used to determine differences from the average of two populations or independent data groups. This relationship can be seen in the following table:

Table 3. Test of normality

	Group	Kolmogorov-Smirnov*:			Shapiro-Wilk		
		Statistik	df	Sig.	Statistik	df	Sig.
TSS RESUTS	TSS SILK	.259	9	.083	.709	9	.002
	TSS LAKE	.128	12	.200*	.950	12	.635
BOD RESUTS	BOD SILK	.295	9	.023	.768	9	.009
	BOD LAKE	.335	12	.001	.697	12	.001
COD RESUTS	COD SILK	.310	9	.013	.767	9	.009
	COD LAKE	.285	12	.008	.764	12	.004
PHENOL RESULTS	PHENOL SILK	.178	9	.200*	.921	9	.401
	PHENOL LAKE	.404	18	.000	.684	18	.000

Information :

*: This is a lower bound of the true significance

**: Lilliefors Significance Correction

Table 4. Statistics Test

	TSS RESULT	BOD RESULT	COD RESULT	PHENOL RESULT
Mann-Whitney U	.000	2.000	.000	33.000
Wilcoxon W	78.000	80.000	78.000	204.000
Z	-3.848	-3.697	-3.839	-2.472
Asymp. Sig. (2-tailed)	.000	.000	.000	.013
Exact Sig. [2*(1-tailed Sig.)]	.000[b]	.000[b]	.000[b]	.012[b]

Information :

a: Grouping Variable: KELOMPOK

b: Not corrected forties.

Based on statistical tests in Table 3 and Table 4 explains the relationship between the influence of water quality in the silk industry and the lake, with an explanation of each parameter as follows:

1.1. T.S.S.

The value of the T.S.S. water quality parameter in the silk industry shows a high value of 68.67–369.33 mg/l, which flows towards the lake so that the water quality parameter value in the lake shows a value of 14.00–16.50 mg/l. Based on the parameter values that have been obtained, an analysis of the effect of water quality parameters in the silk industry on the water quality in the lake is carried out through statistical tests, as shown in Table 3 and Table 4, with the results showing homogeneous data or the influence of T.S.S. water quality in the silk industry on Tempe Lake water quality. It is shown in the Asymp. Sig. (2-tailed) whose value is less than 0.05.

1.2. B.O.D.

The B.O.D. water quality parameter value in the silk industry shows a high value, namely 73.86–463.16 mg/l, which flows towards the lake so that the water quality parameter value in the lake shows a value of 9.37–31.52 mg/l. Based on the parameter values that have been obtained, an analysis of the influence of water quality parameters in the silk industry on the water quality in the lake through statistical tests is shown in Table 3 and Table 4, with the results showing homogeneous data or the influence of B.O.D. water quality in the silk industry on Tempe Lake water quality, which is shown in the Asymp value, Sig. (2-tailed), whose value is less than 0.05.

1.3. C.O.D.

The C.O.D. water quality parameter value in the silk industry shows a high value, namely 164.23–1,150.14 mg/l, which flows towards the lake so that the water quality parameter value in the lake shows a value of 21.10–47.18 mg/l. Based on the parameter values that have been obtained, an analysis of the influence of water quality parameters in the silk industry on the water quality in the lake through statistical tests is shown in Table 3 and Table 4, with the results showing that the data is homogeneous or there is an effect of the influence of C.O.D. water quality in the silk industry on Tempe Lake water quality, as shown in the Asymp. Sig. (2-tailed) whose value is less than 0.05.

1.4. Fenol

The value of the phenol water quality parameter in the silk industry shows a high value of 0.02–0.05 mg/l, which flows towards the lake so that the water quality parameter value in the lake shows a value of 0.01–0.20 mg/l. Based on the parameter values that have been obtained, an analysis of the influence of water quality parameters in the silk industry on the quality of water in the lake through statistical tests is shown in Table 3 and Table 4, with the results showing homogeneous data or the influence of phenol water quality in the silk industry on Tempe Lake water quality, which is shown in the Asymp. Sig. (2-tailed) whose value is less than 0.05.

CONCLUSION

The given conclusion states that the high values of water quality parameters such as B.O.D. (Biochemical Oxygen Demand), C.O.D. (Chemical Oxygen Demand) and phenol in the silk industry significantly impact Lake Tempe. The pollution index calculation for Lake Tempe indicates a moderately polluted water quality status. Furthermore, the statistical analysis reveals a relationship between the silk industry's water quality and Lake Tempe's water quality. Based on

these findings, it is suggested that the government should take action. Firstly, efforts should be made to raise awareness among artisans in the silk industry about the importance of using natural dyes instead of chemical alternatives. It could be achieved through socialization programs and campaigns promoting environmentally friendly practices in the industry.

Additionally, there is a need for a government program to establish a Water Waste Treatment Plant (WWTP) in the Silk Industry, specifically in Pakanna Village, Tanasitolo District. This treatment plant would treat the silk industry's wastewater, ensuring that pollutants are appropriately removed before being discharged into the environment. By implementing such a program, Lake Tempe's environmental and ecosystem sustainability is hoped to be effectively maintained. Overall, the conclusion emphasizes the significance of addressing the water pollution issues caused by the silk industry to protect Lake Tempe's water quality and ecosystem. It also suggests specific measures the government should take to achieve this goal.

ACKNOWLEDGEMENT

The Author would like to express the deepest gratitude to Mr Takdir, Laboratory Staff of the Makassar Health Laboratory Center-Directorate General of Health Services, Ministry of Health, Republic of Indonesia, for playing a decisive role in processing data in this research.

NOTES

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Azanaw, et al., (2022). Textile effluent treatment methods and eco-friendly resolution of textile wastewater. Case Studies in Chemical and Environmental Engineering. Vol. 6, December 2022. 100230. Doi: https://doi.org/10.1016/j.cscee.2022.100230

National Standardization of Indonesian, (2008). SNI 6989.57-2008 concerning Water and Waste Section 57: Surface Water Sampling Method. Jakarta.

Ghaly, A.E., Ananthashankar, R., Alhattab, M.V.V.R., Ramakrishnan, V.V., 2014. Production, characterization and treatment of textile effluents: a critical review. J. Chem. Eng. Process Technol., 5 (1) (2014), pp. 1-19. Doi: http://dx.doi.org/10.4172/2157-7048.1000182

Indonesia. (2021). Government Regulation Number 22 of 2021 respecting the Implementation of Environmental Protection and Management. Jakarta.

Prasetia, Angga, and Walukow, Auldry F. Walukow (2021) Analysis of the water quality of Lake Area Expo Arena with the pollution index method in the city of Jayapura. Indonesian Environmental Dynamics, January 2021, Volume 8, Number 1, P. 42–47 Jayapura, DOI: 10.31258/dli.8.1.p.42–47.

Priya. E. Sanmuga and Selvan. P. Senthamil. (2014). Water hyacinth (Eichhornia crassipes) – An efficient and economical adsorbent for textile effluent treatment – A review. Arabian Journal of Chemistry. Doi: https://doi.org/10.1016/j.arabjc.2014.03.002

YW Saraswati et al. (2014) Spatial and Temporal Sebaean Phenol, Chromium, and Oil Around the Batik Industry Center in Pekalongan Regency Diponegoro Journal of Macquares, Volume 3, Number 1, Year 2014, Page