ISSN 2541-223X
Volume 4 2022

THE CONDITION OF THE SETIAMANAH LAKE IN TERMS OF WATER QUALITY

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ABSTRACT

Setiamanah Lake is located in Setiamanah Village, Central Cimahi District, Cimahi City. This lake has an area of 0.04 ha with a depth of 5 m and a volume of 1.204.5 m^3. This lake functions as a rainwater shelter and is planned to be used as a raw water source. This lake is part of the Cisangkan River watershed. The activities of residents in the watershed significantly affect the lake's water quality. Activities in the Cisangkan River Basin consist of domestic, non-domestic, agricultural, and plantation activities. The Setiamanah lake will be designated as a source of raw water, so it is necessary to analyze the water quality and determine its quality status to find out how the water conditions and the lake management are. Water quality analysis was carried out in October 2021 (rainy season) and April 2022 (dry season) with 23 parameters analyzed. In 2021 12 parameters do not meet the standards, and in 2022 9 parameters do not meet the quality standards. The quality standard used is Government Regulation No.22 of 2021 class I. Based on the calculation of water quality status using the pollutant index method, Setiamanah Lake in both seasons shows mild contamination, with the pollutant index value in 2021 being 8.398 and in 2022 being 8.325.

Keywords: Setiamanah Lake, Cisangkan River, quality standards, water quality, pollutant index

1. INTRODUCTION

Cimahi City every year has increase in population, so the need for clean water also increases. The availability of raw water in this city has decreased in terms of quality and quantity, especially from river water (Cimahi City Environment, Agency, 2020). The quality of river water in Cimahi City has been heavily polluted due to the activities of residents in the catchment area. The number of water experiences large fluctuations during the rainy and dry seasons caused by damage to its watersheds, especially in the upstream part of the river. In the dry season, the amount of water is minimal, while the rainy season can cause flooding in some areas. This is a result of the lack of water absorption and changes in land use. To anticipate this, the Cimahi City Environmental Service will revitalize the lake, which is used as an addition to raw water reserves (Cimahi City Environment, Agency, 2020).

The lake in Cimahi City consists of 8 (eight) lakes, one of which is the Setiamanah Lake. Setiamanah Lake is in Setiamanah Village, Central Cimahi District, West Java. The Setiamanah Lake has an area of 0.04 Ha with a volume of 1.204.5 m^3 (Cimahi City Environment, Agency, 2020). It can be used as primary data for planning for further

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DOI: https://doi.org/10.20885/icsbe.vol2.art15

improvement of the condition of the lake. For the Setiamanah Lake to be used as a source of raw water for daily needs, it is necessary to conduct field research on water quality, border conditions, and water catchment areas and identify sources of pollution that enter the lake. This study analyzes the lake's water quality in two rainy and dry seasons. The data on the lake's water quality can be used as primary data for planning for further improvement of the lake's condition.

Research on ponds, lakes, or reservoirs has been widely carried out in various regions in Indonesia. This is because the existence of these water bodies is threatened and getting more attention from the government, considering the increasingly critical water resources in this country. Almost all the river water quality that crosses Cimahi City, West Java Province, has been polluted, so this city has difficulty finding raw water sources (Wardhani, E., Primalaksono, Y, 2022). Saguling Lake, which is the main lake in West Java Province and a source of raw water at this time, the water quality continues to deteriorate (Eka, W., Suprihanto, N., Dwina, R, 2018). This research can be used as primary data to determine the lake's condition and be the initial data in planning for further improvement of the lake.

2. RESEARCH METHODS

2.1. Research Time and Location

This research is located in Setiamanah Lake, which is located in Setiamanah Village, Central Cimahi District, Cimahi City, at coordinates 06°52'23.1" S and 107°32'03.3" E. Sampling of lake water quality was carried out in October 2021 (rainy season) and April 2022 (dry season) with monitoring at one sampling point. The water extraction method refers to the Indonesian National Standard Number 6989.57-2008 concerning water and wastewater-section 57: surface water sampling method.

2.2. Data Analysis Method

The analytical method used is descriptive analysis, namely analyzing the results of field surveys and analysis of lake water quality. Water quality analysis is carried out by comparing the results of the Setiamanah Lake water quality test with Government Regulation No. 22 of 2021 in Appendix VI, namely the class I designation of lake water quality standards, namely water whose designation can be used for drinking water raw water, and or other designations that require the same water quality with that use.

After making comparisons, determine the lake's quality status by using the pollutant index method. This index is used as an analysis to evaluate the level of pollution in waters. This method is a relative calculation between the results of water quality observations and the quality standards used. The calculation of this method consists of the average index value and the maximum index value. The maximum value is used as the primary pollutant element of the cause of the decline in water quality. Calculation of the pollution index to the Decree of the Minister of the Environment No.115 of 2003 concerning Guidelines for Determining the Status of Water Quality. The pollutant index calculation is calculated using equation 1.

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

Where PI is the pollution index for the designation (j); L_{ij} is the concentration of water quality parameters listed in the water designation standard (j); C_i is the concentration of the measured water quality parameters; $(C_{ij}/L_{ij})_M$, namely the maximum C_{ij}/L_{ij} value; and

$(C_{ij}/L_{ij})_R$, which is the average C_{ij}/L_{ij} value. This method can directly relate the level of pollution to whether or not the lake is used for certain uses with certain parameters. Evaluation on the pollutant index method is if 0 PIj 1.0 then the water quality meets the quality standard (good condition), 1.0 < PIj 5.0 conditionslightly polluted, 5.0 < PIj 10 indicates moderate pollution, and PIj > 10 water quality is categorized as heavily polluted [6].

In addition to water quality, the conditions around the lake are also analyzed to determine the effect of land use on water quality.

3. RESULT AND DISCUSSION

3.1. Picture and Discussion

Lake has an area of 0.04 Ha with a storage volume of 1.204.5 m^3 and a depth of 5 m. A water inlet and outlet originate from the Cisangkan River, part of the Citarum River sub-watershed in the Bandung Basin area. Densely populated residential buildings surround the Embung Setiamanah border area. The results of the survey regarding the Setiamanah Embung and its surrounding locations can be seen in Figure 1.

Conditions around the lake affect the water quality in Setiamanah Lake. The Cisangkan River, located around the lake, has wastewater discharge outlets from several sectors, including the domestic sector, which consists of waste resulting from residents' daily activities, and cottage industries such as the tuna fish factory industry (Euthynnus affairs). Based on the survey results in this lake, no complete food network was detected. Eating and eating only occurs between plankton, benthos, and small fish because this lake is no longer a fish habitat. The condition of the lake's waters is that no water plant cover spreads; only leaves fall into the water due to being carried away by the wind, so it does not interfere with the function of the lake. Siltation occurs in this lake. It causes a decrease in the volume of the lake. Based on the results of interviews, the depth of the lake in 2015, which was 5 m changed to 1.5 m, or there was an accumulation of soil in the lake, which caused the water depth to decrease.

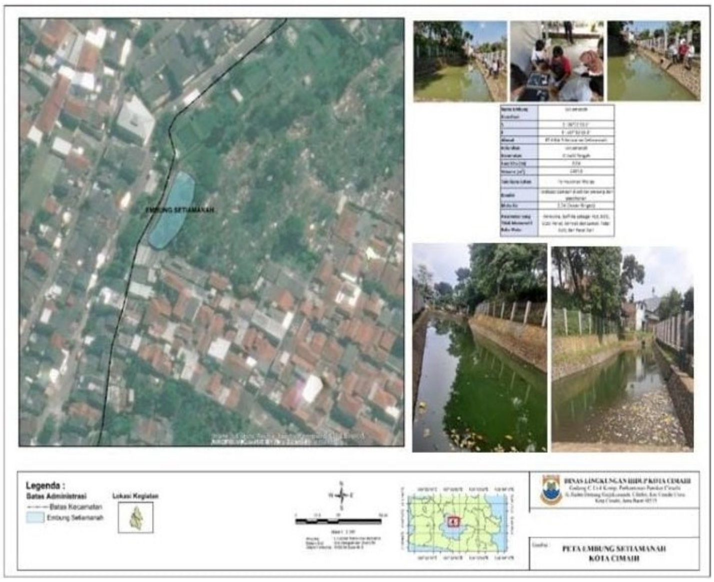

Figure 1 Setiamanah Lake Condition

ISSN 2541-223X
Volume 4 2022

3.2. Water Quality Analysis

Laboratory analysis consisted of physical and chemical parameters (organic and inorganic chemistry). Based on the results of the study, there were 12 (twelve) parameters that did not meet the quality standards. In October 2021, TSS, free chlorine, dissolved Mn, dissolved Zn, total phosphate, sulfide, MBAS, DO, BOD_5, COD, oil and grease, and phenol. In April 2022, 9 (nine) parameters did not meet the quality standards, namely free chlorine, dissolved Mn, total phosphate, sulfide, DO, BOD_5, COD, oil and grease, and phenol. Parameters that do not meet the quality standards are displayed in graphical form, which can be seen in Fig. 2 to 13. The complete data are presented in Table 1.

Table 1 Setiamanah Lake Water Quality in Year 2021 and 2022

Parameters	Unit	Setiamanah Lake Water Quality		Quality standards
		Year 2021	Year 2022	
Temperature	°C	28	26	Dev 3
Total suspended solids (TSS)	mg/L	29.8	13.1	25
Total dissolved solids (TDS)	mg/L	274	271	1.000
Color	Pt-Co Unit	7.21	5.25	15.0
pH	-	7.17	6.79	6 - 9
Free chlorine	mg/L	0.46	0.05	0.03
Chloride	mg/L	35.2	18.4	300
Sulfate	mg/L	12.7	13.6	300
fluoride	mg/L	0.06	0.06	1
Dissolved Fe	mg/L	0.178	0.0198	0.3
Dissolved Mn	mg/L	0.992	0.5	0.4
Dissolved Zn	mg/L	0.0571	0.0127	0.05
Cu dissolved	mg/L	0.011	0.0071	0.02
Cr (VI)	mg/L	0.0367	0.0367	0.05
Total Phosphate	mg/L	0.032	0.097	0.01
Cyanide	mg/L	0.01	0.005	0.02
Sulfide	mg/L	0.014	0.012	0.002
MBAS	mg/L	0.493	0.2	0.2
DO	mg/L	1.97	5.66	6
BOD_5	mg/L	20.03	20.10	2
COD	mg/L	59.6	48.8	10
Oil & Grease	mg/L	10.6	2.89	1
Phenol	mg/L	0.264	0.263	0.002

Note: the red color is a parameter that does not meet the quality standard

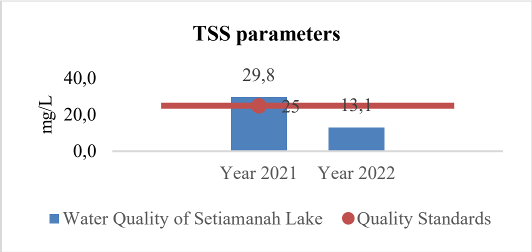

Figure 2 TSS Parameter Graph

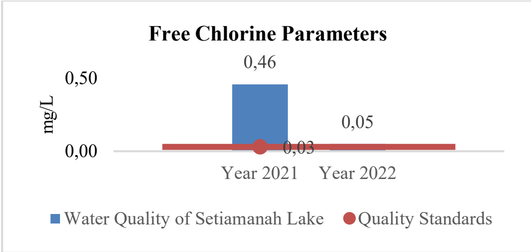

Figure 3 Free Chlorine Parameter Graph

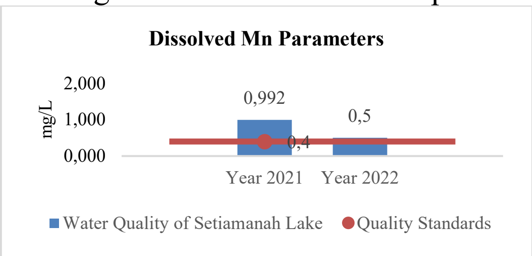

Figure 4 Dissolved Mn Parameter Graph

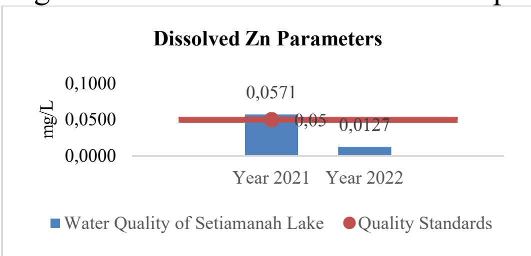

Figure 5 Dissolved Zn Parameter Graph

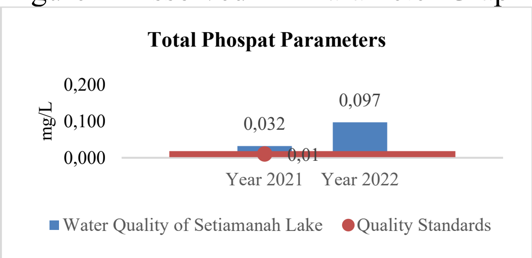

Figure 6 Total Phosphate Parameter Graph

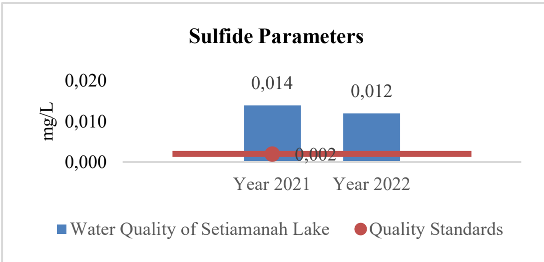

Figure 7 Sulfide Parameter Graph

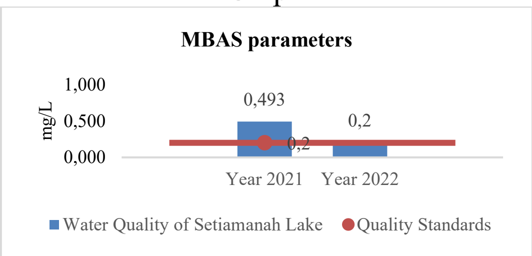

Figure 8 MBAS Parameter Graph

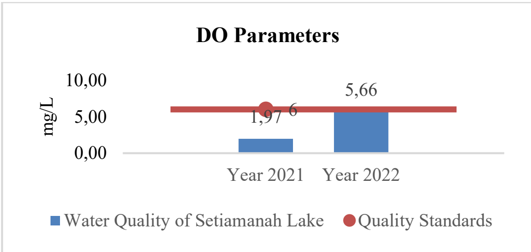

Figure 9 DO Parameter Graph

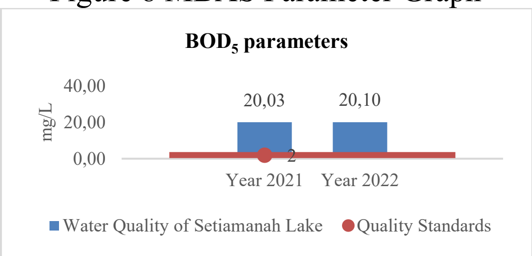

Figure 10 BOD_5 Parameter Graph

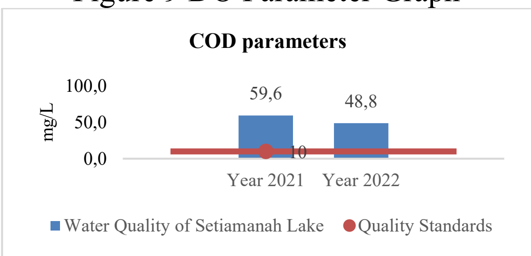

Figure 11 COD Parameter Graph

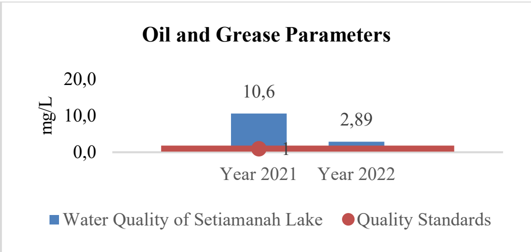

Figure 12 Oil and Grease Parameter Graph

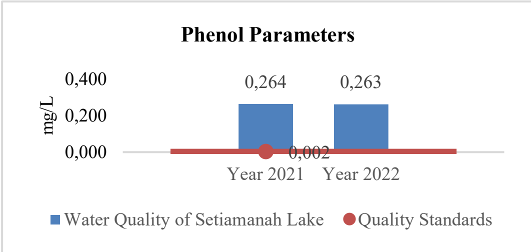

Figure 13 Phenol Parameter Graph

3.2.1. Total Suspended Solid (TSS)

Based on Figure 2, during the rainy season in 2021, TSS does not meet the quality standard; the concentration reaches 29.8 mg/L. The cause of the high TSS in the rainy season is the high erosion rate because soil particles are carried in by rainwater into the Setiamanah Lake. In addition, the cause of high TSS is influenced by the high water discharge of the Cisangkan River during the rainy season, which brings sedimentation into the lake so that suspended solids increase. The water quality of the Cisangkan River has been polluted. It can be seen from several parameters that have exceeded the quality standards, such as DO, BOD_5, and COD. The high concentration of TSS causes the water to become cloudy and blocks sunlight from entering the water body (Rosmeiliyana and Eka Wardhani, 2021).

3.2.2. Free Chlorine

Chlorine is produced from clean water treatment processes, human activity waste, hospital waste, and various industrial activity processes that can pollute the environment (Rosmeiliyana and Eka Wardhani, 2021). The measurement results from both seasons stated that the free chlorine parameter in Setiamanah Lake exceeded the quality standard set at 0.03 mg/L. In the rainy season in 2021, the free chlorine concentration is 0.46 mg/L and in the dry season in 2022 is 0.05 mg/L, as shown in Figure 3. The free chlorine concentration in the rainy season is more significant than in the dry season.

3.2.3. Dissolved Mn

Manganese in the waters is caused by direct contact between the water and the soil layer. Excessive amounts of manganese can cause problems. Namely, the water becomes tasted, causing sediment and turbidity (Yogafanny, 2015). The measurement results from both seasons stated that the dissolved Mn parameter in Setiamanah Lake exceeded the specified quality standard of 0.4 mg/L. The rainy season in 2021 has a higher dissolved Mn concentration (0.992 mg/L) than the dry season in 2022 (0.5 mg/L), which can be seen in Figure 4.

3.2.4. Dissolved Zn

Zinc (Zn) is a type of metal produced from domestic and non-domestic activities such as industry and agriculture, which causes polluted rivers, high concentrations of Zn will cause toxic effects, and Zn toxicity will decrease as dissolved oxygen decreases (Wardhani, E., Roosmini, D., Notodarmojo, S., 2021). The measurement results from both seasons stated that only in 2021 (0.0571 mg/L) did the dissolved Zn parameter in Setiamanah Lake exceed the quality standard (0.05 mg/L), which can be seen in Figure 5.

3.2.5. Total Phosphate

The phosphate content in water causes algae to increase in water (eutrophication), which will block the smooth flow of water and interfere with the entry of dissolved oxygen into the water (Yogafanny, 2015). The measurement results from both seasons stated that the total phosphate parameter in Setiamanah Lake exceeded the quality standard (0.01 mg/L). The dry season in 2022 has a higher total phosphate concentration (0.097 mg/L) than the rainy season in 2021 (0.032 mg/L), which can be seen in Figure 6. The high total phosphate concentration comes from domestic waste, namely detergent, that enters the Cisangkan River. Thus affecting the quality of the total phosphate parameter in Setiamanah Lake.

3.2.6. Sulfide

Sulfide is a gas produced from the decomposition of organic matter by anaerobic bacteria, which is toxic. The decomposition results undergo the anaerobic decomposition of various sulfur-containing substances and produce an unpleasant odor or H_2S gas, which indicates a lack of oxygen (Wardhani, E., Roosmini, D., Notodarmojo, S., 2021). Measurement results from both seasons stated that the sulfide parameter in Setiamanah Lake exceeded the quality standard (0.002 mg/L). The rainy season in 2021 has a higher sulfide concentration (0.014 mg/L) due to the low concentration of dissolved oxygen entering the lake compared to the dry season in 2022 (0.012 mg/L), which can be seen in Figure 7.

3.2.7. MBAS

The measurement results from both seasons stated that only in 2021 (0.493) did the MBAS parameter in the Setiamanah Lake exceed the quality standard (0.2 mg/L), which can be seen in Figure 8. The high MBAS was caused by detergent waste containing surfactants. Detergent waste is one type of pollution that endangers aquatic organisms because it can inhibit the supply of incoming oxygen due to being covered by foam on the surface of the water (Yuniarti, Danang Biyatmoko, 2019).

3.2.8. Dissolved Oxygen (DO)

Dissolved oxygen parameters are needed in waters to support the life of living things in the waters (Daroini, TA, and Arisandi, A., 2020). The requirements for the quality standard of DO parameters for lakes are at least 6 mg/L, which can be seen in Fig. 9. In 2021 (1.97 mg/L) and 2022 (5.66 mg/L), the DO concentration does not meet the required quality standards. The low DO concentration is caused by the high concentration of BOD_5 in Setiamanah Lake, which can inhibit the photosynthesis rate. Theoretically, the DO concentration will be inversely proportional to BOD_5. The higher the BOD_5 concentration in water, the lower the DO concentration in the water. The decrease in DO was caused by the aerobic organic matter degradation process.

3.2.9. Biochemical Oxygen Demand (BOD_5)

BOD_5 parameter represents the concentration of biodegradable organic matter in waters. The BOD_5 value is the number of oxygen microbes needed to oxidize all organic substances dissolved in water and some organic substances suspended in water (Daroini, TA, and Arisandi, A., 2020). The measurement results from both seasons stated that the BOD_5 parameter in Setiamanah Lake exceeded the quality standard (2 mg/L). The high concentration of BOD_5 in the lake is caused by the waste of organic matter from the domestic sector and cottage industry that enters the Cisangkan River, thus affecting the water body of the Setiamanah Lake. In 2022, the BOD_5 parameter has a higher concentration (20.10 mg/l), which can be seen in Figure 10.

3.2.10. Chemical Oxygen Demand (COD)

COD measures waste regarding the total amount of oxygen required for oxidation to carbon dioxide (Yogafanny, 2015). The measurement results from both seasons stated that the COD parameter in Setiamanah Lake exceeded the required quality standard (10 mg/L). The high concentration of COD is due to the contamination of the Setiamanah Lake water by organic substances that can be decomposed and cannot be decomposed by biological processes and the lack of dissolved oxygen that enters the water. The source of COD comes from the entry of domestic and industrial waste into the Cisangkan River, thus affecting the water quality of Setiamanah Lake. The rainy season in 2021 has a higher COD concentration (59.6 mg/l) than the dry season in 2022 (48.8 mg/L), which can be seen in Figure 11.

3.2.11. Oil and Grease

Oil and grease can reduce dissolved oxygen levels and increase BOD_5 due to the formation of an oil layer on the water's surface. Waste originating from domestic activities, namely the kitchen, is the highest contributor to the concentration of oil and grease. The measurement results from both seasons stated that the oil and grease parameters in Setiamanah Lake exceeded the required quality standard (1 mg/L). The high concentration of oil and grease is due to the large amount of organic waste that is difficult to be broken down by bacteria. The source of the waste comes from domestic waste resulting from household activities. The rainy season in 2021 has a higher concentration of oil and grease (10.6 mg/L) than the dry season in 2022 (2.89 mg/L), which can be seen in Figure 12.

3.2.12. Phenol

Phenol can cause water to smell and taste due to industrial waste. High phenol levels due to the decay of organic matter such as wood, leaves, and bamboo in rivers, in addition to the rest of animal feed and organic fertilizers that accumulate in rivers, can cause the river to be polluted. The results of the measurements of the two seasons stated that the phenol parameters in Setiamanah Lake exceeded the required quality standard (0.002 mg/L). The rainy season in 2021 has a higher phenol concentration (0.264 mg/L) than the dry season in 2022 (0.263 mg/L), which can be seen in Figure 13.

3.3. Pollutant Index (PI)

The pollution index is used to determine the quality status of Setiamanah Lake. The parameters used to calculate the pollutant index are listed in Table 1. The results of the calculation of the pollution index at each time of collection can be seen in Table 2.

Table 2 Pollutant Index Value and Water Quality Status of Setiamanah Lake

Sampling Year	Pollutant Index Value	Water Quality Status
2021	8.398	Moderately polluted
2022	8.325	Moderately polluted

Based on Table 2 above, it can be concluded that the status of the Setiamanah Lake water quality using the pollutant index method is moderately polluted. The pollutant index value in the Setiamanah Lake has decreased because in 2022, namely in the dry season, the average concentration value of each parameter will decrease.

The high value of the pollutant index is influenced by essential parameters such as TSS, BOD_5, and COD. This parameter is high during the rainy season (2021) because much waste enters the Cisangkan River, and the high discharge can affect the water quality of Setiamanah Lake. With these conditions, it is necessary to have reasonable control of the Cisangkan River and Setiamanah Lake, as well as regular monitoring of water quality and mapping of potential pollutant sources in each location so that the status of water quality can be improved, which can later be used as a source of raw water.

4. CONCLUSION

Based on the results of the discussion, in 2021, there are 12 (twelve) of 23 (twenty-three) parameters that do not meet the quality standards, namely TSS, free chlorine, dissolved Mn, dissolved Zn, total phosphate, sulfide, MBAS, DO, BOD_5, COD, oil and grease, and phenols. Meanwhile, in 2022 there are 9 (nine) of 23 (twenty-three) parameters do not meet the quality standards, namely free chlorine, dissolved Mn, total phosphate, sulfide, DO, BOD_5, COD, oil and grease, and phenol. The results of calculating the water quality status using the Setiamanah Lake pollutant index in both seasons, including moderate pollution with the parameter index value in 2021 is 8.398 and in 2022 8.325. In existing conditions, The Setiamanah Lake is drained by the Cisangkan River, which produces domestic waste from human activities and non-domestic waste from home industries so that it can be the cause of the contamination of the Setiamanah Lake, and the most influential parameters as pollutant factors are TSS, BOD_5, and COD. So it is necessary to control and monitor water quality regularly and map potential pollutant sources in each location so that the status of water quality can be improved, which can later be used as a source of raw water.

5. ACKNOWLEDGEMENT

Thank you to all parties involved in this research, especially the Department of Environment and Forestry of the City of Cimahi, for being willing to provide all data related to this research.

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