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Regional Case Study

Determination of Quality and Trophic Status of Cibabat Lake, Cimahi City

Eka Wardhani[1], Tri Rizki Nopiyani[1]*, Dian Noor Handiani[2]
[1] Environmental Engineering Program, Faculty of Civil Engineering and Planning, Institut Teknologi Nasional Bandung, Jalan PHH Mustafa No.23 Bandung, Indonesia 4012
[2] Geodetic Engineering Program, Faculty of Civil Engineering and Planning, Institut Teknologi Nasional Bandung, Jalan PHH Mustafa No.23 Bandung, Indonesia 4012
*Corresponding Author, email: Tririzki21@gmail.com

Abstract
In Cimahi City, the river water is heavily polluted, and well water is not suitable for drinking water, so to anticipate the lack of clean water, the Environmental Service is planning to revitalize one of the ponds, namely the Cibabat Lake. This study's purpose is to determine the reservoir's condition based on water quality and trophic status. The method used for calculating water quality status is the Pollutant Index, which refers to the Decree of the Minister of Environment Number 115 of 2003 with results is 8,450, and will be 8,751 in 2022, with the water quality classified status as moderately polluted. Meanwhile, the method to assess trophic status uses the Carlson Trophic State Index (TSI) method by taking air samples for the parameters Total Nitrogen, Total Phosphate, Chlorophyll-a, and brightness which is included in the hypereutrophic category. The Cibabat Reservoir has been polluted by domestic waste based on the calculation of the potential pollutant load such as BOD, COD, TSS, Total Phosphate and Total Nitrogen in the border area is 2,219,600; 3,051,950; 2,108,620; 11,623; and 108,206 kg/day, respectively. DTA area is 1,886.660: 2,594.158; 1,792.327; 9,905; 91.975 kg/day, respectively. This is influenced by the increasing population each year.

Keywords: Lake; pollutant index; water quality status; trophic status; hypereutrophic; potential pollutant load

1. Introduction

Water is an essential human need both now and in the future, so it is not only the quantity that must be considered but also the quality issue. The total population of Indonesia in 2021 is 272.7 million people (BPS, 2022). The increasing population and the rapid development of the level of public education can affect the need for clean water, this condition is the main factor that drives the fulfillment of water needs to ensure good sanitation in urban areas (Dirgawati et al., 2021).

The problem of clean water and sanitation is one of the classic unresolved problems in Indonesia. Sanitation achievement targets in the Millennium Development Goals (MDGs), which ended in 2015, and in the Sustainable Development Goals (SDGs), which are still ongoing today have not been optimally achieved (Suryani, 2020). Water quality can affect the condition of the aquatic environment and also have an impact on humans, both directly and indirectly. Effects related to poor water quality are related to public health or waterborne diseases (Dirgawati et al., 2021).

One of the impacts of the development that occurred in Cimahi City is the conversion of open land to being built, the driving factors in the form of domestic activities and population growth, which continue to occur every year, significantly affect the needs of the community, including the need for clean water. The water availability in Cimahi City in several locations is very high, reaching >36 m3/year. Based on this need, Cimahi City is experiencing pressure regarding the availability of clean water to meet the needs of its people (DIKPLHD, 2021). According to the Cimahi City Regional Environmental Management Work Information Document (DIKPLHD), river water in Cimahi City has been heavily polluted, and the quality status of well water is unfit for drinking water, so to anticipate this the Cimahi City Environment Agency (DLH) will revitalize the lake.

Cibabat Lake is one of five lakes that will be used as a raw water storage facility in the Cibabat Regional General Hospital (RSUD) Complex in Cibabat Village, North Cimahi District, Cimahi City. This lake has an area of 0.060 Ha with a volume of 3,040 m3. The land around this lake is a hospital complex, a garden, and wild plants (DLH, 2021).

Many types of research on water quality and determination of trophic status have been carried out, for example, in Lake Tondano, North Sulawesi, it can be seen that based on the tropic class, the lake is currently unable to accommodate the incoming pollutant load, has exceeded the mesotrophic class limit (Rares et al., 2017). The water quality of the Saguling Reservoir, West Java, along with the development of water needs, the function of this reservoir is to develop as a source of raw water for domestic and industrial needs. Still, the condition of the reservoir water has been polluted (Wardhani et al., 2021). Water can be considered clean in physical terms such as not cloudy, colorless, odorless, tasteless, and non-foaming, with due diligence tests, namely temperature, turbidity, dissolved solids (TDS), and water conductivity (Mastikaa et al., 2017). However, so far, there has been no research on the water quality and trophic status of Lake Cibabat. Therefore, research must be carried out on where this lake will function as a rainwater reservoir for Cimahi City.

This study aims to determine the condition of Lake Cibabat based on water quality status and trophic status, because trophic status can indicate the impact that lake water has been polluted by nutrient waste and can also determine efforts to improve and manage the lake so that it can be used and function properly. Lake water quality is compared with the quality standards stated in Government Regulation Number 22 of 2021 concerning the Implementation of Environmental Protection and Management. Determination of quality status uses the Pollutant Index (IP), which refers to the Decree of the Minister of Environment No. 115 of 2003 concerning Guidelines for Determining Water Quality Status while Determining Trophic status using the Trophic Status Index method according to Carlson (1977) which is stated in the guidelines for managing lake ecosystems of the Ministry of Environment (2008).

2. Methods

2.1. Water Quality Status

The method used in buying air status is using secondary data. The data used is in the form of water quality data for the Cibabat Reservoir in 2021 and 2022 sourced from the Cimahi Environment Agency. Secondary Data Sampling was conducted on October 6, 2021, at 8.19 WIB until finished and on April 13, 2022, at 08.13 WIB until finished. Based on SNI 6989.57:2008 concerning Water and Wastewater Section 57: Surface Water Sampling Method, sampling was carried out at coordinates S: 06°52'79.3” E: 107°33'04.5” with only one sampling point due to airflow depth <10 meters. The Reservoir water quality data is then compared with the class I lake water quality standards listed in Appendix VI of Government Regulation 22 of 2021 concerning the Implementation of Environmental Protection and Management.

Determination of water quality status is based on analysis of physical, chemical, and biological parameters. Good water quality will comply with the regulations issued by the government with the maximum permissible level (concentration). Determination of the water quality status using the Pollutant Index (IP) method can be carried out with collection of pollutant parameter concentration data (Ci), determination of quality standards (Lij), calculation of the (Ci/Lij) value, calculation of the $(Ci/Lij)^2R$ and $(Ci/Lij)^2M$ value, and calculation of the PIj value.

Where, Lij is the concentration of parameter by the quality standard for water use (j), Ci is the concentration of parameter (i) from the sampling results at the water sampling location, P is constant determined from the results of previous environmental observation studies, PIj is Pollution Index for designation, $\left(\frac{Ci}{Lij}\right)^2 M$ and $\left(\frac{Ci}{Lij}\right)^2 R$ are the maximum value of the result of the parameter Ci/Lij divisor and average value of Ci/Lij for all parameters.

If the value (Ci/Lij > 1.0), then; use the new (Ci/Lij) = 1.0 + 5 LOG (Ci/Lij) calculation (all parameters apply). In addition, several parameters use special rules in calculating values (Ci/Lij), including such as pH parameters and DO parameters. In pH parameters there are two conditions, for $C_i \leq L_{ij}$ average, $\left(C_i/L_{ij}\right)_{New}$ value was determined by dividing of the results from the concentration of parameter (i) from the sampling results at the water sampling location (Ci) minus average of the concentration of parameter by the quality standard for water use (j) (Lij) with the results from (Lij) minimum minus (Lij) average (see Eq. (1)). And for $C_i > L_{ij}$ average, $\left(C_i/L_{ij}\right)_{New}$ value was determined by dividing of the results from the concentration of parameter (i) from the sampling results at the water sampling location (Ci) minus average of the concentration of parameter by the quality standard for water use (j) (Lij) with the results from (Lij) maximum minus (Lij) average (see Eq. (2)):

$$\left(C_i/L_{ij}\right)_{New} = \frac{\left[C_i - \left(L_{ij}\right)_{Average}\right]}{\left[(L_{ij})_{minimum} - (L_{ij})_{Average}\right]} \quad (1)$$

$$\left(C_i/L_{ij}\right)_{New} = \frac{\left[C_i - \left(L_{ij}\right)_{Average}\right]}{\left[(L_{ij})_{maximum} - (L_{ij})_{Average}\right]} \quad (2)$$

Meanwhile, in DO parameters, determination the theoretical value or maximum value of Cim (e.g., for DO, then Cim is the value of DO saturation). In this case, the measured Ci/Lij value is replaced by the calculated Ci/Lij value was determined by dividing of the Cim minus Ci measuring with Cim minums Lij (see Eq. (3)):

$$\left(C_i/L_{ij}\right)_{New} = \frac{C_{im} - C_{i_{measuring}}}{C_{im} - L_{ij}} \quad (3)$$

The pollution index is used to determine the level of pollution. Calculating the pollution index must first select the results of measuring the concentration of pollution parameters, namely those studied directly in the lake. The formulation of the pollution index (PIj) value was determined by the squared root of the dividing the maximum value of the result of the parameter Ci/Lij divisor plus average value of Ci/Lij for all parameters with two (see Eq. (4)):

$$IPj = \sqrt{\frac{\left(\frac{Ci}{Lij}\right)^2 M + \left(\frac{Ci}{Lij}\right)^2 R}{2}} \quad (4)$$

Determination of water quality status uses the Pollutant Index (IP) method, which refers to Minister of Environment Decree No. 115 of 2003 concerning Guidelines for Determining Water Quality Status. The IP standard is based on these guidelines, namely if $0 \leq IP \leq 1$, the water quality is in the category of meeting quality standards (good water body conditions), $1 < IP \leq 5$ is in the category of mildly polluted, $1 < IP \leq 5$ is classified as moderately polluted, and if the IP value is > 10 then the meaning of water bodies is included in the heavily polluted category.

2.2. Trophic Status

Determination of the trophic status of the Cibabat Lake water is done by knowing the water fertility status by calculating the Carlson Trophic Method State Index (TSI), which is stated in the guidelines for managing lake ecosystems of the Ministry of Environment (2008). Classification of lake water quality is determined based on the status of the eutrophication process caused by increased levels of nutrients in the water. Sampling was conducted at the Cibabat Reservoir on September 9, 2022, at 09.40 WIB until finished. Analysis was carried out from 9 to September 15, 2022, at the Water Quality Laboratory of the Bandung Institute of Technology for parameters Total Phosphate and Total Nitrogen using an analytical method that refers to Standard Methods For The Examination of Water and

Wastewater 23rd Edition 2017 (APHA) and parameter testing Chlorophyll- using a solvent extraction method whose absorbance was read using UV-Vis Spectrophotometer conducted at the Ecology Laboratory of Padjadjaran University, Bandung City.

Carlson's method tested several parameters, namely brightness level, total phosphorus concentration, and chlorophyll-a content, and then calculated the average TSI Carlson (1977) presented in Eq. 5-8:

TSI-TP = 14.42×Ln [TP] + 4.5 (μg/l) (5)

TSI-Chlorophyll-a = 30.6 + 9.81×Ln [Chlorophyll-a] (μg/l) (6)

TSI-SD = 60 – 14.41×ln [SD] (meters) (7)

$$Average\ TSI = \frac{(TSI-P+TSI-Cla+TSI-SD)}{3} \quad (8)$$

Where, TSI-TP is the Trophic Status Index for Total Phosphorus, TSI-Klorophyll-a is the Trophic Status Index value for chlorophyll-a, and TSI-SD represents the Trophic Status Index value for the Sechi Disk depth. The calculation of the average TSI is then compared to find out the group of water fertility levels with the categories determined by Carlson (1977), as shown in Table 1.

Table 1. Trophic status categories based on Carlson's Trophic Status Index

Classification	Trophic Status	Information
<30	Ultraoligotoph	Clearwater, very low nutrient levels
30-40	Oligotroph	Clearwater, low nutrient levels
40-50	Mesotroph	Moderate water brightness, moderate nutrient levels
50-60	Light Eutrophs	Decreased water hardness, increased nutrient levels
60-70	Moderate Eutrophs	Bloom (*microcystis*) high nutrient content
70-80	Heavy Eutrophs	Algae blooms and water weeds overgrow, and nutrient levels are very high
>80	Hypereutrophic	Algae blooms, waters are in anoxic conditions, which causes mass fish death, and nutrient levels are very high.

The brightness measurement method uses a Secchi disk cooled with a string and then lowered slowly until the black and white parts on the Secchi disk pieces are not visible in the air. Then measure and record as D1, lift slowly until the white components are not visible, and measure and carat as D2. Sunny data collection was carried out on September 15 at 09.30 WIB with bright cloudy light conditions. Algae sampling was carried out in conjunction with chlorophyll-a sampling. Observation of algae in the Cibabat Lake was carried out by taking the most common sample in the net plankton, which was then observed using a microscope and was then identified and counted the number of cells observed (APHA, 2017).

2.3. Pollutant Load Potential

Potential pollutant load is calculated based on pollutant factors released per person per day for five main parameters of domestic waste, including BOD, COD, TSS, Total Nitrogen, and Total Phosphate. Lawsuits for pollution loads from the domestic sector use Eq. (9). For rice fields, use Eq. (10), and for plantations/fields, use Eq. (11).

PBP (Domestic) = ΣTotal Population x Pollution Factor x α x Rec x FK (9)

PBP (Rice Field) = land area x pollution factor x 10%* (10)

PBP (Plantation) = land area x pollution factor x 1% * (11)

Where, PBP is the potential pollutant load (kg/day), ΣTP is number of projected population (people), A is load transfer coefficient, determined based on the distance of the settlement to the river with the following criteria. Then, α value = 1 for locations where the location is between 0 and 100 meters from the river, assuming that 100% of domestic household waste is disposed of into the river, whereas α value = 0.85 for location area, which is located between 100-500 meters from the river, assuming that 85% of domestic household waste is disposed of into the river, and α value = 0.3 for locations more than 500 meters from the river, assuming that 30% of domestic household waste is disposed of into the river. And then, Rec is equivalent city ratio, the value of the equivalent ratio for each city, namely city = 1; suburb = 0.8125; and interior = 0.625, and Fk is unit conversion factor, 1 kg = 1,000 grams (Iskandar, 2007).

For PBP (domestic) value was determined by multiplying of total population, pollution factor, α value, rec, and FK. For PBP (rice field) value was determined by multiplying of land area, pollution factor, with 10%. And for PBP (plantation) value was determined same as PBP (rice field) only multiplied by 1%.

Pollution factors for domestic or settlements, rice fields, and plantations/reeds/fields/moor fields are described in Table 2.

Table 2. Pollution Factor

Land Use	Unit	Emission Factor				
		BOD	COD	TSS	Total Phosphate	Total Nitrogen
Residential (Domestic)	(g/person/day)	40	55	38	1.95	0.21
Paddy field*	kg/Ha	225		0.4	10	20
Farm/Reed/Moor/Field*	kg/Ha	32.5		1.6	1.5	3

*(Kurniawan, 2014)

3. Result and Discussion

3.1 Water Quality Status

The water quality status shows the quality conditions of water sources in polluted or good conditions by comparing them with predetermined quality standards. Based on the results of calculating the water quality status of the lakes for 2021 and 2022, they are included in the moderately polluted category with respective values of 8.450 and 8.751. The Pollution Index in Cibabat Lake water is caused by twelve parameters that have exceeded the quality standards, namely the parameters DO, Free Chlorine, TSS, Total Phosphate, Sulfide, MBAS, Color, BOD, COD, Oil and Fat, Dissolved Mn and also Phenol so that the domestic sector becomes a contributor to pollution the tallest, as shown in Table 3. Residential areas, rice fields, fields, and gardens dominate the water catchment area (DTA) around the lake. A large number of settlements around the lake has resulted in domestic channels flowing into the lake, in addition to domestic media, there is also waste from rice fields and plantations around the lake.

Table 3. Water quality parameters in Cibabat Lake

Parameters	Unit	Cibabat Lake Water Quality		Quality Standards
		The year 2021	The year 2022	
Temperature	°C	26	23.5	Dev 3
Total Suspended Solids (TSS)	mg/L	85.5	46.8	25
Total Dissolved Solid (TDS)	mg/L	304	205	1000
Color	Pt-Co Unit	30.6	7.33	15
pH	-	6.97	6.89	6 - 9
Free Chlorine	mg/L	0.68	0.35	0.03
Chloride	mg/L	45.1	10.4	300
Sulfate	mg/L	26.3	17.7	300
Fluoride	mg/L	0.06	0.06	1
Dissoled Fe	mg/L	0.228	0.05	0.3
Dissolved Mn	mg/L	0.860	0.0039	0.4
Dissolved Zn	mg/L	0.0363	0.0127	0.05

Parameters	Unit	Cibabat Lake Water Quality		Quality Standards
		The year 2021	The year 2022	
Cu Dissolved	mg/L	0.011	0.0071	0.02
Cr (VI)	mg/L	0.0367	0.0367	0.05
Total Phosphate	mg/L	0.244	0.388	0.01
cyanide	mg/L	0.01	0.01	0.02
Sulfide	mg/L	0.059	0.025	0.002
MBAS	mg/L	0.869	0.6	0.2
DO	mg/L	4.17	7.47	6
BOD	mg/L	22.3	44.4	2
COD	mg/L	63.2	121	10
Oil and Grease	mg/L	14.3	3.05	1
Fenol	mg/L	0.259	0.335	0.002

The TSS value obtained in 2021 and 2022 is 85.5 and 46.8 mg/l, respectively, so the TSS value does not comply the standards set. TSS can consist of silt, fine sand, and microorganisms, mainly caused by erosion or soil erosion carried into water bodies (Piranti, Rahayu, & Waluyo, 2018). The activity Public around Lake could influence height TSS levels in Cibabat Lake. Based on the observation of the results, Cibabat Lake water is influenced by channels domestic inhabitants around incoming to the lake, which allows the carrying of silt and fine sand, which is eroded when the water flows into the lake. High concentrations of TSS can cause the turbidity of the water to increase and decrease the concentration of dissolved oxygen in the water because sunlight entering the water is blocked by suspended particles, thus disrupting the process of photosynthesis (Dirgawati, Sururi, Wiliana, & Widiawati, 2021).

The high value of the watercolor parameter in Cibabat Lake in 2021 is 30.6 TCU because the lake is surrounded by plants which cause the water to turn colored. When taking water samples taken, it was the rainy season, so the water in Cibabat Lake became more turbid due to a large amount of soil or particles carried by the water due to erosion in the waterway area. The soil that settles at the bottom of the lake will experience turbulence when it rains, causing the color of the water to exceed the quality standard (Alfaroby & Wardhani, 2021).

BOD measures the amount of oxygen needed to remove waste organic matter from water in the decomposition process by aerobic bacteria. The BOD value in 2021 and 2022 is 22.30 and 44.40 mg/l, respectively. Exceeded score raw permissible quality is caused by organic material originating from household and agricultural, domestic waste that enters water bodies. The high concentration of BOD in Cibabat Lake indicates that the waters are polluted (Junaidi, 2021)

DO levels can decrease if organic materials are input from domestic waste (Zharifa et al., 2019). The year 2021 earned a DO value of 4.17 mg/l, which does not comply raw quality. The low DO concentration in water signifies Microorganisms need oxygen to decompose organic materials is relatively high. The common DO and the high BOD level influence the Cibabat Lake in the reservoir because theoretically the DO concentration will be inversely proportional to BOD, where the higher the BOD concentration, the lower the DO value. The higher the dissolved oxygen (DO) content, the better the water quality (Junaidi, 2021).

COD is the amount of oxygen needed to oxidize organic matter to CO_2 and H_2O chemically. The water's organic content causes a high COD content (Santoso, 2018). The COD value in Cibabat Lake water does not meet the quality standards was 63.2 mg/l in 2021 and 121 mg/l in 2022, the increase in the COD value in the lake waters is due to the entry of domestic waste, which is organic matter contained in challenging to degrade biologically (Dirgawati et al., 2021). Chlorine can be produced from clean water treatment processes, waste from human activities, hospital waste, and various industrial activity processes that can pollute the environment (Hayat, 2020). The results obtained for the free chlorine parameter did not meet quality standards. The results obtained in 2021 were 0.68 mg/l and 0.35 in 2022. The low DO content value also influenced the high free chlorine content.

The detergent content comes from domestic waste (Hermawan & Wardhani, 2021). Detergent concentration in Lake Cibabat does not meet quality standards. In 2021 the detergent level will be 0.869 mg/l, and in 2022 it will be 0.6 mg/l. Phosphate concentration in Cibabat Lake does not meet quality standards. The results obtained was 0.244 mg/l for 2021 and 0.388 mg/l in 2022, this is due to the water's significant content of organic and inorganic compounds. In addition to the water's high phosphate levels, Cibabat puffs are affected by high detergent concentrations.

In 2021 the level of dissolved Mn will be higher is 0.86 mg/l which will result in not meeting the quality standards, while in 2022, the level of dissolved Mn will decrease to 0.0039 mg/l. Water containing excess manganese causes taste, color (brown/purple/black), and turbidity (Febrina & Ayuna, 2015). The high levels of Mn in 2021 are due to the rainy season, making it easier for manganese to enter water bodies carried by domestic channels (Hermawan & Wardhani, 2021).

Sulfide is a very toxic gas that smells bad due to putrefactive activity by decomposing bacteria, so sulfide levels in water affect water quality (Alfaroby & Wardhani, 2021). The results obtained for the sulfide parameter at Cibabat Lake did not meet quality standards, the results obtained in 2021 were 0.059 mg/l, and in 2022 they were 0.025 mg/l. The high content of sulfides is caused by biological oxidation that occurs by microorganisms in water bodies due to the significant range of existing organic pollutants and is one of the things that affects the high BOD value and reduced DO value in a body of water (Alfaroby & Wardhani, 2021).

The phenol concentration in Cibabat Lake exceeds the quality standard, where the results obtained in 2021 was 0.259 mg/l and 0.335 mg/l, and the results obtained for the parameters Oil and grease was 14.3 mg/l in 2021 and 3.05 mg/l in 2022. The causes of high phenol levels in waters can be in the form of industrial waste and domestic waste. Phenol compounds are found in oil refining processes, the chemical industry, textiles, plastics, and others (Prasiwi & Wardhani, 2018). According to field observations, the high concentration of phenols, oils, and fats in the lake is due to the large amount of plastic waste in the lake body and the presence of organic waste that is difficult to decompose, which is carried by residents domestic channels that enters the water body. High levels of phenols can cause odors and tastes. They can be toxic to living things in the waters, and the presence of Oil and grease in the waters can interfere with the penetration of sunlight, thereby reducing the rate of photosynthesis in the water (Hermawan & Wardhani, 2021).

Previous studies have used the pollutant index to measure water quality status, such as the Gili Meno Saltwater Lake on Lombok Island with moderately polluted water quality status (Abdullah, 2021), Situ Parigi in South Tangerang has been moderately polluted (Zharifa, Fachrul, & Hendrawan, 2019), on Area Expo Arena Lake in Jayapura City with moderately polluted water quality status (Prasetia & Walukow, 2021), Rawa Pening Lake in Semarang Regency is already heavily polluted (Piranti et al., 2018). Sunter Lake in Jakarta City is lightly polluted (Saputro, Sunaryo, & Fahdiran, 2020). When compared with several water bodies, the results show that the water quality in Cibabat Lake is not much different from other water bodies.

3.2. Trophic Status

The content of nutrients in water can increase water fertility, and this process is called eutrophication. The method of eutrophication under certain conditions can be a stimulant for the growth of aquatic flora, which causes the waters to be closed and disturbs the ecological conditions of the waters (Samudro, Sasongko, & Susanti, 2012). The process of eutrophication is a natural process that usually occurs in every body of water, but human activities around it can cause this process to speed up.

Regulation of the Minister of Environment and Forestry Number 28 of 2009 explains that eutrophication is caused by increased levels of nutrients, especially nitrogen and phosphorus parameters, in lakes and reservoir water. The measurement result for the total phosphate parameter is 905μg/l, total nitrogen 132,000 μg/l, chlorophyll-a 6,675 μg/l, and brightness 0.298 m, as shown in Table 4.

Table 4. Trophic Value of Cibabat Lake Index

Total Index Status	TSI results
TSI-TP (μg/L)	102.320
TSI-Chlorophyll-a (μg/L)	116.988
TSI-SD (m)	77,446
Average TSI	98.92

The measurement results were then calculated for the Total State Index value to determine trophic status based on the Carlson method, which obtained an average of 98.92, indicating that the classification of trophic status includes the Hypereutrophic category. Carlson's method is based on three parameters closely related to water pollution elements: total P, chlorophyll-a, and brightness. The condition of waters that have experienced enrichment can make it more challenging to manage the water used as raw material for drinking water (Samudro et al., 2012).

The data above concludes that Cibabat Lake is included in the Hypereutrophic category or contains very high levels of nutrients. Increasing the Phosphate element will also increase the amount of chlorophyll-a, which can inhibit the entry of sunlight into the lake. High chlorophyll concentrations indicate the level of fertility of these waters. The content of the reservoir that is polluted with organic substances (N and P) can cause a lack of oxygen at night. Besides being influenced by the intensity of incoming sunlight, brightness is also influenced by the time of measurement and weather conditions (Samudro et al., 2012). The high nitrogen and phosphorus values in Cibabat Lake are caused by domestic, agricultural, and plantation wastes found around the lake and then enter through runoff and erosion into the water bodies. (Wardhani & Sugiarti, 2021).

Previous research has been carried out on several funds and reservoirs, such as Manggar Lake in Balikpapan City, with mild Mesotrophic and Eutrophic trophic status (Samudro et al., 2012), Maninjau Lake in Agam Regency is included in the Eutrophic category (Kurniati & Komala, 2021), Sutami Reservoir in Malang Regency with Eutrophic to hypertrophic types (Juantari, Sayekti, & Harisuseno, 2013), Panai Lake in Papua (Samuel & Ditya, 2019) and Diatas Lake in West Sumatra (Samuel & Adiansyah, 2016) both of which are included in the Mesotrophic category, and the Salerejo Reservoir in Malang Regency has a Hypereutrophic trophic status (Sayekti et al., 2015).

The brightness value is strongly influenced by weather, measurement time, turbidity, and suspended solids. The results obtained for the brightness are 0.298 m. High TSS values and turbidity affect the brightness value of Cibabat Lake. Low brightness values can inhibit the rate of photosynthesis in plankton because high nutrients block sunlight.

The results of observations of algae in Cibabat Lake showed ten types of algae, namely *Pachus* sp., *Melosira* sp., *Euglena* sp., *Pediastrum* sp., *Trachelomoas* sp., *Cyclotella* sp., *Scenedesmus* sp., *Cymbella* sp., *Phormedium* sp., and *Naviculla* sp. The dominating species found in Cibabat Lake are *Euglena* sp. and *Phacus* sp., as shown in Table 5. In general, the habitats of *Euglena* sp. and *Phacus* sp. are similar, *Euglena* sp. will be found in many eutrophic lake waters, and a lot of nitrogenous organic matter as well in *Phacus* sp. is mostly obtained in lake or pond waters at a eutrophic status level. Many organic matters come from livestock and waste (Sulastri, 2018). The high organic content influences the abundance of these algae in Cibabat Lake in the waters. Besides that, the status level of Cibabat Lake is included in the hypertrophy, which contains high levels of phosphate and nitrogen, which causes *Euglena* sp. and *Phacus* sp. to thrive in these waters. Cibabat Lake does not have mycrocystis caused by low temperatures and nitrates in the waters.

Table 5. Phytoplankton Observation Results

Types of Phytoplankton	Observation result	Plankton Abundance (Individual/L)	In Percent Units
***Phacus* sp.**	30	300	1.665
***Euglena* sp.**	1,727	17.270	95.838
***Melosira* sp.**	12	120	0.666
***Pediastrum* sp.**	3	30	0.166
***Trochelomonas* sp.**	3	30	0.166
***Cyclotella* sp.**	2	20	0.111
***Scenedesmus* sp.**	21	210	1.165
***Cymbella* sp.**	2	20	0.111
***Phormidium* sp.**	1	10	0.055
***Nvicula* sp.**	1	10	0.055
Amount	1,802	18020	100

3.3. Pollutant Load Potential

The parameters used in this calculation are the key parameters of water pollution. The key parameters are contaminants that often occur with a probability of ≥80% with general parameters including BOD, COD, TSS, Total Phosphate, and Total Nitrogen (Sampe, Juwana, & Marganingrum, 2018). The potential pollutant load is calculated in the domestic and agricultural sectors in the border areas and watersheds. In the domestic sector, the potential pollutant load can be determined by calculating the emission factors for domestic waste originating from human activities, such as black water waste (human waste) and gray water waste (liquid waste used for bathing, washing, and kitchens) and the number of residents. In contrast, potential pollution loads from the agricultural sector are influenced by the area of land and the type of agricultural land, whether it belongs to the class of rice fields, plantation crops, or crops (Rahayu, Juwana, & Marganingrum, 2018). The average load of agricultural pollutants entering water bodies (delivery load) in Indonesia is around 10% from paddy fields and 1% from plantations. The measured height of Total Nitrogen and Total Phosphate in water is predicted to originate from domestic and agricultural activities in the catchment area and riparian zones (Iskandar, 2007).

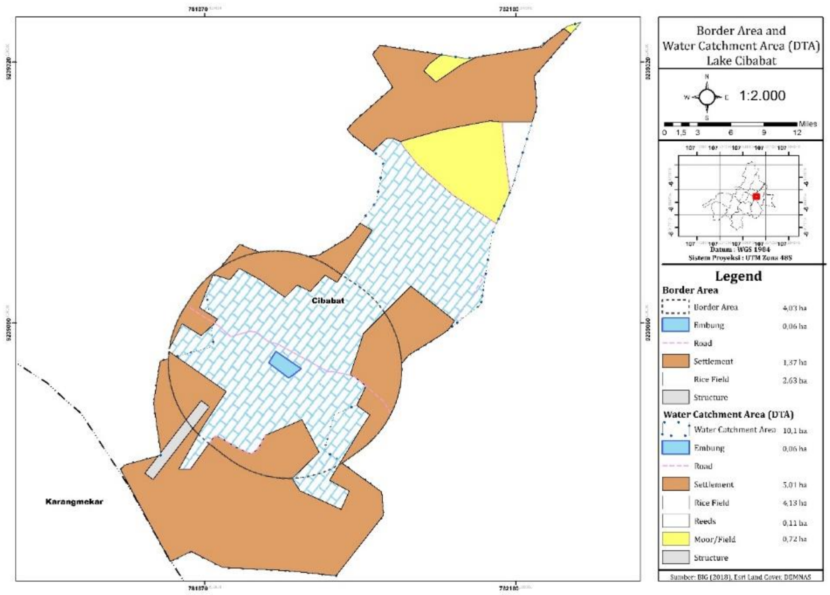

Figure 1. Border Area and Water Catchment Area (DTA) Lake Cibabat

Potential Pollutant Loads that affect the water quality of Cibabat Lake, as described in Figure 1, come from settlements, agriculture, reeds, and fields. Calculation results of potential pollutant load are presented in Table 6 and Table 7.

Table 6. Pollutant Load Potential in the Cibabat Lake Boundary Area

Land Use	**Pollutant Load (kg/day)**				
	BOD	**COD**	**TSS**	**Total Phosphate**	**Total Nitrogen**
Residential (Domestic)	2,219.600	3,051.950	2,108.620	11.653	108.206
Rice fields	59.175	-	0.121	2.63	5.26

Table 7. Pollutant Load Potential in the Cibabat Lake Water Catchment Area

Land Use	**Pollutant Load (kg/day)**				
	BOD	**COD**	**TSS**	**Total Phosphate**	**Total Nitrogen**
Residential (Domestic)	1,886.660	2,594.158	1,792.327	9.905	91.975
Rice fields	92.925		0.190	4.130	8.260
Farming/Reeds/Moor/ Fields	1.038		0.02	0.042	0.083

Calculation results for the potential pollutant load in the border area and DTA, domestic in this case settlements are the most significant contributor to the potential pollutant load with a BOD of 2,219.600 kg/day, COD 3,051.950 kg/day, TSS 2,108.620 kg/day, Total Phosphate 11.623 kg/day, and Total Nitrogen 108.206 kg/day. Residential catchment areas remain a potential contributor to a large pollutant load for the five parameters: BOD 1,886.660 kg/day, COD 2,594.158 kg/day, TSS 1,792.327 kg/day, Total Phosphate 9.905 kg/day, and Total Nitrogen 91.975 kg/day. The higher population density and the distance between the settlement and the lake cause the high value of the potential pollutant load in settlements (Kurniawan et al., 2017). The more pollutant load generated. Domestic waste greatly affects the quality of lake water because in addition to being a source of pollutants in these five parameters, such as washing water containing detergents and other wastewater, which causes high Phosphate levels and is harmful to the environment (Rahayu et al., 2018). Based on this, it is necessary to first carry out domestic wastewater management by creating Local or Integrated Domestic Wastewater Distribution Systems with residential and urban scales.

The calculation results for the catchment area settlements remain a potential contributor to the large pollutant load for the five parameters, namely BOD 1,886.660 kg/day, COD 2,594.158 kg/day, TSS 1,792.327 kg/day, Total Phosphate 9.905 kg/day, and Total Nitrogen 91.975 kg/day. Rice fields and plantations contribute BOD of 92.925 kg/day and 1.038 kg/day, respectively, TSS of 0.190 kg/day and 0.020 kg/day, Total Phosphate 4.130 kg/day and 0.040 kg/day, Total nitrogen of 0.083 kg /day. In the rice field border areas, BOD contributed the most among other parameters, namely 59.175 kg/day, TSS 0.121 kg/day, Total Phosphate 2.63 kg/day, and 5.26 kg/day for Total nitrogen. In the catchment area, aside from settlements, Paddy fields contributed the highest BOD value compared to other parameters indicating the presence of organic matter in lake water agriculture. In addition, rice fields also make the value of the potential pollutant load on the Total Phosphate and Total Nitrogen parameters significant (Sampe et al., 2018). Because rice fields use nitrogen and phosphate fertilizers, the management can reduce the use of pesticides and fertilizers that contain chemicals excessively.

4. Conclusions

The water quality status of Cibabat Lake, based on the Pollutant Index value, is moderately polluted. The high value of the pollution index is influenced by several parameters that exceed quality standards, such as TSS, Colour, DO, BOD, COD, Free Chlorine, Total Phosphate, Dissolved Mn, Sulfide, Phenol, Oil and Fat, and MBAs originating from residents' domestic waste and agricultural activities around the lake. The trophic status of Cibabat Lake is hypereutrophic, meaning that nutrients have heavily polluted it because it has high concentrations of Nitrogen and Phosphate. The high levels of Nitrogen and Phosphate make the Euglena sp. and Phacus sp. types of phytoplankton thrive because their habitat requires abundant organic matter for survival. The most significant pollutant load potential for BOD, COD, TSS, Total Phosphate, and Total Nitrogen in the catchment area and border areas are settlements because settlements are the largest areas. As an effort to manage the lake, it is necessary to have a Local or Integrated Domestic Wastewater Distribution System on a settlement or urban scale to treat domestic waste first.

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