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Original Research

Study of Water Quality Status of *Dendam Tak Sudah* Lake in Bengkulu City, Indonesia: Using CCME Index

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Abstract

Dendam Tak Sudah Lake (DDTS), located in Bengkulu City, is the largest lake that has a vital role in the hydrological system of the area. Along with economic and regional development, this lake faces threats, especially the decline in water quality. This study aimed to determine lake water parameter characteristics and its quality status. The study used the lake water dataset monitoring obtained from the Environmental Service of Bengkulu City, which measured four observation points from May 2017 to March 2019. There were 17 parameters observed in this study and compared with Class I of lake water quality standards based on Government of Indonesia Regulation Number 22 Year 2021. The lake water quality status was analyzed using the water quality index of CCME. The analysis results show that the lake water quality index ranges between 44.64-56.72, so the status of lake water is included in the poor and marginal categories. Furthermore, the parameters that still meet the lake water quality standards are: temperature, TDS, TSS, pH, Fe, Sulfate, Mn, Cu, DO, Oil and greases, and detergent. In contrast, the remaining 6 parameters were detected to exceed the lake water quality standard: Zn, BOD, COD, Phosphate, total coliform, and fecal coliform.

Keywords: CCME index, Dendam Tak Sudah Lake

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Introduction

Water resources are essential in supporting the survival of living things, including humans. The community uses surface water from rivers, lakes, and swamps for various purposes. The utilization of surface water includes agriculture, fisheries, industry, recreation, and raw water. One of the challenges faced, especially in developing countries, is the deterioration of water quality due to pollution [1]. Water pollution has become an acute problem and has become a serious threat to both humans and natural ecosystems [2]. The sustainability of water resources must be maintained so that the water quality can be guaranteed according to its nature. Many efforts can be made to prevent a decrease in water quality by controlling water pollution. Thus, efforts to control water pollution can be carried out so that water met its various purposes and functions.

Pollution that occurs in various types of water bodies often causes negative impacts and significant losses, and can even be related to public health. Various anthropogenic activities, including land use and utilization on the surrounding, can change and/or becomes a pressure to the the water quality [3-5]. Lakes for example, are vulnerable to eutrophication, mainly due to the agricultural activities [4]. Various organic and inorganic pollutants enter and contaminate the lakes and being accumulated [5].

Dendam Tak Sudah Lake (Danau Dendam Tak Sudah/DDTS) which is also known as Danau Dendam Dusun Besar is the largest lake in Bengkulu City. The existence of this lake has an important and strategic role in the ecosystem of the region. This lake is a source of irrigation for about 600 hectares of rice fields. The lake is located in an area that has been designated as a conservation site since Dutch colonial era, which is a habitat of the orchid (*Papilionanthe hookeriana*) and Nepenthes (*Nepenthes ampullaria*).

Various extractive developments around the lake area in the form of settlements, the opening of access roads, and agriculture have provided positive benefits for the area's economy. In addition, this area is also a potential tourist object because the natural conditions are lovely and exotic [6]. But on the other hand, this condition often reduces environmental quality, such as changing lake water quality due to environmental pollution. Various high-intensity activities around the lake cause exploitation of the lake's water resources, and the release of huge pollutants often causes a decrease in lake water quality [7].

Regularly measuring lake water quality is a preventive measure to protect aquatic ecosystems. It measures specific parameters to ensure water quality conditions according to their natural or meets existing quality standards. The results of these measurements can provide information on the health status of aquatic ecosystems, potential materials as sources of water pollution, and anthropogenic activities that affect water quality. This information can be used to formulate regional management policy strategies, including land use planning in the vicinity. Thus, it can ensure the sustainability of the watershed ecosystem and lake water quality. It shows the importance of measuring lake water quality to maintain environmental sustainability [8]. This study aims to determine both lake water quality parameters and the status of DDTS in Bengkulu City, Indonesia.

Material and Methods

Study Area and Time of Research

The research was conducted at Dendam Tak Sudah Lake which is located in the Village of Dusun Besar, Singaran Pati District, Bengkulu City, Indonesia. Astronomically it is between 03°45'45" to 03°49'01" South Latitude and 102°18'07" to 102°20'15" East Longitude. The DDTS area is bordered by the following: to the north, it is bordered by Surabaya Village, Kembang Seri, and Nakau Villages; to the east by Pagar Dewa Village; to the south by Dusun Besar Village, Sidomulyo Village; and to the west by Dusun Besar Village. This area is included in the Air Bengkulu River Basin ecosystem in the downstream part. It is located in the area of *Dusun Besar* Lake Nature Reserve (Cagar Alam Danau Dusun Besar/CADDB). Overall this area has 557 hectares, and the lake surface area is 67 hectares. The area is currently designated as a Natural Tourism Park (Taman Wisata Alam/TWA). The area's ecosystem and surroundings generally include lakes, swamps, shrubs, and community-owned plantations [9]. The study used data from the results of water quality monitoring conducted by the Environment Service of Bengkulu City from 2017 to 2019. Lake water quality was measured by taking samples at 4 (four) sites (Fig. 1 and Table 1).

Data and Parameters

The study used lake water dataset monitoring from the Environmental Service of Bengkulu City. The used data includes results of the measurement from May 2017 to March 2019. Measurements are carried out twice every year representing the rainy season and dry season. The analyzed water quality parameters included 17 parameters: temperature, total dissolved solids (TDS), total suspended solids (TSS), pH, Iron (Fe), Sulfate, Manganese (Mn), Copper (Cu), Zinc (Zn), biological oxygen demand (BOD), dissolved oxygen (DO), chemical oxygen demand (COD), Phosphate, Oil and Grease, detergent (Methylene Blue Active Substances/MBAS), Total Coliform, and Fecal Coliform. These measured parameters are standard factors based on Government Indonesian Regulation (GR) Number 22 Year 2021 regarding Implementing Environmental Protection and Management. Table 2

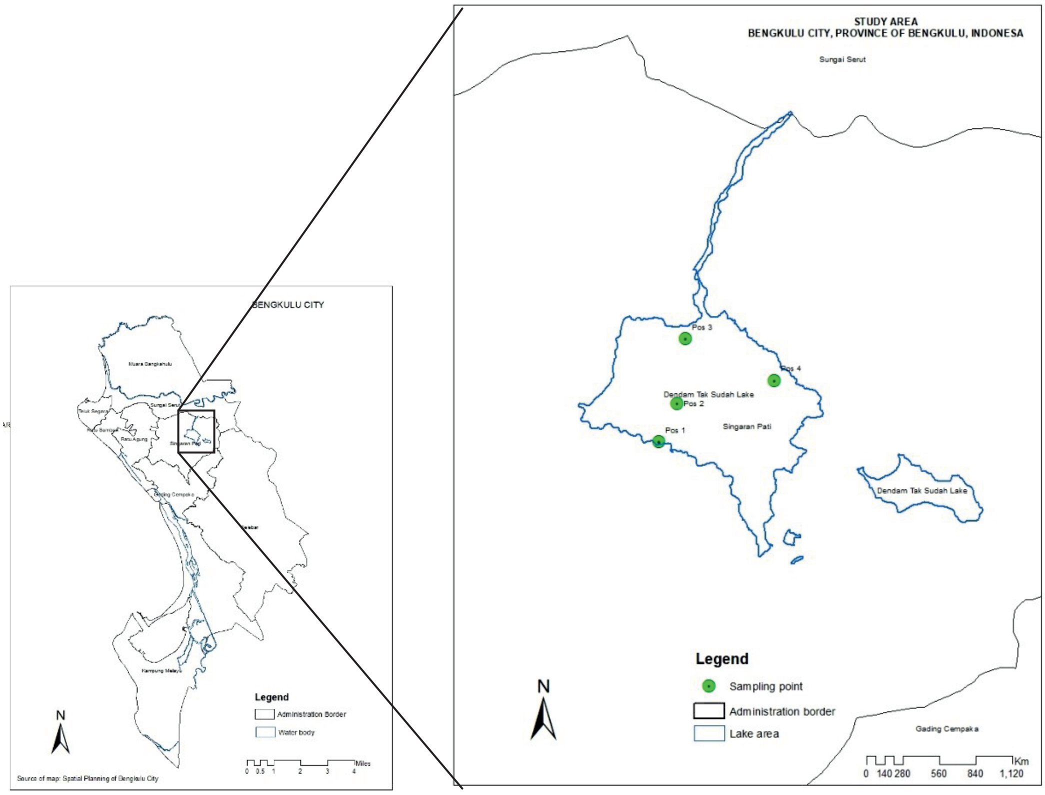

Fig. 1. Research location and sampling point.

Table 1. Sampling point.

No	Sampling point	Coordinates	
1	Post 1	3°48’16.6”S	102°18’26.5”E
2	Post 2	3°48’11.7”S	102°18’28.8”E
3	Post 3	3°48’03.4”S	102°18’29.9”E
4	Post 4	3°48’08.8”S	102°18’41.3”E

shows the parameters and lake water quality standard based on the regulation.

Data Analysis

The determination of lake water quality was analyzed using the CCME (Canadian Council of Ministers of the Environment) water quality index. The CCME index can provide concise information about water quality by simplifying complex parameters to make them easier to understand [10]. The method can be applied if there is a lot of data (not single data) and can provide information related to water quality and its changes over time [11]. Another advantage of this method is that the number and parameters used can be more flexible [12]. The CCME index is a combination of three elements which include F1 (Scope), F2 (Frequency), and F3 (amplitude). F1 (Scope), namely the number of parameters that do not meet water quality standards; F2 (Frequency), which is the total number of measurement results that do not meet the water quality standards; and F3 (amplitude), the amount of the difference in measurement results that do not up to the quality standards [13].

The calculation of each of these elements is carried out according to the following CCME guidelines:

1. F1 (*Scope*) is calculated by the following formula:

$$F_1 = \left(\frac{\text{Number of failed parameters}}{\text{Total number of parameters}}\right) \text{x } 100 \quad (1)$$

2. F2 (*Frequency*) is calculated by the following formula:

$$F_2 = \left(\frac{\text{Number of failed tests}}{\text{Total number of tests}}\right) \text{x } 100 \quad (2)$$

3. F3 (*Amplitude*) is calculated by the following formula:

   i) ‘Excursion’ calculation, namely the difference in the measurement results of each parameter compared to the quality standard. For the value of the measurement results that should not exceed the quality standard, use the following formula:

$$excursion_i = \left(\frac{\text{Failed test value}_i}{\text{Objective}_j}\right) - 1 \quad (3a)$$

Meanwhile, the measurement results should not be below the quality standard value using the following formula:

Table 2. Standard Parameters and their values for lake water standard.

No.	Parameters	Unit	Lake Water Quality Standards*)			
			Class I	Class II	Class III	Class IV
1	Temperature	ºC	Dev 3	Dev 3	Dev 3	Dev 3
2	Total dissolved solids (TDS)	mg/L	1.000	1.000	1.000	1.000
3	Total suspended solids (TSS)	mg/L	25	50	100	400
4	pH		6-9	6-9	6-9	6-9
5	Iron (Fe)	mg/L	0.3	-	-	-
6	Sulfate	mg/L	300	300	300	400
7	Manganese (Mn)	mg/L	0.4	0.4	0.5	1
8	Copper (Cu)	mg/L	0.02	0.02	0.02	0.2
9	Zinc (Zn)	mg/L	0.05	0.05	0.05	2
10	Biochemical oxygen demand (BOD)	mg/L	2	3	6	12
11	Chemical oxygen demand (COD)	mg/L	10	25	40	80
12	Dissolved oxygen (DO)	mg/L	6	4	3	1
13	Phosphate	mg/L	0.01	0.03	0.1	-
14	Oil and Grease	mg/L	1	1	1	1
15	Detergent (MBAS)	mg/L	0.2	0.2	0.2	-
16	Total Coliform	Total/ 100 mL	1.000	5.000	10.000	10.000
17	Fecal Coliform	Total/ 100 mL	100	1.000	2.000	2.000

*) Government of Indonesia Regulation (GR) No. 22 /2021 regarding Implementing Environmental Protection and Management.
Class I is water can be used for raw drinking water and/or other designations requiring the same water quality.
Class II is water that can be used for water recreation infrastructure/facilities, freshwater fish cultivation, animal husbandry, water for irrigating crops, and/or other uses that require the same water quality.
Class III is water that can be used for freshwater fish cultivation, animal husbandry, water for irrigating plants, and/or other uses that require the same water quality.
Class IV is water that can be used to irrigate crops and/or other uses that require the same water quality.

$$excursion_i = \left(\frac{\text{Objective}_j}{\text{Failed test value}_i}\right) - 1 \quad (3b)$$

ii) Calculation of *nse* (normalized sum of excursions), which is the total number of differences that do not exceed the quality standard compared to the total number of measurements, using the following formula:

$$nse = \left(\frac{\sum_{i=1}^{n} excursion_i}{\text{Total number of tests}}\right) - 1 \quad (4)$$

iii) The following formula calculates F3:

$$F_3 = \left(\frac{\text{nse}}{0.01\text{nse}+0.01}\right) \quad (5)$$

After the values for the three elements or factors above are obtained, the CCME index can be calculated by the following formula:

$$CCME - WQI = 100 - \left(\frac{\sqrt{(F_1)^2+(F_2)^2+(F_3)^2}}{1.732}\right) \quad (6)$$

As a divisor, 1.732 is used, a normality value between 0 and 100. The value of zero describes the worst water quality condition, and a value of one hundred represents the best condition. Based on this index, the water quality status can be classified as follows.

Results and Discussion

Lake Water Quality Status

Based on the analysis of DDTS water quality, there are some parameters that did not meet the lake water quality standard. In May 2017, of the 17 parameters measured, 7 parameters did not fulfill the quality standards. The number changes in the next

Table 3. Classification of water quality by category of assessment.

Values	Categories	Description
95-100	Excellent	Water quality is maintained without threat or disturbance; conditions that are very close to natural or pure conditions
80-94	Good	Water quality is protected with minimal damage or disturbance; conditions that are close to natural conditions
65-79	Fair	Water quality has been compromised; conditions that have changed from natural or desired conditions
45-64	Marginal	Water quality is already threatened or compromised, which is worse; water conditions have deviated from natural or desired conditions.
0-44	Poor	Water quality is seriously threatened or badly disturbed; conditions have changed from natural conditions or desired.

Source: CCME [13]

Table 4. Calculation of CCME index value in DDTS in May 2017-March 2019.

No	Elements	May 2017	Sep 2017	March 2018	October 2018	March 2019
		Value/ Category	Value/ Category	Value/ Category	Value/ Category	Value/ Category
1	Scope-F1	41.18	35.29	35.29	29.41	41.18
2	Frequency-F2	36.76	32.35	25.00	14.71	39.71
3	nse	1.55	1.36	2.81	3.74	3.34
4	Amplitude-F3	60.75	57.69	73.77	78.89	76.95
5	Water quality indices	52.61	56.72	50.63	50.65	44.64
6	Categories	Marginal	Marginal	Marginal	Marginal	Poor

Source: Result of Analysis (2022)

measurement to 5-7 parameters. Several parameters that often detected exceed the quality standards are BOD, COD, phosphate, DO, detergent, Zn, Cu, Total Coliform, and Fecal Coliform. The calculation value of the CCME index based on its elements to describe the quality of lake water for each observation period is ranging from May 2017 to March 2019 (Table 4, Fig. 2). These values are classified as poor and marginal water quality.

These CCME indexes indicate that, generally, the quality of DTTS water cannot be used as a raw water source because it has been polluted. Some of the observed parameters that have exceeded the quality standard, are thought to come from anthropogenic activities such as urban activities (settlements), agriculture/plantations, tourism, and small industries [14, 15].

Forest cover changes in the area of DDTS have caused a decrease in the quality of soil and water in the area. In 2010, around 63% of the DDTS area was converted to function and encroached on by the community, causing forest damage, and decreasing soil and water quality [16]. It was further stated that the converted area consists of oil palm plantations, mixed gardens, rice fields, main roads, and disturbed land. The region's rapid socio-economic development, especially in urban areas, and the rapid occurrence of urbanization have caused land use and land cover changes to impact the aquatic environment [17, 18]. It has become an important issue that DDTS has been designated as a natural tourism park. Besides being an opportunity, it can also be a threat to the sustainability of the area. Based on the land use and spatial pattern map, it knowns that the allocation around the area is surrounded by housing and settlement areas which add to the pressure on the location and lake water quality.

Lake Water Quality Parameters

The results show that 11 parameters still meet the lake water quality standards: temperature, pH, TDS, TSS, Fe, Sulfate, Mn, Cu, DO, Oil and Grease, and detergent. At the same time, the remaining 6 parameters are often detected exceeding the lake water quality standard: Zn, BOD, COD, Phosphate, total coliform, and fecal coliform. Each parameter of the lake water quality will be explained further. The overall results of the analysis are presented in Figs 3-7.

Temperature, Acidity, Total Dissolved Solids and Total Suspended Solids

The standard of lake water temperature quality based on statutory regulations is a deviation of 3ºC from the average water temperature. The temperature

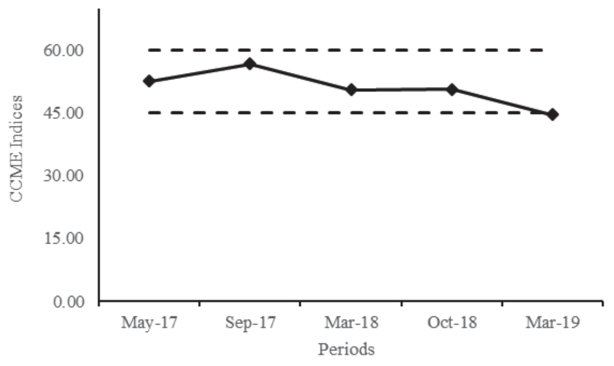

Fig. 2. DDTS Water quality status.

parameters of DDTS from 2017-2019 range between 25-31.8ºC (Fig. 3). The lowest measurement results occurred in March 2018 at the postal 4 measurement locations. At the same time, the highest measurements were for May 2017 (Post 3) and October 2018 (Post 2). The difference in lake water temperature may be related to the seasonal conditions in the area. Generally, the lake water temperature still meets the lake water quality standard for Class I. In water, the temperature parameter is related to biological and chemical reactions. In addition, it will affect the photosynthetic process of plants, the metabolism of organisms in the water, and water's taste, smell, color, and corrosive properties [19]. Previous research has shown a correlation between zoobenthos density and composition with water temperature [20]. If the water temperature deviation is large enough, it can indicate water pollution. The value of the degree of acidity, known as pH, in DDTS ranges from 5.5-8.7 (Fig. 3). In general, the results of pH measurements still meet the lake water quality standards (6-9). An exception occured in September 2017 at Post 2 and Post 3 which is below the quality standard (5.8 and 5.5, respectively). The smaller the pH value indicates that the lake water is increasingly acidic and more corrosive and vice versa [19].

The total dissolved solids (TDS) of Dendam Tak Sudah Lake measurement results have a large enough variation, ranging from 0.04-62 mg/L (Fig. 3). This value still meets the Class I lake water quality standard of 1,000 mg/L. Based on the TDS value, the lake water quality did not exceed the standard. The lowest measurement value of dissolved solids occurred in March 2018, while the highest value occurred in March 2019. The results of this measurement show an increasing trend of total dissolved solids in the last year (October 2018 and March 2019), indicating a decrease in lake water quality. Changes in the TDS value can be harmful and affect the life of microorganisms in the water [21]. TDS is a solid that has a smaller size than suspended solids. TDS can be in the form of organic materials derived from the decomposition of vegetation and inorganic compounds derived from minerals, metals, and gases carried into the water after contact with materials on the surface and soil. A weathering process around the lake which is then carried by water

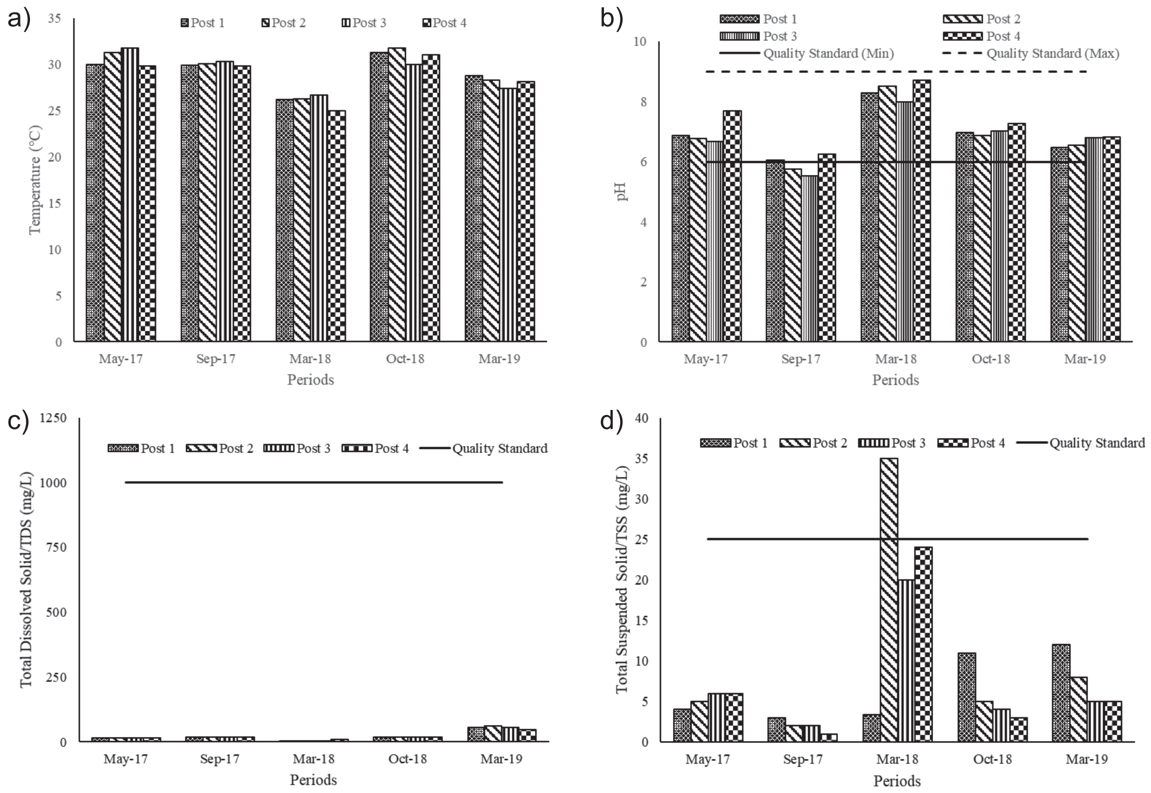

Fig. 3. Parameters of Temperature a); pH b); TDS c); and TSS d).

into the lake affects the TDS value. The TDS value can also provide information about household or domestic waste entering the lake waters. In addition, waste or weathering processes originate from agricultural/ plantation activities in the area.

Total suspended solids (TSS) are suspended in water that can be organic or inorganic. TDS can be in the form of mud, dirt, weathered plants, industrial waste, and sand carried into water bodies by erosion. The size and weight of TSS particles are smaller than sediments but are insoluble so that they can cause water turbidity [22]. Lake water quality Class I standard for TSS parameter is 25 mg/L. From May 2017-March 2019, the TSS value in DDTS fluctuated significantly, ranging from 1-35 mg/L (Fig. 3). The lowest value at all observation posts occurred in September 2017. On the contrary, the highest value occurred in March 2018, reaching 35 mg/L exceeding the Class I lake water quality standard. Then it decreased in October 2018 and rose again in March 2019. There is an increasing trend. The TSS value indicates that changes in lake water quality have started due to environmental pollution [23]. It can threaten the lake ecosystem's sustainability if no efforts are made to manage the area around the lake.

Iron, Manganese, Zinc and Copper

The results of measurements of the parameters of iron (Fe) and manganese (Mn) in DDTS were detected to be still low, ranging from 0.004-0.212 mg/L and 0.012-1.39 mg/L, respectively (Fig. 4). This value meets the required lake water quality standard for Class I, 0.3 mg/L. The highest iron parameter was detected in March 2018. Meanwhile, the Mn parameter measurement results in May 2017, but it tends to decrease for the next year's measurements. From March 2018 to March 2019 the value of the Mn parameter still met the quality standard. Although naturally, this type of metal is commonly detected in lakes or rivers, it can come from the weathering of minerals and sediments. However, in this study, relatively small metal parameters were detected. The low level of these elements may not directly affect the condition of the waters in the study area.

The results of DDTS water quality measurements for the detected zinc (Zn) and copper (Cu) parameters ranged from 0.01-0.44 mg/L and 0-0.18 mg/L, respectively (Fig. 4). In general, the value of Mn still meets the lake water quality standard, which is 0.4 mg/L, except for the May 2017 measurement at Post 1. Meanwhile, the results of the Cu parameter measurements in the May 2017 and September 2017 measurements are quite high and exceed the quality standard, but for the next year, measures tend to go down. From March 2018 to March 2019 the Cu parameter value met the quality standard. In general, the entry of pollutants in the form of heavy metals into surface water resources can occur due to soil erosion, direct waste disposal into water bodies, and various other anthropogenic activities [15]. Referring to previous research, this increase in Zn value is probably related to drainage channels and household waste carried into lake waters. In addition,

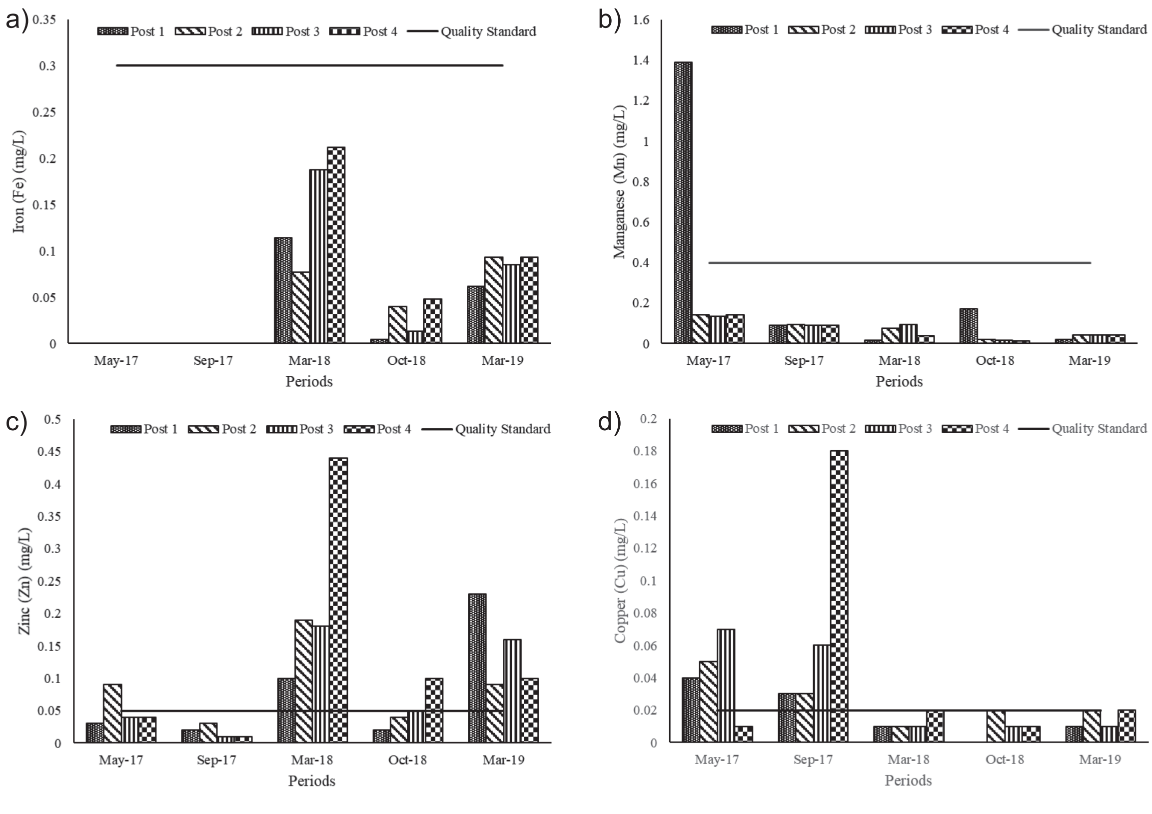

Fig. 4. Parameters of Fe a); Mn b); Zn c); and Cu d).

using chemical fertilizers for agricultural and plantation soils in the lake's upper reaches can also contribute to an increase in dissolved heavy metals. This heavy metal can bioaccumulate living things, including humans, through the food web process and endanger health [24].

Sulfate, Phosphate, Biological Oxygen Demand and Chemical Oxygen Demand

The results of the analysis of the Sulfate parameter in DDTS were detected to be quite low, ranging from 1-38 mg/L in each measurement (Fig. 5). This value is still far below the lake water quality standard for Class I, 300 mg/L. It indicates that human activities surrounding the lake did not affect the increase in sulfate levels. Furthermore, the detected phosphate parameters ranged from 0.1-1.15 mg/L (Fig. 5). These values have greater than the lake water quality standard of 0.01 mg/L. Phosphate compounds that were detected probably came from domestic waste and agricultural activities that developed around the lake area and were then transported and entered the lake waters. It is consistent with previous research showing a significant increase in phosphates in water originating from domestic waste, agriculture, and an increase in built-up land [7]. This condition is reinforced by research by [4], which states that agricultural activities significantly increase phosphate. Using fertilizers that use phosphate elements to increase agricultural and plantation production is one of the common practices carried out by communities around the lake. The results of measurement of the Biological Oxygen Demand (BOD) parameter in DDTS are quite volatile, showing their values ranging from 1-15 mg/L (Fig. 5). The value of Class I of lake water quality standard for the BOD parameter is 2 mg/L. Almost every BOD value measurement detected is relatively high, except for measurements in March 2018 and October 2018 for several measurement posts. However, the BOD value has exceeded the Class I lake water quality standard. Furthermore, the results of the Chemical Oxygen Demand (COD) parameter measurement ranged from 3-38 mg/L (Fig. 5). All measurement results except for March 2018, the COD value exceeded the Class I water quality standard of 10 mg/L. The highest measurement was in March 2019 for Post 2. The BOD value describes the number of oxygen organisms need to decompose organic matter under aerobic conditions [25]. BOD and COD parameter values indicate that DDTS may have been polluted by lake water originating from organic materials. Weathering of organic matter from various domestic activities, agriculture, animal husbandry, and land use around the lake contribute to changes in BOD and COD parameter values [26, 27]. An increase in non-point sources originating from urbanization caused by population growth and changes in urban land cover around the lake also contributed to the rise in BOD and COD [28, 29]. In general, it can be said that this parameter is related to anthropogenic activity because it is close to residential areas with lakes [3].

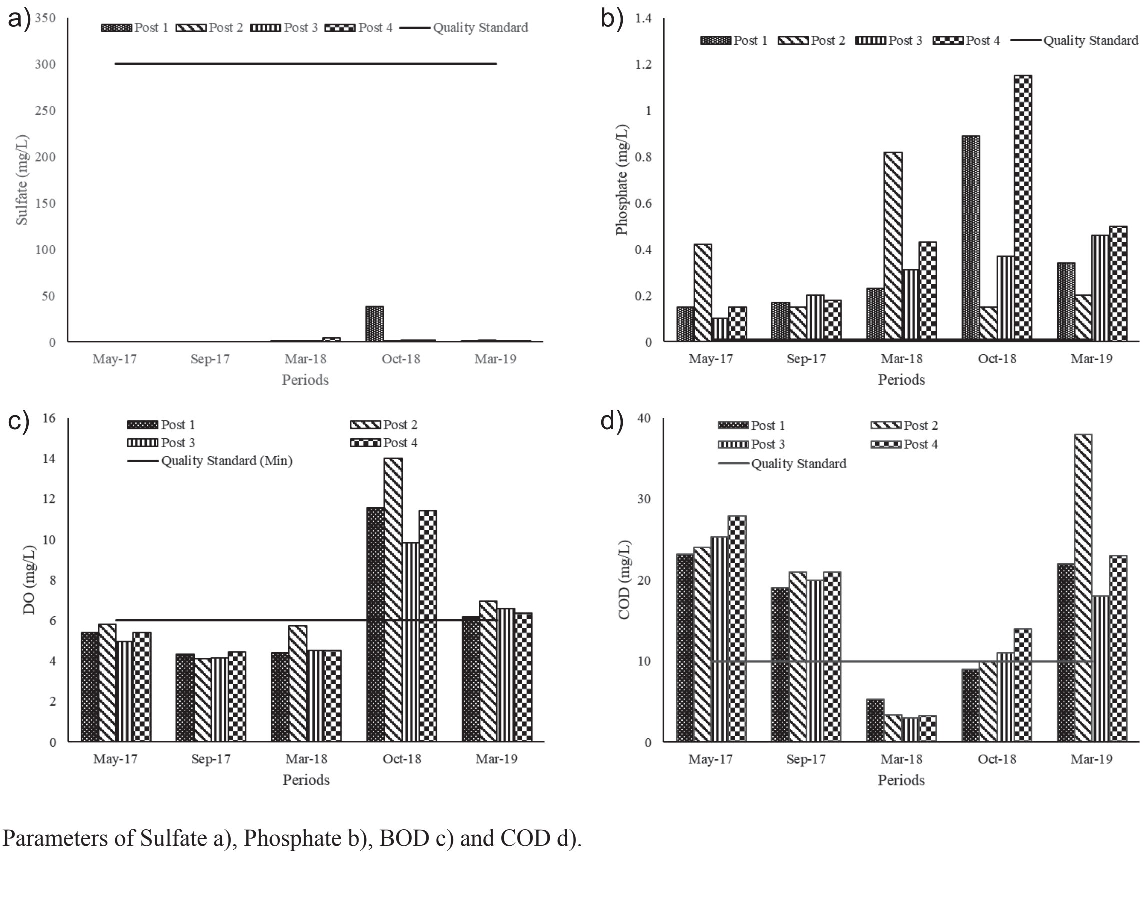

Fig. 5. Parameters of Sulfate a), Phosphate b), BOD c) and COD d).

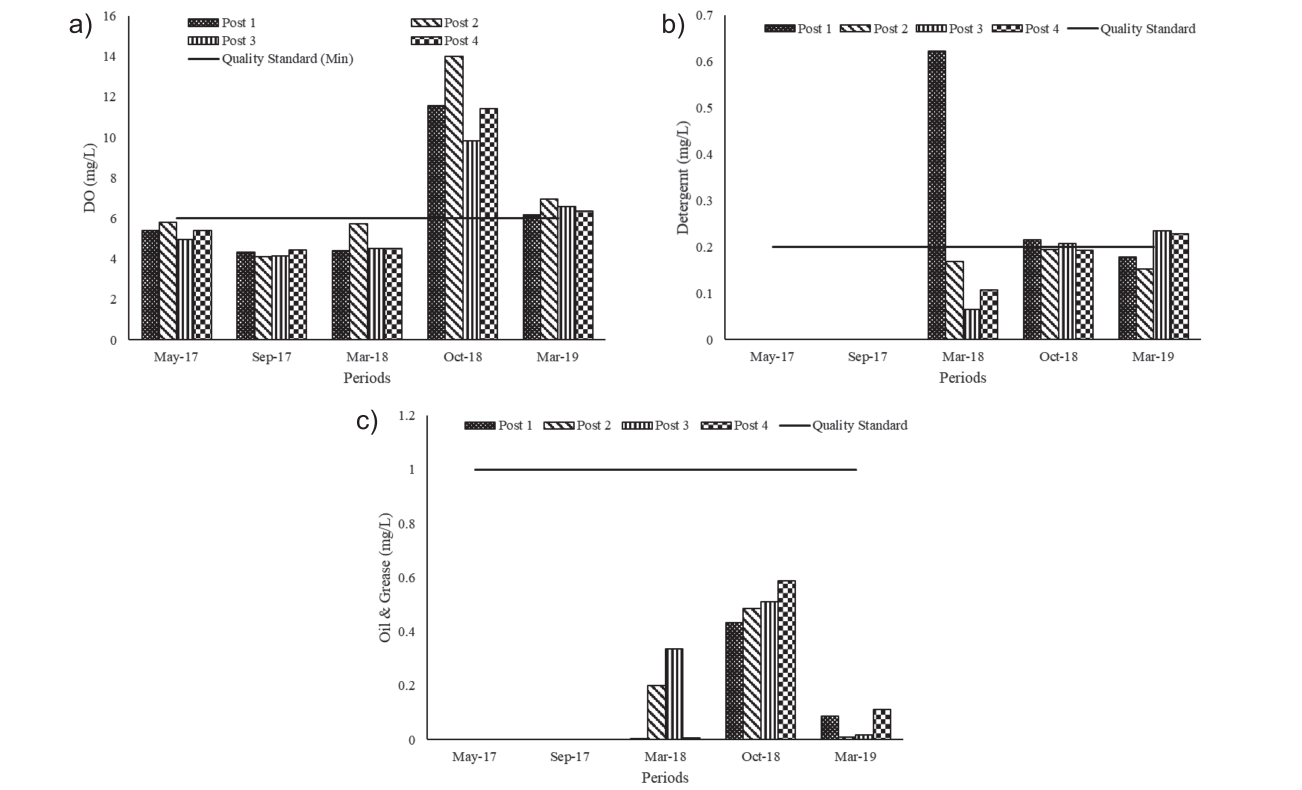

Fig. 6. Parameters of DO a), Detergent b), Oil and Grease parameters c).

Dissolved Oxygen (DO), Detergents, and Oils and Grease

The analysis of the Dissolved Oxygen (DO) value in DDTS in May 2017-March 2019 showed a fluctuating value ranging from 4.11-14 mg/L (Fig. 6). The highest DO values and meet the Class I lake water quality standards (>6 mg/L) were detected in measurements in October 2018 and March 2019. Meanwhile, at other times the DO values were not met the quality standards. DO can describe the amount of oxygen required by microorganisms or living things to oxidize and reduce organic and inorganic matter in waters [25]. Information about DO is essential to describe the sustainability of aquatic ecosystems, including lakes. Based on the analysis, a low DO parameter indicates that the water quality of DDTS has been contaminated. Residential and plantation activities around the lake may contribute to the decline in DO value.

The detergent parameters analysis in DDTS from March 2018-March 2019 ranged from 0.066-0.622 mg/L (Fig. 6). This value is close to the Class I lake water quality standard, 0.2 mg/L. Furthermore, the measurement results for oil and grease parameters are between 0.002-0.588 mg/L. These results still meet the lake water quality standard. The parameters show that activities around the lake affect decreased DDTS water quality. However, efforts to manage the surrounding environment are still needed so that pollutants do not affect these two parameters, considering that these

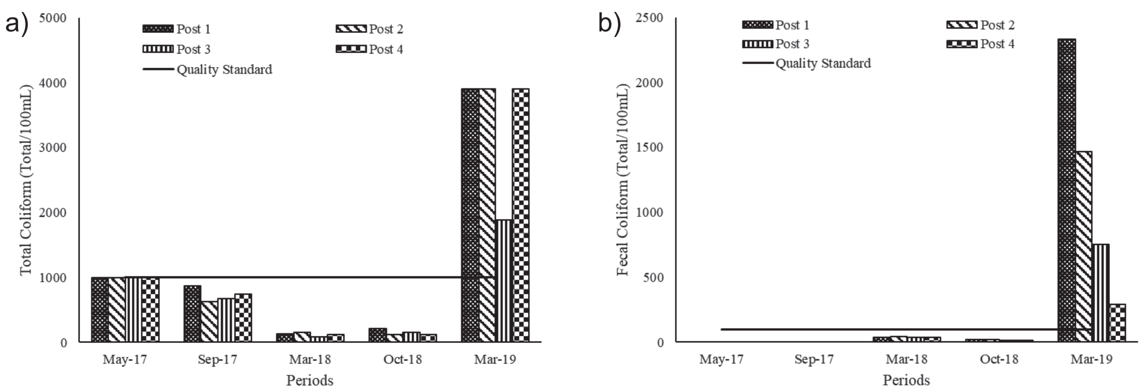

Fig. 7. Parameters of Total Coliform a) and Fecal Coliform b).

materials are widely used by the community, such as domestic activities, workshops, and restaurants. Previous research has shown that oil and fat parameter values are higher in densely populated areas [30]. In addition, detergent is an active organic substance that is widely used by the community as a cleansing and purifying agent, which can be in the form of powder or liquid. This active ingredient should be biodegradable up to 90%, but the residue is often not adequately degraded, so it enters the waters and pollutes the environment [31]. These pollutants can reduce the penetration of oxygen and light into the waters, affecting the photosynthesis process.

Total Coliform and Fecal Coliform

The biological parameters measured included total coliform and fecal coliform. The analysis results of these two parameters in DDTS in March 2018-March 2019, have a fairly high variation between 89-3900/100 ml and 14-2330/100 ml. The measurement of these two parameters in March 2019 has shown a relatively high increase compared to the previous measurement. The last measure of total coliform and fecal coliform showed that the quality of the lake water had exceeded the quality standard, namely 1000/100 ml and 100 total/100 ml. Total coliforms detected ranged from 1889-3900/100ml. Meanwhile, the fecal coliform parameters ranged from 290-2330/100ml (Fig. 7). The high value of coliform is thought to be related to the activity of residents around the lake. This pathogen contamination can come from settlements and construction activities in urban areas that enter pollutants into the lake water system [32]. Meanwhile, the fecal coliform value indicates the possibility of pathogenic fecal contamination [33].

Conclusions

The CCME index of the Dendam Tak Sudah Lake (DDTS) ranges from 44.64-56.72, which classified as poor and marginal category. It indicates that, generally, the quality of DTTS water cannot be used as a raw water source. In comparison to the class I water quality standards (Appendix VI of GR 22/2021), 11 parameters of DDTS still meet the lake water quality standards, namely temperature, TDS, TSS, pH, Fe, Sulfate, Mn, Cu, DO, Oils and Grease, and detergents. At the same time, 6 (six) parameters are often detected exceeding the lake water quality standard, i.e Zn, BOD, COD, Phosphate, total coliform, and fecal coliform.

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Conflict of Interest

The authors declare no conflict of interest.

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