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Water Quality of Gatal Lake, Kotawaringin Lama, Central Kalimantan

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ABSTRACT

Gatal Lake is located in the Kotawaringin Lama District, West Kotawaringin Regency, Central Kalimantan, Indonesia. The government and the surrounding communities use Gatal Lake for recreation, irrigation, livestock, and fisheries. Geographically, Gatal Lake, is close to oil palm plantations and palm oil processing factories that contributed to water pollution, especially the pollutants originating from plantation activities in the form of large-scale use of fertilizers and pesticides. This study aimed to determine the status of the water quality of Gatal Lake, Kotawaringin Lama based on the physicochemical parameters. The samples from five stations were analyzed based on the following parameters: temperature, TDS, TSS, pH, BOD, COD, DO, nitrate, nitrite, phosphate, Pb, Cd, H_2S, oil and grease, detergent, and phenol. The study was conducted using a purposive sampling method and determining the status of water quality based on Government Regulation No. 82/2001. The results of the physicochemical analysis of Gatal Lake showed that the water quality parameters which exceeded the water quality standards, are BOD (6.94 to 8.65 mg L), COD (9.58 to 15.7 mg/L), and DO (4.20 to 5.10 mg/L), while the parameters that did not exceed the water quality standards for Class I, II, III, and IV are temperature, TDS, TSS, pH, nitrate, nitrite, phosphate, Pb, Cd, H_2S, oils and fats, detergents and phenols. On the basis of the STORET method, the water quality of Gatal Lake for Class I, II, and III are included in the highly polluted category, and for Class IV is in the moderate category.

Keywords: Gatal Lake, water quality, physical-chemical parameters, STORET

INTRODUCTION

Water is a fundamental constituent in life and is very important for all needs. Water has an important role in various fields including agriculture, horticulture, livestock, fisheries, domestic consumption, industry, energy generators, and recreation [Sukmawati, *et al*. 2019]. Freshwater ecosystems such as lakes, reservoirs, and rivers are natural resources that play an important role in ensuring the availability of water on land. The 2030 Agenda for Sustainable Development recognizes the importance of water quality and includes specific water quality targets in Sustainable Development Goal (SDGs) 6 [United Nations, 2016]. However, the surface water pollution remains a major problem worldwide, caused by natural processes and anthropogenic activities [Rahim & Soeprobowati, 2019].

The surface water quality is a very sensitive and critical issue in many countries [Sener, *et al.* 2017]. The condition of freshwater in Indonesia has always been a threatening issue and a national problem [Soeprobowati *et al.* 2016]. For example, the problem of Rawapening Lake in Central Java Province is the occurrence of eutrophication, sedimentation, decreased water quality, and the blooming of water hyacinths [Soeprobowati *et al.* 2017, 2019; Hidayati *et al.* 2018]. The same problem also occurs in other national priority lakes, including Lake Toba, Maninjau, Singkarak, Kerinci, Tondano, Limboto, Poso, Tempe, Matano, Mahakam Semayang-Melintang Jempang Waterfall, Sentarum, Sentani, Batur, [Rahim & Soeprobowati, 2019], even in the small volcano lakes in Dieng [Soeprobowati *et al.*, 2017, 2018, 2019, 2020]. Lake Batur in Bali also experiences silting due to the cultivation activities around the lake, agricultural activities, and the presence of waste both residential and tourism waste [Sukmawati, *et al*. 2019].

Gatal Lake (Figure 1) is one of the oxbow lakes located in Rungun Village, Kotawaringin Lama District, West Kotawaringin Regency. The area of Gatal Lake is 1,500 Ha with a length of 2,000 m and a width of 900–1,100 m. The depth of Lake Gatal in the rainy season is 6 m, while in the dry season it is 4–5 m [Indonesia.go.id/kalteng, 2020]. The government and the surrounding communities use Gatal Lake for recreation, irrigation, livestock, and fisheries. The lake is located close to oil palm plantations and palm oil processing factories, the pollutants from which can enter the waters (Figure 2). The main sources of pollutants that enter to the lake waters are the excessive use of pesticides and fertilizers in agriculture and domestic waste from local communities. Agriculture is identified as the largest contributor to pollution for surface and groundwater in the world [Rahim & Soeprobowati, 2019].

Monitoring the quality of surface water and groundwater is very important as a basis for the management of water pollution. The water quality monitoring process involves determining the sampling points and analyzing the water characteristics to obtain the correct interpretation of the results [Sukmawati, et al. 2019]. The most frequently used water quality parameters are the physicochemical and biological parameters. The physicochemical parameters play an important role in maintaining the restoration system and regulating the water quality [Musliu, *et al.* 2018]. This study aimed to determine the status of the water quality of Gatal Lake, Kotawaringin Lama based on the physicochemical parameters.

MATERIALS AND METHODS

Study Area

This field work was conducted from August to September 2020 at Gatal Lake (02º23’37.7 “S 111º25’01.2” E), Rungun Village, Kotawaringin Lama District, West Kotawaringin Regency, Central Kalimantan, Indonesia. There are five sampling stations with different characteristics by purposive random sampling which represent each activity around the Gatal Lake waters (Table 1 and Figure 3). Determination of the research stations was based on the level of depth from the edge to the middle of the water (horizontal).

Water Sample Collection and Analysis

Water sampling was carried out at each station by the Indonesian National Standard (SNI 6989.57–2008) on how to take the surface water samples with a lake depth of less than 10 meters. The water samples were collected in 1L clean plastic bottles, labeled and then put into a cooler. The physicochemical parameters such as temperature, pH, and dissolved oxygen were measured directly *(in-situ)* in the field and other parameters were analyzed at the Mutuagung Lestari Laboratory, Pasir Panjang Village, West Kotawaringin District, Central Kalimantan, Indonesia.

The results of the physical and chemical parameter values of the water obtained were then compared with the water quality standard criteria in Government Regulation Number 82 of 2001 concerning Water Quality Management and Water Pollution Control. Determination of Gatal Lake water quality was performed using the STORET (Storage and Retrieval) method which refers to the Regulation of the Minister of Environment of the Republic of Indonesia No. 115/2005 concerning Guidelines for Determining Water Quality Status.

Figure 1. Gatal Lake, Kotawaringin Lama district, West Kotawaringin regency

a) b)

Figure 2. (a) Oil palm plantations and (b) Palm oil processing factories owned by PT. BGA Group (Source: bumitama-agri.com)

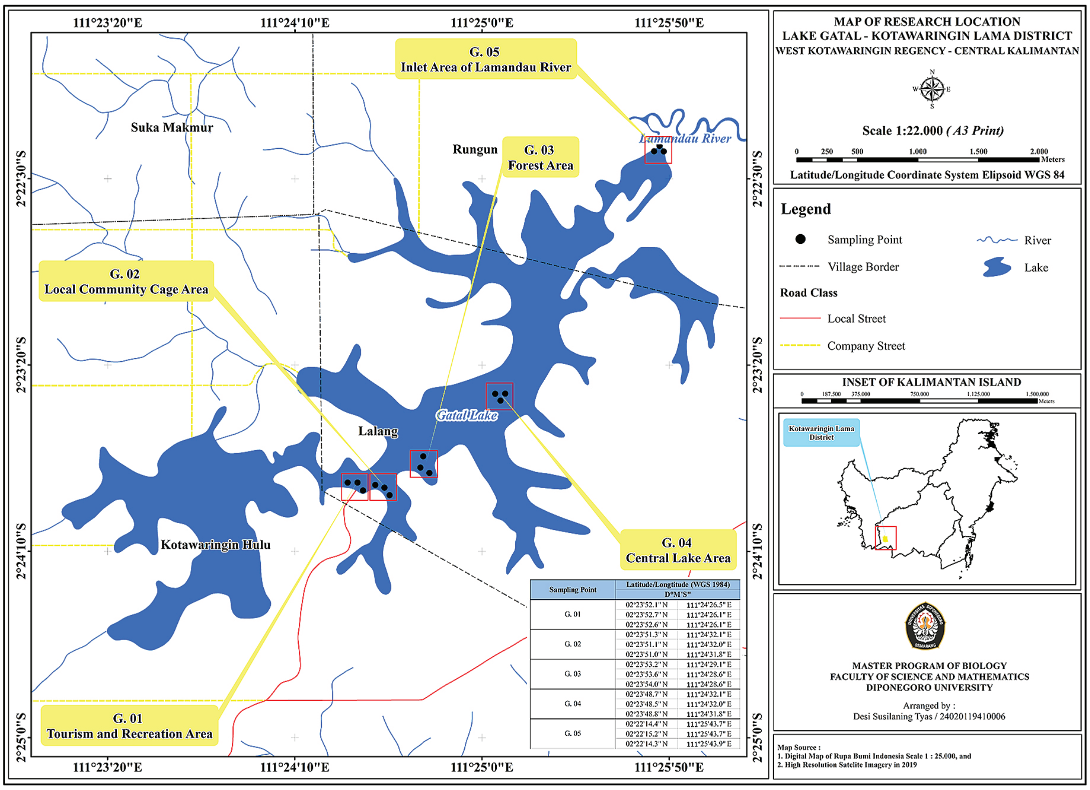

Figure 3. The 5 research stations in Gatal Lake, Central Kalimantan

Table 1. Geographical position and description of the research stations of Gatal Lake, Central Kalimantan

Stations	Geographical position	Sites description
G-1	02º23'52.1"S 111º24'27.3"E	Tourism and recreation area
G-2	02º23'51.3"S 111º24'26.5"E	Local community cage area
G-3	02º23'53.2"S 111º24'29.1"E	Forest area
G-4	02º23'48.7"S 111º24'32.1"E	Central lake area
G-5	02º22'14.4"S 111º25'43.7"E	Inlet area of the Lamandau river

The STORET method is one of the techniques often used in Indonesia to determine the status of water quality based on the US-EPA (United State-Environmental Protection Agency) value system to categorize the water quality into four classes (Table 2) [Rahim & Soeprobowati, 2019]. Through the STORET method, we can find out which parameters have met or exceeded the water quality standards by comparing the water quality data with the water quality standards that are adjusted to their designation to determine the status of water quality [Rintaka, et al. 2019].

Determination of the water quality status using the STORET method is carried out according to the following stages:
1. Periodically conducting the water quality data collection to form data time series.
2. Comparing the measurement data of each water parameter with the quality standard value according to the water class.
3. If the measurement results meet the water quality standards (measurement results <quality standards), then a score of 0 is given.
4. If the measurement results do not meet the water quality standards (measurement results> quality standards), then a score is given as in Table 3.
5. The negative sum of all the parameters is calculated and the quality status of the total score is obtained using the defined score system.

Determination of Water Class

Determination of the water class is carried out by comparing the concentration of all water quality parameters listed in Government Regulation Number 82 of 2001 then compared with the water quality standards for Class I, Class II, Class III, and Class IV for each of these parameters. Water quality classification is divided into four classes:
1. Class I, water intended for drinking, raw water and/or other uses requiring the same quality of water as the said use.
2. Class II, water intended for water recreation infrastructure/facilities, freshwater fish farming, animal husbandry, water for irrigating crops, and/or other uses requiring the same water quality as the said use.
3. Class III, water intended for the cultivation of freshwater fish, animal husbandry, water for irrigating crops, and/or other uses which require the same water quality as the said use.
4. Class IV, water intended to irrigate crops and or other uses that require the same water quality as the said use.

Table 2. Water quality classification according to the US-EPA value system

Score	Class	Characteristics of water quality
0	A	Meet the quality standard
-1 to -10	B	Slightly polluted
-11 to -30	C	Moderately polutted
≥ -31	D	Highly polluted

RESULTS AND DISCUSSION

This study uses the water samples from five sampling stations. The coordinates of the location are recorded using GPS (Global Positioning System). The results of measuring the water quality of Gatal Lake, Kotawaringin Lama District based on the physicochemical parameters can be seen in Table 4.

Water Temperature

The water temperature of all sampling stations ranged from 27°C to 31°C with an average water temperature of the five stations of 29.2°C. The highest water temperature is at station 2 at 31ºC which is the cage net aquaculture area of the local community. The lowest water temperature is at station 5 with a value of 27ºC which is the inlet area of the Lamandau River. The high water temperature at station 2 is caused by hot weather so that the intensity of the Sun's radiation is quite high and the absence of water plants growing in the cage area is also one of the causes. Muhaemi *et al.* (2015) said that the temperature of water bodies is influenced by several factors such as season, latitude, height above sea level (asl), time, air circulation, water flow, tides, and water depth. Romanescu *et al.* (2016) said that the water temperature can have different values based on the season that occurs in the location of these waters. The average value of Gatal Lake water temperature still meets the criteria for water quality standards based on Government Regulation Number 82 of 2001 for classes I, II, III, and IV which state that the water temperature is at a 3°C deviation from the natural conditions of the surrounding environment. The causes of temperature changes include weather, removal of shaded lakeside vegetation, dam, discharge of cooling water, urban rainwater, and groundwater flow into lakes [Bhateria & Jain, 2016].

TDS (Total Dissolved Solid)

The results of the TDS analysis of all sampling stations in Gatal Lake obtained the TDS values ranging from 2.00 to 18.00 mg/L (Table 3) and an average value of 12.0 mg/L. The average TDS value for Gatal Lake still conforms to Government Regulation Number 82 of 2001 for classes I, II, III and IV which states that the total dissolved residue is at the maximum limit of 1000 mg/L for classes I, II and III and 2000 mg/L for class IV. The high TDS value at station 5 is since the inlet area has experienced a lot of erosion from the upstream area, resulting in the water becoming more turbid than other stations. The low TDS value at station 4 is since station 4 is the middle area of the lake which has a lot of woody water plants, causing the water in the area to be less contaminated by the pollutants from natural activities such as erosion and activities of the surrounding community. Dewi *et* al. 2018 said the dissolved residue in the middle of the lake comes from the leaves and branches of trees that grow in the area. The solids found in the waters consist of three forms, namely suspended, volatile, and dissolved. Suspended solids include silt, stirred bottom sediment, decomposed plant matter, or sewage treatment effluent [Bhateria & Jain, 2016]. High TDS levels can reduce the water palatability [Shishaye, 2017].

TSS (Total Suspended Solid)

The results of TSS analysis from all sampling stations in Gatal Lake obtained the TSS values ranging from <3.28 to 11.3 mg/L (Table 3) with an average value of 5.54 mg/L. The TSS average value for Gatal Lake is still by Government Regulation no. 82 of 2001 because it is still below the quality standards for classes I, II, III, and IV. The highest TSS value is at station 5 of 8.00 mg/L which is the inlet area of the Lamandau River. The high TSS value at station 5 is caused by soil erosion due to the river currents entering the lake. Yulius *et al*. (2018) said the composition of suspended solids in waters has a positive correlation with turbidity. Turbidity occurs due to the presence of suspended substances in the water, but because these suspended substances consist of various kinds of substances with different shapes and density, turbidity is not always proportional to the suspended substance content (Figure 4).

pH (The Degree of Acidity)

The results of measuring the value of the degree of acidity from all sampling stations in Gatal Lake obtained the pH values ranging from 5.67 to 6.46 (Table 3) with an average value of 5.99. The average pH value of Gatal Lake water is still by Government Regulation no. 82 of 2001 because it is still within the threshold of water quality standards for classes I, II, III, and IV which states the pH should be within the range of 6 – 9. The degree of acidity (pH) of water indicates the presence of hydrogen ions in water, as hydrogen ions are acidic. Overall, the water pH conditions of the five sampling stations were acidic (Figure 5). Romanescu *et al.* (2016) said the acidification of waters can be influenced by water temperature through the distribution of seasons and day and night cycles. Yondra (2017) said this is due to the influence of water catchment areas in the form of peat swamp forests. The acidity level of peat swamp forests has a close relationship with the content of organic acids such as humic and fulvic acids.

Table 3. Assessment of water quality parameters (KLH No. 115/2003)

Number of parameters	Value	Parameter		
		Physical	Chemical	Biology
< 10	Maximum	-1	-2	-3
	Minimum	-1	-2	-3
	Average	-3	-6	-9
≥ 10	Maximum	-2	-4	-6
	Minimum	-2	-4	-6
	Average	-6	-12	-18

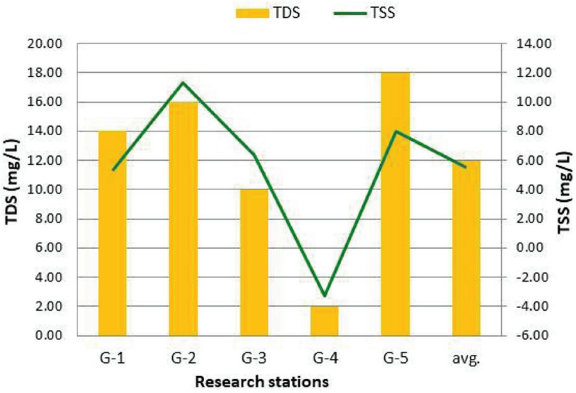

Figure 4. TDS and TSS of Gatal Lake, Central Kalimantan

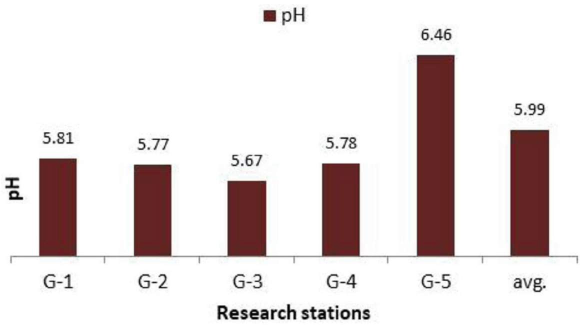

Figure 5. pH (the degree of acidity) of Gatal Lake, Central Kalimantan

BOD (Biochemical Oxygen Demand)

The results of BOD analysis from all sampling stations ranged from 6.94 to 8.65 mg/L (Table 3) and a mean value of 8.02 mg/L. The average BOD value for Gatal Lake water is based on Government Regulation No. 82 of 2001 has exceeded the quality standards for Class I, II, and III with permissible limits of 2, 3, and 6 mg/L respectively. However, it is still below the Class IV water quality standard, which is 12 mg/L. On the basis of the BOD concentration, the Gatal Lake water is not suitable for use as a source of raw material for drinking water, recreational facilities, and aquaculture activities, but agricultural activities are still allowed. Nuraini *et al.* (2019) said the waters with high BOD values indicate pollution by organic matter. The BOD value in water can be influenced by the type of waste, the acidity level (pH), and the overall water condition.

COD (Chemical Oxygen Demand)

The results of COD analysis from all sampling stations ranged from 9.58 to 15.7 mg/L (Table 3) and a mean value of 12.5 mg/L. The

Table 4. Physicochemical Parameters for Gatal Lake, Central Kalimantan

Parameters	Unit	Sampling location					Standard of Government Regulation No. 82/2001			
		G 1	G 2	G 3	G 4	G 5	Class I	Class II	Class III	Class IV
Physical										
Temp.	ºC	29.0	31.0	30.0	29.0	27.0	Dev 3	Dev 3	Dev 3	Dev 5
TDS	mg/L	14.0	16.0	10.0	2.00	18.0	1000	1000	1000	2000
TSS	mg/L	5.33	11.3	6.33	<3.28	8.00	50	50	400	400
Inorganic chemical										
pH	–	5.81	5.77	5.67	5.78	6.46	6–9	6–9	6–9	6–9
BOD_5	mg/L	6.94	8.65	8.41	8.41	7.67	2	3	6	12
COD	mg/L	11.5	11.1	14.6	9.58	15.7	10	25	50	100
DO	mg/L	5.00	4.90	4.20	4.80	5.10	6	4	3	0
Nitrate	mg/L	3.26	5.17	3.89	5.81	2.40	10	10	20	20
Nitrite	mg/L	<0.00054	<0.00054	0.001	<0.00054	0.01	0.06	0.06	0.06	–
Phosphate	mg/L	<0.053	<0.053	<0.053	<0.053	<0.053	0.2	0.2	1	5
Pb	mg/L	0.0065	0.0023	0.0022	0.0016	0.0037	0.03	0.03	0.03	1
Cd	mg/L	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.01	0.01	0.01	0.01
H_2S	mg/L	0.00023	0.00041	0.00028	0.00025	0.00027	0.002	0.002	0.002	–
Organic chemical										
Oils and fat	µg/L	300	200	500	200	600	1000	1000	1000	–
Detergent	µg/L	<3.10	<3.10	<3.10	<3.10	<3.10	200	200	200	–
Phenol	µg/L	<1.0	2.30	<1.0	<1.0	<1.0	1	1	1	–

average COD value of Gatal Lake water based on Government Regulation Number 82 of 2001 has exceeded the Class I quality standard with an allowable limit of 10 mg/L. However, it is still below the threshold of Class II, III, and IV quality standards. On the basis of the COD concentration, the Gatal Lake water is not suitable for use as a source of raw material for drinking water, but it is allowed for recreational activities, aquaculture and agriculture activities. The high COD concentration is caused by the presence of organic waste that enters the water. This organic waste can come from household activities, agricultural activities, and aquaculture activities. The magnitude of the COD value indicates the amount of organic material that is difficult to decompose in these waters [Sepriani, *et al.* 2016]. The decomposition of organic matter accumulated in lake sediments and the oxidation of inorganic chemicals such as ammonia and nitrites can also contribute to increasing the value of chemical oxygen demand in water [Hernandez *et al.* 2020]. The high concentration of COD is proportional to the increase in the concentration of BOD in the water. The lower the oxygen content in the water, the greater the COD and BOD values in these waters [Aldo, *et al*. 2015] (Figure 6).

DO (Dissolved Oxygen)

The DO analysis results from all sampling stations ranged from 4.20 to 5.10 mg/L (Table 3) with a mean value of 4.80 mg/L. DO average value based on Government Regulation no. 82 of 2001 is still below the Class I quality standard which states DO 6 mg/L. However, it exceeds the Class II, III, and IV water quality standards. Devi *et al.* (2017) stated that the low dissolved oxygen content in lake waters is caused by the high content of organic waste in the waters. Sinaga, *et al.* (2016) said the dissolved oxygen levels in the waters are closely related to water temperature. As the water temperature increases, the oxygen solubility level decreases (Figure 7).

Nitrate

The results of nitrate (NO_3-N) analysis from all sampling stations ranged from 2.40 to 5.81 mg/L (Table 3) with a mean value of 4.11 mg/L. The average nitrate concentration in Gatal Lake is still below the threshold of Government Regulation No. 82 of 2001 the water quality standards for Class I, II, III, and IV. The high nitrate concentration is at station 4 which is the middle area of the lake. The high concentration of nitrate is influenced by sediment. In this sediment, nitrate is produced from the biodegradation of organic materials into ammonia which is then oxidized to nitrate [Patty, 2015]. The amount of nitrate is usually greater than the amount of nitrite because nitrite is unstable in the presence of oxygen and nitrite is also a transitional form from ammonia to nitrate (Figure 8). Nitrate is an unwanted ion in water because it has detrimental effects on the human health [Ewaid & Abed, 2017].

Nitrite

The results of the nitrite (NO_2-N) analysis from all sampling stations ranged from <0.00054 to 0.01 mg/L (Table 3) with a mean value of <0.0025. The average value of the Lake Gatal water nitrite is still within the Class I, II, III, and IV water quality standards of Government Regulation No. 82 of 2001 which states that with conventional drinking water treatment, the nitrite concentration must be below ≤1 mg/L. The nitrite concentrations in natural waters are very low. The nitrite toxicity can increase if the pH level of the

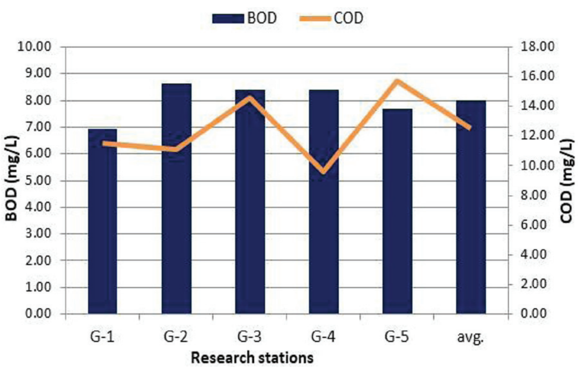

Figure 6. BOD and COD of Gatal Lake, Central Kalimantan

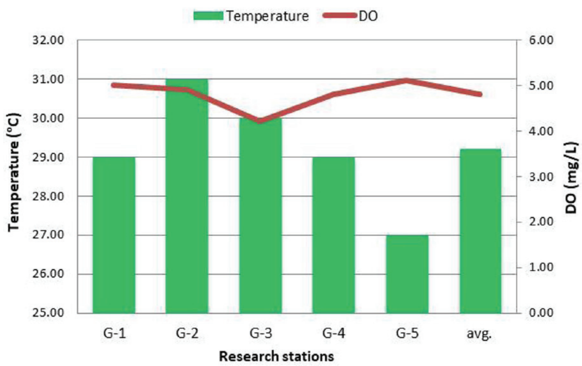

Figure 7. Temperature and dissolved oxygen of Gatal Lake, Central Kalimantan

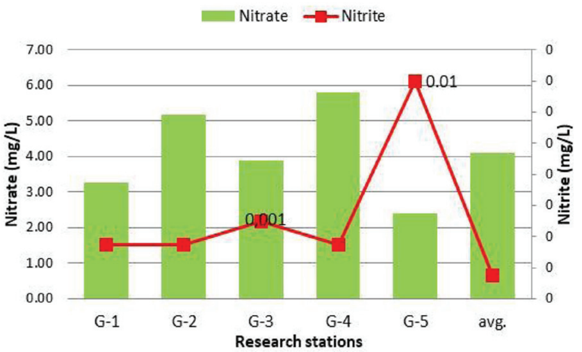

Figure 8. Nitrate and Nitrite of Gatal Lake, Central Kalimantan

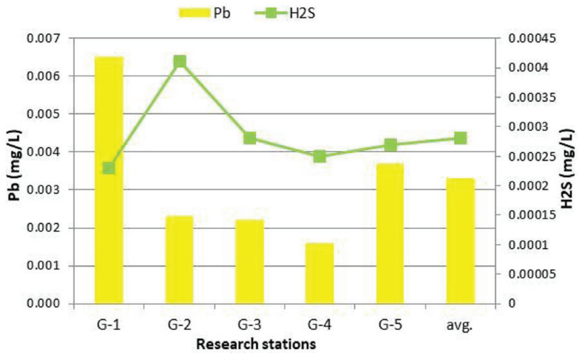

Figure 9. Pb and H_2S of Gatal Lake, Central Kalimantan

water is low [Shishaye, 2017]. The increase in nitrite in the waters is caused by the increase in water runoff during the rainy season which transports the ammonium and ammonia cations found in fertilizers as well as the nitrite and nitrate due to the nitrification process [Wang *et al*. 2019].

Phosphate

The phosphate concentration of the Gatal Lake water after the analysis obtained the results of <0.053 mg/L from all sampling stations (Table 3) with an average value of <0.053 mg/L. The average value of phosphate in the waters of Gatal Lake is still below the threshold by Government Regulation Number 82 of 2001 for Class I, II, III, and IV water quality standards (Figure 9). Phosphate is an important nutrient in waters, but if its concentration exceeds a predetermined threshold, it can cause digestive problems [Shishaye, 2017]. If phosphates and nitrates are in high concentrations in water, they can cause eutrophication or population growth in that water [Tanjung, *et al.* 2019]. The high concentrations of nitrate and phosphate that accumulate in water tend to be caused by human activities [Wang *et al.* 2019].

Concentration of Heavy Metals

The results of the Pb and Cd analysis obtained from all sampling stations were as follows: the Pb metal concentrations ranged from 0.0016 to 0.0065 mg/L (Table 3) with an average value of 0.0033 mg/L.

The average value of Pb in Gatal Lake is still below the water quality standard threshold for Class I, II, III, and IV based on Government Regulation Number 82 of 2001 which states that the concentration of Pb for conventional drinking water quality standards must be below ≤ 0, 1 mg/L. The Pb concentration in Gatal Lake can still be said to be harmless and Dewi et al. (2018) said that if the organisms living in these waters are taken, they are still fit for consumption. If the solubility level of Pb in water is low, it will result in a relatively low Pb level in the water [Tjahjono, *et al.* 2017]. The concentration of Cd metal from all sampling stations was <0.0020 mg/L (Table 3) with an average value of <0.0020 mg/L. The average value of Cd metal concentration in the waters of Gatal Lake is still below the water quality standard threshold for Class I, II, III, and IV based on Government Regulation Number 82 of 2001. Heavy metals are naturally distributed back into the environment through geological processes and biological cycles. The concentration of this heavy metal varies greatly depending on the extent of exposure to the mineral [Rakotondrabe, *et al.* 2018]. If there are many types of heavy metals in the water, they may originate from human activities apart from natural activities [Shehu, 2019].

Above a certain limit, heavy metals can be toxic to humans [Rakotondrabe, *et al.* 2018]. Heavy metals are a group of pollutants that can reduce the water quality and damage ecosystems [Kukrer & Mutlu, 2019]. If heavy metals with concentrations exceeding the threshold – that may be absorbed by plants and then enter the food chain – are present in the waters, this is very dangerous for animals and humans. The heavy metal exposure in humans can increase the risk of various neurological diseases. Many studies have shown that most of the chemical elements have neurotoxic properties, one of which is Pb and Cd [Demaku & Bajraktari, 2019].

Concentration of Sulfur (H_2S)

The sulfur concentration of all sampling stations ranged from 0.00023 to 0.00041 mg/L (Table 3) with a mean value of 0.00028 mg/L. The

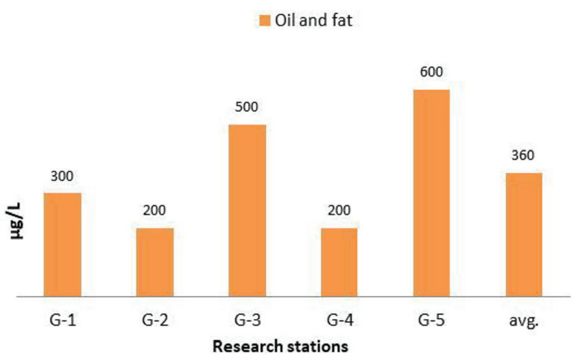

Figure 10. Concentration of oil and fat of Gatal Lake, Central Kalimantan

sulfur concentration in the waters of Gatal Lake is still below the water quality standard threshold for Class I, II, III, and IV based on Government Regulation Number 82 of 2001. The concentration of sulfur in waters can come from the aerobic decomposition of organic matter containing sulfur and the resulting aerobic conditions for the reduction of sulfates by microorganisms. The sulfate concentrations in waters are seasonal and can affect several cycles of trace metals in waters [Tanjung, *et al.* 2019].

Concentration of Oil and Fat

The results of the analysis of the oil and fat content of all sampling stations ranged from 200 to 600 μg/L (Table 3) with an average value of 360 μg/L (Figure 10). The average oil and fat concentration values in the waters of Gatal Lake are still below the water quality standards for Class I, II, III, and IV based on Government Regulation Number 82 of 2001.

Detergent

After analysis, the detergent content was found at <3.10 μg/L from all sampling stations (Table 3) with an average value of <3.10 μg/L. The concentration of detergent in the waters of Gatal Lake is still below the water quality standard threshold for Class I, II, III, and IV, based on Government Regulation Number 82 of 2001. The low detergent content in the waters makes the phosphate content in these waters also low because detergents are a significant contributor to the phosphate levels in the waters [Patricia *et al*. 2018]. Detergent contains the chemicals which when enter the water in high concentrations capable of harming the human body and causing eutrophication of the lake [Pattusamy *et al.* 2013]. Detergents can cause changes in water properties and are active in water systems because they increase solubility in water [Gundogdu, *et al.* 2018]. Detergents play an important role in increasing pollution from household wastewater, agricultural runoff in the form of herbicide and insecticide residues, and from certain industries [El-Gawad, 2014].

Concentration of Phenol

After analyzing the phenol content, the results were <1.0 μg/L from all sampling stations (Table 3) with an average value of <1.0 μg/L. The phenol concentration in the waters of Gatal Lake is still below the water quality standard threshold for Class I, II, III, and IV based on Government Regulation Number 82 of 2001. High phenol content in waters can cause fish poisoning and has the potential to cause bioaccumulation [Asuhadi *et al*. 2019]. The phenol toxicity process is related to two things, namely the unexplained toxicity associated with the hydrophobicity of individual compounds and the formation of free radicals. Phenolic compounds and their derivatives have the ability to change the membrane structure, causing an imbalance in the cell environment and resulting in cell death [Bezverbna & Radziwill, 2018].

Determination of Water Quality Status

Determination of the overall water quality status can be performed using the STORET method which can describe the parameters that meet quality standards or exceed quality standards. The scoring is based on the US-EPA system. On the basis of calculations using the STORET method, the status of Gatal Lake water quality can be seen in Table 5. Table 5 shows the status of Gatal Lake water quality using the STORET method with the classification of water quality status based on Government Regulation Number 82 of 2001 which can be explained as follows: Class I is used as a source of raw material for drinking water has a pollution index of -36, Class II which is used for recreational facilities, livestock, and aquaculture, the fisheries sector has a pollution index of -40, Class III which is used for livestock, aquaculture in the fishery sector and agricultural activities has a pollution index of -40 and Class IV used for agricultural activities have a pollution index of -20.

Table 5. Status of Gatal Lake Water Quality Using the STORET Method

Parameters	Unit	Min	Max	Avg.	Score Class I	Score Class II	Score Class III	Score Class IV
Physics								
Temperature	ºC	27.0	31.0	29.2	0	0	0	0
TDS	mg/L	2.00	16.0	12.0	0	0	0	0
TSS	mg/L	<3.28	11.3	5.54	0	0	0	0
Inorganic chemical								
Ph	–	5.67	6.46	5.99	0	0	0	0
BOD_5	mg/L	6.94	8.65	8.02	-20	-20	-20	0
COD	mg/L	9.58	15.7	12.5	-16	0	0	0
DO	mg/L	4.20	5.10	4.80	0	-20	-20	-20
Nitrate	mg/L	2.40	5.81	4.11	0	0	0	0
Nitrite	mg/L	<0.00054	0.01	<0.0025	0	0	0	0
Phosphate	mg/L	<0.053	<0.053	<0.053	0	0	0	0
Pb	mg/L	0.0016	0.0065	0.0033	0	0	0	0
Cd	mg/L	<0.0020	<0.0020	<0.0020	0	0	0	0
H_2S	mg/L	0.00023	0.00041	0.00028	0	0	0	0
Organic chemical								
Oil and fat	µg/L	200	600	360	0	0	0	0
Detergent	µg/L	<3.10	<3.10	<3.10	0	0	0	0
Phenol	µg/L	<1.0	<1.0	<0.34	0	0	0	0
Pollution Index					-36	-40	-40	-20

On the basis of the US-EPA system, the information on the status of water quality from each class is Class I as a source of raw drinking water with a score of -36 into class D with the highly polluted category; Class II as a means of recreation, livestock, and aquaculture in the fisheries sector with a score of -40 is included in class D with the very polluted category; Class III as a means of animal husbandry, aquaculture in the fishery sector and agricultural activities with a score of -40 is in class D with the very polluted category; and Class IV which is used for agricultural activities with a score of -20 is included in class C with the medium polluted category**.**

CONCLUSIONS

On the basis of the results of the analysis carried out at 5 sampling locations in Gatal Lake several parameters exceed the water quality standards, namely COD, BOD and DO, while the parameters that do not exceed the water quality standards are temperature, TDS, TSS, pH, nitrate, nitrite, phosphate, Pb, Cd, H_2S, oil and fat, detergent, and phenol.

The Gatal Lake water quality for Class I, II, and III is categorized as highly polluted, and Class IV is categorized as moderate.

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