

Water quality status of Buatan Lake, Rumbai Pesisir, Pekanbaru City Riau Province using pollution index

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Abstrak

Danau Buatan merupakan satu-satunya danau di Pekanbaru yang dibangun dengan membendung dua sungai, yakni Sungai Ambang dan Sungai Merbau. Tujuan utama dibangunnya danau ini adalah untuk irigasi, perikanan, dan kegiatan pariwisata. Berbagai aktivitas baik di dalam danau maupun di sekitar danau tentunya akan menyebabkan masuknya bahan-bahan pencemar ke dalam danau. Penelitian ini bertujuan untuk mengetahui status kualitas air Danau Buatan Pesisir Rumbai Kota Pekanbaru. Penelitian ini dilaksanakan pada bulan Juli sampai Agustus 2023 di Danau Rumbai Pesisir Buatan Kota Pekanbaru Provinsi Riau. Metode penelitian yang digunakan adalah metode survei. Pengambilan sampel air dilakukan sebanyak tiga kali dengan selang waktu satu bulan. Penentuan status kualitas air menggunakan metode Indeks Pencemaran (IP). Parameter yang digunakan untuk menentukan status mutu adalah pH, oksigen terlarut, BOD, COD, TSS, total fosfat, total nitrogen, klorofil-a, dan Fecal coliform. Analisis kualitas air dibandingkan dengan baku mutu air kelas II (PP No.22 Tahun 2021). Hasil penelitian menunjukkan rata-rata parameter kualitas air belum memenuhi baku mutu kelas II yaitu BOD berkisar antara 5,6 – 5,8 mg/L, total fosfat berkisar antara 0,7 - 0,8 mg/L, total nitrogen berkisar antara 5 -18 mg/L, dan Fecal coliform berkisar antara 10,666 – 28,333 MPN/100 mL. Rata-rata nilai IP Danau Rumbai Pesisir Buatan berkisar antara 3,3 hingga 4,2 dengan kategori tercemar ringan di seluruh stasiun pengamatan. Pencemaran di Danau Rumbai Buatan disebabkan oleh tekanan dari pengayaan bahan organik, nitrogen, dan fosfat.

Kata kunci: *bahan organik, Danau Buatan, kualitas air, Indeks Pencemaran, fecal coliform*

Abstract

Buatan Lake is the only lake in Pekanbaru which was built by damming two rivers, namely the Ambang River and the Merbau River. The main purpose of building this lake is for irrigation, fishing, and tourism activities. Various activities both in the lake and around the lake will certainly cause the entry of pollutant materials into the lake. This research aims to determine the water quality status of the Rumbai Coastal Buatan Lake, Pekanbaru City. This research was carried out from July to August 2023 at the Rumbai Pesisir Buatan Lake, Pekanbaru City, Riau Province. The research method used is a survey method. Water samples were taken three times with an interval of one month. Determining water quality status using the Pollution Index (PI) method. The parameters used to determine quality status are pH, dissolved oxygen, BOD, COD, TSS, total phosphate, total nitrogen, chlorophyll-a, and fecal coli. Water quality analysis compared to class II water quality standards (PP No.22 of 2021). The research results show that the average water quality parameters do not meet class II quality standards, namely BOD ranging from 5,6 – 5,8 mg/L, total phosphate ranging from 0,7 – 0,8 mg/L, total nitrogen ranging from 5 - 18 mg /L, and Fecal coli ranges from 10.666 – 28.333 MPN/100 mL. The average IP value of the Buatan Lake ranges from 3,3 to 4,2 with the category being lightly polluted at all observation stations. Pollution in the Rumbai Buatan Lake is caused by pressure from the enrichment of organic matter, nitrogen, and phosphate.

Keywords: *Buatan Lake, water quality, Pollution Index (PI), fecal coli, organic matter*

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Introduction

Fresh water is very important for human life and life in general (Markad *et al.* 2021). However, urbanization, agriculture, industrialization, and other anthropogenic activities have increased the level of freshwater pollution. One of the sources of fresh water in Pekanbaru City is an Buatan Lake known as Lake Bandar Khayangan. This lake was created

by damming two rivers, namely the Ambang River and the Merbau River. The location of this lake is approximately 10 kilometers from the center of Pekanbaru City. This lake has become a tourist destination for the community. The Lakes are used as a source of raw water for drinking water, fish cultivation, irrigation activities, and tourism (Mazidah *et al.* 2013). The Buatan lake water catchment area is

currently changing into a residential area, an oil palm plantation, and a tourism area. Land use change is one of the factors that influences ecosystem structure and function (Argaw & Yohannes 2024). Land use changes in lake water catchment areas can cause increased transport of pollutants and sediments, resulting in increased eutrophication rates and decreased water quality (Petrovski et al. 2024; Wang et al. 2021). In addition, Buatan lakes also have problems with the inflow of materials for organic fish farming activities in cages (Mazidah et al. 2013).

Various activities both in the lake and around the Buatan lake will certainly cause the entry of pollutants into the lake, thereby reducing the quality of the water. Water quality is a very important factor for human life and influences the growth and life of aquatic organisms. The growth and development of organisms will run well if the environment is supportive and is still within the permitted tolerance limits (Nurmayani et al. 2018). Water quality status is the level of water quality condition, which shows that the water is categorized as polluted or in good condition at a certain time by comparing the established quality standards (Hamakonda et al. 2019).

The Pollution Index (PI) method is one way to assess the status of water quality. Moreover, PI is a method to determine the level of pollution relative to permissible water quality parameters. The pollution index can provide input for decision-making to assess the quality of water bodies in a designated area and take action to improve the quality if there is a decrease in quality due to the presence of pollutant compounds. The PI method has been used to determine the water quality level of a number of lakes, such as Xinyun Lake in China (Chen et al. 2024), Bhatiari Lake in Bangladesh (Ganguli et al. 2022), UniSZA Lake in Malaysia (Md-Batti et al. 2022), and Lake Balang Tonjong Maksar Indonesia (Ahram 2024). These lakes use the pollution index to

provide information on water conditions suitable for each activity and use.

PI can be used as one of the methods to determine the water quality status of Buatan Lakes. Although much research has been conducted on the water quality of the Buatan Lake. As reported by Oktaviandora et al. (2013), Mazidah et al. (2013), and Nurmayani et al. (2018), The results of this research only describe the condition of water quality in Buatan lakes in general based on physical, chemical, and biological factors. However, until now, research regarding the water quality status of Buatan lakes has not been carried out. For this reason, it is necessary to research the quality status of the Rumbai Pesisir.

Method

This research was conducted in the period July-August 2023 at the Danau Buatan, Rumbai Pesisir, Pekanbaru City, Riau Province (Figure 1). Three sampling points were determined to take water samples, namely in the part of the lake affected by domestic sewage, tourism, and fishery activities (Table 1). Water samples were taken at the three stations with three repetitions once a month.

Water quality analysis was carried out at the Laboratory of the Faculty of Fisheries and Marine Affairs, Riau University, and the Health and Environment Laboratory of Riau Province. This research was conducted using a field survey. The data collected is water quality data consisting of temperature, brightness, pH, DO, BOD, COD, TSS, total phosphate, total nitrogen, chlorophyll-a, and fecal coli.

This research was conducted using a field survey. The data collected is water quality data consisting of temperature, brightness, pH, DO, BOD, COD, TSS, total phosphate, total nitrogen, chlorophyll-a, and fecal coli Buatan Lake using the pollution Index.

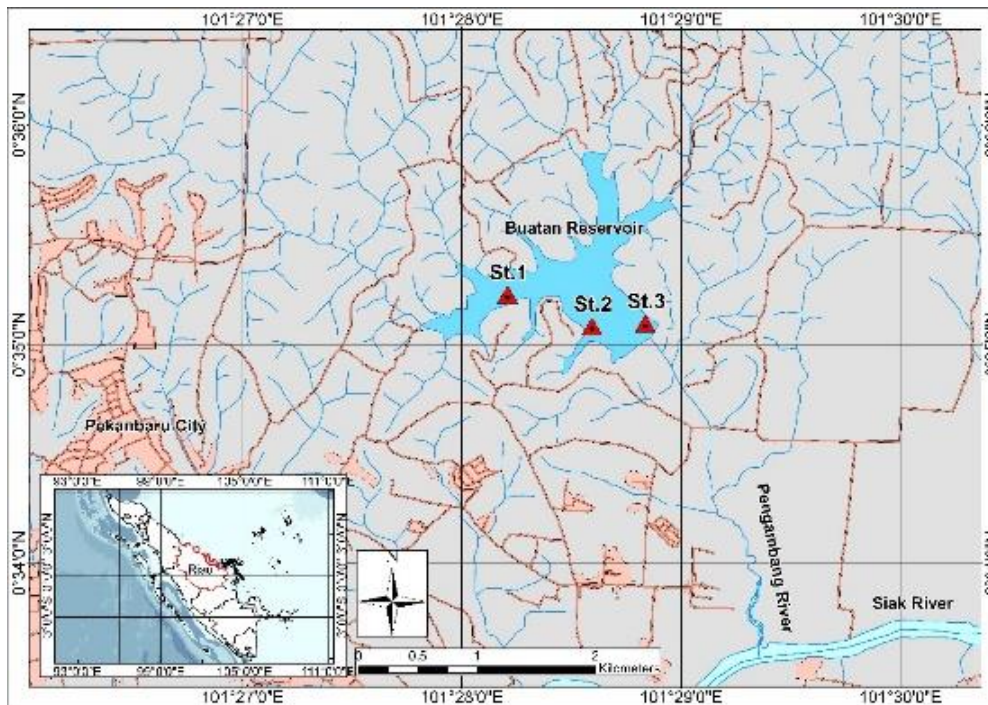


Figure 1. Research Station in Buatan Lake

Table 1. Observation station

Sampling Point	Coordinate Point	activities in the lake catchment and within the lake
1	0°35'08" N 101°28'11" E	tourist area
2	0°35'03" N 101°28'34" E	settlements
3	0°35'03" N 101°28'34" E	floating net cages

Table 2. Water Quality Parameters

Parameters	Unit	Tools/Methods	
	Physic		
Temperature	°C	<i>Thermometer</i>	<i>in situ</i>
TSS	Mg/L	Gravimetric	<i>ex situ</i>
Brightness	Cm	<i>Sechi Disk</i>	<i>in situ</i>
	Kimia		
pH	-	pH Indicator	<i>in situ</i>
BOD	mg/L	Titration Winkler	<i>ex situ</i>
DO	mg/L	Titration Winkler	<i>in situ</i>
COD	mg/L	Gravimetric	<i>ex situ</i>
Total Phosphate	mg/L	SnCl ₂	<i>ex situ</i>
Total Nitrogen	mg/L	Cu-Cd	<i>ex situ</i>
	Biology		
Chlorophyll-a	mg/m ³	Miliopore	<i>ex situ</i>
Fecal coliform	jml/ 100	MPN	<i>ex situ</i>

Water samples were taken using a water sampler with a volume of two and a half liters, Water samples are taken at the surface of the water to a depth of one meter from the surface of the water. Next, the sample water was put into a 500-ml PolyEthylene bottle and then

stored in a cool box before being analyzed in the laboratory.

The quality status of each research station is carried out by calculating the Pollution Index (KEPMEN-LH No. 115 of 2003), which can be calculated using the formula:

$$IP_j = \sqrt{\frac{(C_i/L_{ij})^2_m + (C_i/L_{ij})^2_r}{2}}$$

Information:

L_{ij} = Shows the content of water quality parameters in the Quality Standards for a Water Designation (j);

C_i = Water quality obtained from the analysis results;

P_{ij} = Pollution Index (j) calculated as a function of C_i/L_{ij} .

The number of each quality status is determined by calculating the Pollution Index

value for each location monitoring data. The parameters measured can be seen in Table 2.

Result and Discussion

The results of the water quality analysis in the Buatan lake are presented in Table 3. These values show that the water quality in the Buatan Lake during the study met class II quality standards, except for the BOD, total phosphate, total nitrogen, and Fecal coliform parameters.

Table 3. Average Value of Water Quality Parameters for Each Station

No.	Parameters	Unit	Station			Quality standards
			S1	S2	S3	
Fisika						
1.	Temperature	°C	28	28	29	Dev 3
2.	Brightness	Cm	79	77	69	60-90
3.	TSS	mg/L	7,6	10,3	12,6	50
Biologi						
4.	Fecal coliform	MPN/100 mL	11.333	10.666	28.333	1.000*
5.	Chlorophyll-a	mg/m3	7,5	13,8	12,6	50
Kimia						
6.	pH		7	6,6	7	6-9
7.	DO	mg/L	5,8	5,7	5,6	4
8.	BOD	mg/L	3,8	3,8	3,6	3*
9.	COD	mg/L	13,6	18,6	15,6	25
10.	Total Phosphate	mg/L	0,07	0,07	0,08	0,03*
11.	Total Nitrogen	mg/L	18	6	5	0,75*

The average temperature in Buatan Lake during the study ranged from 28 to 29 °C (Figure 2). Stations 1 and 2 have the same temperature, namely 28°C, while at station 3, it is higher, namely 29°C.

The relative temperature range does not experience significant differences because temperature measurements are carried out in relatively similar weather conditions. The low temperature was caused by the lack of light entering during the measurement because it

was covered by many trees around the lake. Yunita & Agam (2021) explained that the low water temperature was caused by cloudy weather at the time of sampling. Cloudy weather causes the intensity of sunlight reaching the water surface to be low, so the water temperature is also low. Meanwhile, the high temperature at station 3 was due to measurements carried out during the day, where the intensity of light entering was greater than during measurements in the morning.

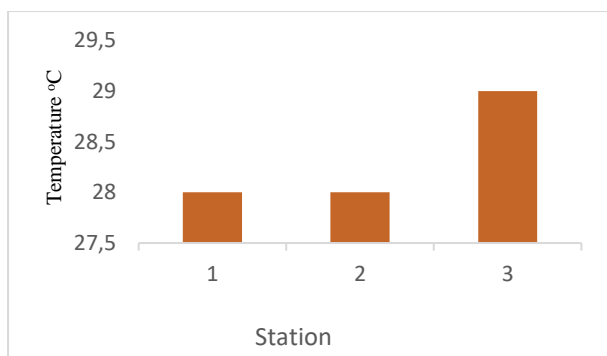


Figure 2. Average temperature

The brightness value in the Buatan Lake during the research ranged from 69 to 79 cm (Figure 3). The brightness value at station 3 (69 cm) is lower than at station 1, namely 79 cm. The low brightness value at station 3 is caused by the high level of suspended particles, namely 12.6 mg/L. This happens because station 3 is a location for floating net cage fish cultivation. Based on observations, fish food residues were found that were not consumed by fish in these waters. The remaining food in the water becomes floating particles, which causes the brightness to decrease. Optimal brightness conditions for successful cultivation of fish and other biota range from 30 to 40 cm, as suggested by Maniagasi *et al.* (2013).

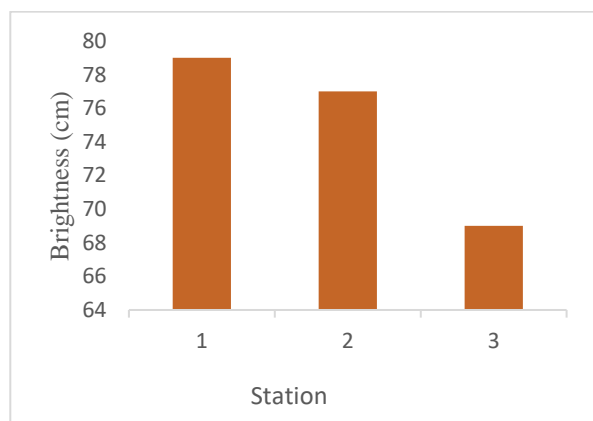


Figure 3. Average Brightness

From table 6, it can be seen that the pH value ranges from 6.6 to 7.0 (Figure 4). At stations 1 and 3, the water pH value is the same, namely 7, while at station 2, the water pH value is lower, namely 6.6. The decrease in pH value at station 2 was caused by the impact of domestic activities. At station 2, the lake waters receive direct household waste disposal, which

directly puts the waste into the lake waters. Dewi *et al.* (2015) stated that the discharge of residential waste into lake waters can carry various acidic chemical compounds, including detergents, which can reduce the pH value of the waters. This waste causes the formation of organic acid compounds, which cause a lower pH. Previous studies, such as those conducted by Tobing *et al.* (2014), Rizki *et al.* (2015), and Yuningsih *et al.* (2014), show that the input of organic and inorganic compounds from domestic activities can influence the pH value of waters. Based on Government Regulation Number 22 of 2021 Class II, the pH value in the Buatan Lake meets quality standards, namely 6 to 9.

The dissolved oxygen (DO) during the study was relatively the same, namely around 5.6–5.8 mg/L (Figure 5). The DO value is quite good for lake waters, but at station 3, it is lower, namely 5.6 mg/L. The decrease in dissolved oxygen (DO) values was caused by floating net cage fish farming activities. This cultivation practice triggers an increase in organic matter in the water, which is then broken down by microbes using oxygen in the decomposition process.

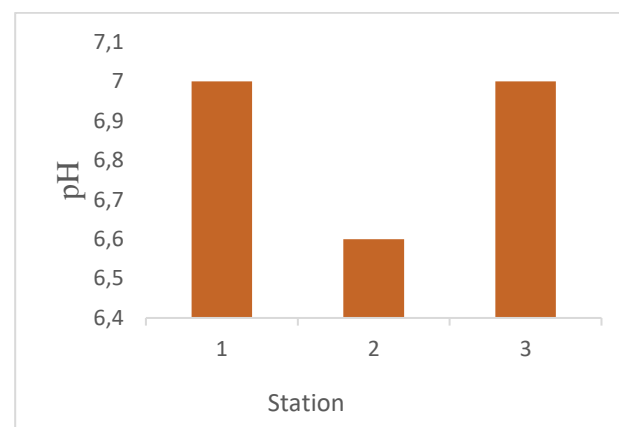


Figure 4. Average of pH

According to Tuan *et al.* (2023), microbes degrade organic matter in waters, which causes a decrease in dissolved oxygen concentrations. The DO concentration of the Buatan lake at all observation stations is still sufficient for aquatic life. According to Salmasi *et al.* (2021), the oxygen content in waters still supports aquatic biota in the range of 5–9 mg/l.

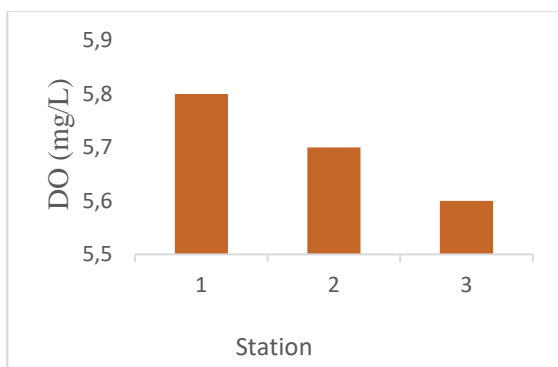


Figure 5. Average DO

The average BOD value is relatively the same, ranging from 3.6 to 3.8 mg/L (Figure 6). Based on PP Number 22 of 2021, the three station points do not meet class II quality standards, namely 3 mg/L. This means that it has been polluted by organic materials. The high BOD value is due to the presence of waste from tourism visitors and the disposal of domestic waste, such as household waste, including used washing water, waste from toilets, and food waste. It can cause organic matter to enter the water. Yuliati *et al.* (2022) reported that BOD levels in water were found to be higher in areas that received domestic waste. Domestic waste contains organic compounds that require oxygen for decomposition. Tatangidatu *et al.* (2011) stated that the high BOD value is caused by the large amount of organic material in the waters, which requires oxygen to be oxidized by microbes.

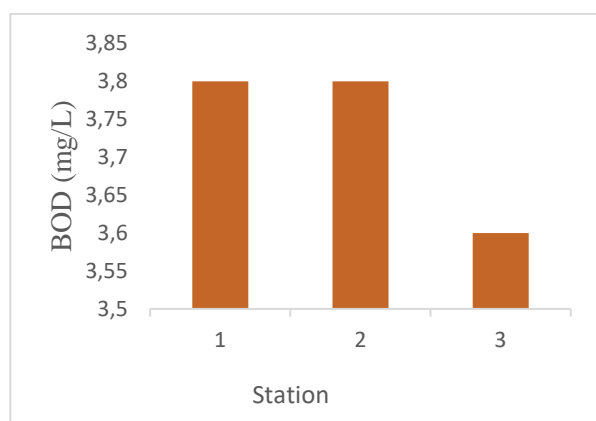


Figure 6. Average BOD

The COD value in the Buatan Lake is relatively the same, namely around 13.6–18.6 mg/L (Figure 7). The highest COD value was at Station 2, namely 18.6 mg/L. The increase in

the COD value at this point is caused by the high COD value at this point being influenced by domestic activities as the main source of pollution. According to Sukmawati *et al.* (2019), the high levels of COD in Buatan lake water are likely due to the high discharge of organic compounds due to community activities in the form of domestic waste and KJA. If the organic matter is high, the COD in the waters will be high. This is thought to be because a lot of dissolved oxygen is needed to oxidize the organic matter found in the waters. In accordance with the opinion of Effendi (2003), the COD value will increase in line with the increase in the value of organic matter in the waters. Meanwhile, in KJA, excessive amounts of feed are given, or if the quality of the feed is poor, the fish may not be able to digest all the feed, and the remaining feed will rot in the lake waters.

The average TSS value in the Buatan Lake varies, ranging from 7.6 to 12.6 mg/L (Figure 8). TSS values vary, namely between 7.6 mg/L and 12.6 mg/L. The highest TSS value was at Station 3, namely 12.6 mg/L, while the lowest value was at Station 1, namely 7.6 mg/L. In general, the Total Suspended Solids (TSS) content value is still at a low level, so it can still be tolerated in the context of fishing activities.

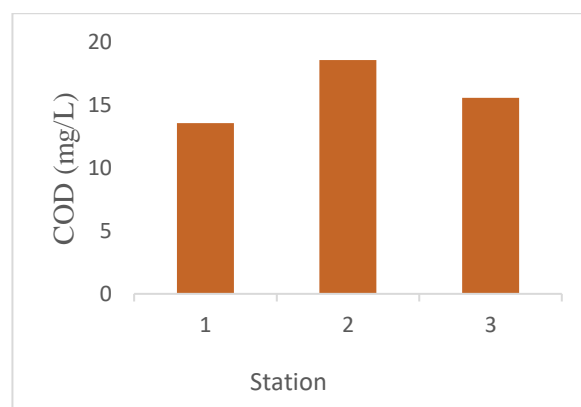


Figure 7. Average COD

The high TSS value at Station 3 is because at that location there is floating net cage fish cultivation. Overfeeding fish or poor maintenance in aquaculture can produce food residue and waste that contributes to TSS.

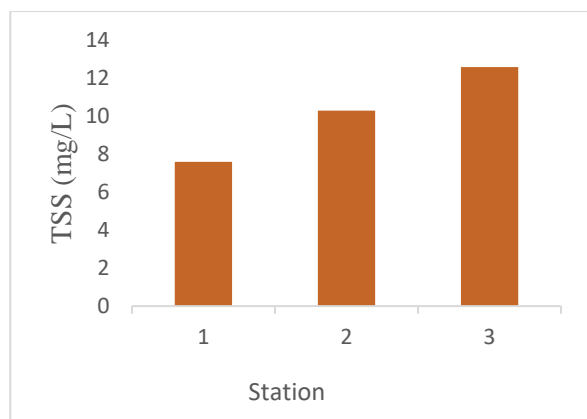


Figure 8. Average TSS

Total Phosphate in Rumbai Pesisir Buatan Lake is relatively the same, ranging from 0.07 to 0.08 mg/L. The highest Total Phosphate value at station 3 was 0.08 mg/L. According to Effendi (2003), waters with high fertility levels are those with phosphate content ranging from 0.051 to 0.1 mg/L. Based on the Total Phosphate value, Rumbai Pesisir Buatan Lake can be said to be waters with high fertility levels. This is because there are trees around Rumbai Pesisir Buatan Lake. The presence of dry leaves from trees that fall into the lake waters causes an increase in the total phosphate value. In addition, the source of phosphate in the Buatan Lake also comes from domestic waste. This nutrient source can contain high phosphate, which then flows into the lake. Total Phosphate in lake waters also causes eutrophication. The addition of nutrients such as phosphate to the lake can trigger eutrophication, which is an increase in the growth of algae and aquatic plants. Excessive algae growth can change the dynamics of the lake ecosystem, change water quality, and can cause a decrease in dissolved oxygen in the water, which in turn can affect other aquatic organisms. In addition, high phosphate levels also come from fish farming in floating nets that come from the use of fish feed.

Rumbai Pesisir Buatan Lake is also used by the community as a location for fish farming. This can trigger high phosphate in the waters. Research by Tatangindatu *et al.*, (2013) showed that phosphate is also produced from discarded pellet feed. Not all pellet feed given to fish is eaten by fish, some is carried away by the current caused by the movement of fish

when fighting for food. The total phosphate content in this study can be said to be not too different compared to the phosphate content in other waters, such as Lake GOR Limboto with the lowest phosphate content of 0.7 - 1.6 mg / L (Lihawa *et al.* 2017). Based on the research results, the total phosphate in the Rumbai Pesisir Buatan Lake no longer meets the class II quality standard, namely 0.03 mg/L (PP No. 22 of 2021).

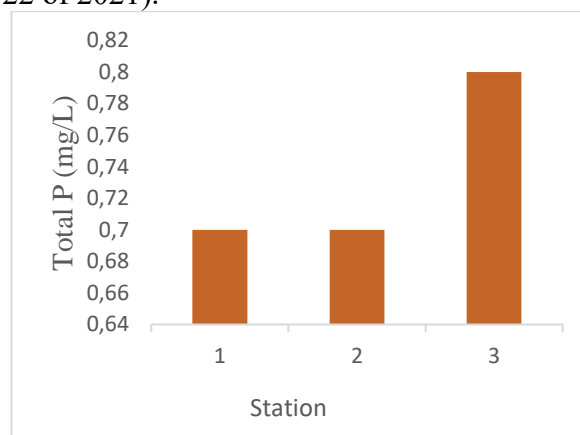


Figure 9. Average Total Phosphate

The total nitrogen (TN) in the Buatan Lake varies, ranging from 5 to 18 mg/L. According to PP Number 22 of 2021 (class II), the total nitrogen value in lake waters is 0.75 mg/L. This shows that the total nitrogen in the Buatan Lake has passed the quality standard. Total nitrogen can exceed the quality standard in lake waters when the nitrogen content in the waters increases beyond the predetermined threshold value, which can cause a decrease in water quality. Increased nitrogen concentrations in lakes can come from various sources, including tourism waste, domestic waste, agricultural and other human activities. Excessive nitrogen levels in Buatan lake waters will have an impact on increasing nutrients and ultimately eutrophication. The high TN concentration in the water causes rapid algae growth, leading to significant fish mortality. One important limiting factor for lake eutrophication has been shown to be total nitrogen (Xia *et al.* 2024). Furthermore, nitrogen transformation activities may produce hazardous chemicals in eutrophic environments, posing major dangers to human health (Brooks *et al.* 2016). As a result,

maintaining the ecological health of lakes depends heavily on the efficient monitoring and control of their total nitrogen content.

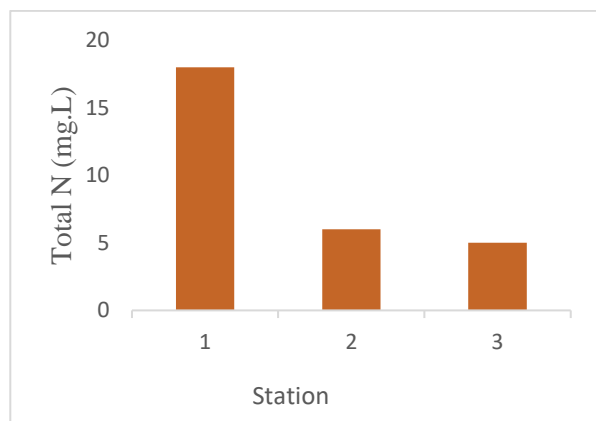


Figure 10. Average of Total Nitrogen (TN)

Chlorophyll-a shows in Figure 11, the maximum value at S3 (13.8 mg/m³), while the minimum is at S1 (7.8 mg/m³). This value indicates that waters are less productive and are classified as oligotrophic. Chlorophyll-a in waters is very dependent on the nutrient element, namely P. Therefore, the high chlorophyll-a at station S3 is caused by higher levels of p. According to Avila *et al.*, (2023), chlorophyll-a, it is very dependent on light, temperature, and nutrient content in waters such as N and P. The claim made by Surga (2000) that phosphorus and chlorophyll-a are directly associated supports this as well.

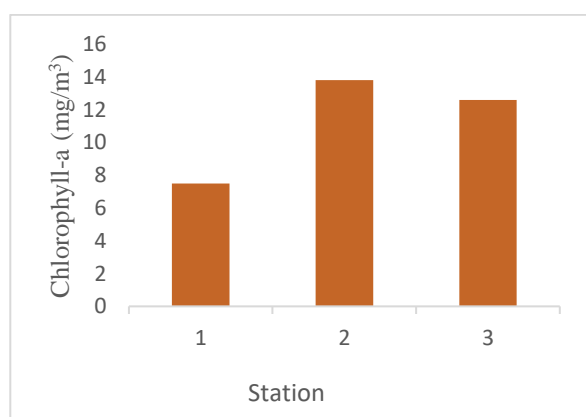


Figure 11. Average Chlorophyll-

In the Buatan Lake, *F. coliform* concentrations ranged from 10,666 to 28,333 MPN/100 mL (Figure 12). The classification is very high because the value is very far from the established quality standards. Thus, the Buatan

lake has been polluted by *F. coliform* bacteria. These bacteria are indicators of the presence of fecal waste in water. Sources of *F. coliform* bacteria include tourism activities at the lake. Visitors still throw trash directly into the lake. Apart from that, the source of bacterial pollution also comes from household waste from settlements around the lake. The lake water is contaminated with human and animal waste, causing the biological quality to decrease. The contamination of the lake by bacteria shows that the lake water is not suitable for sanitation and hygiene for people's daily needs (Daramusseng & Syamsir, 2021).

To determine the effect of activities around the Buatan Lake on water quality status was determined using the Pollution Index (IP) method. The average IP results in the lake waters range from 3.3 to 4.2. Water quality status data can be seen in Table 4.

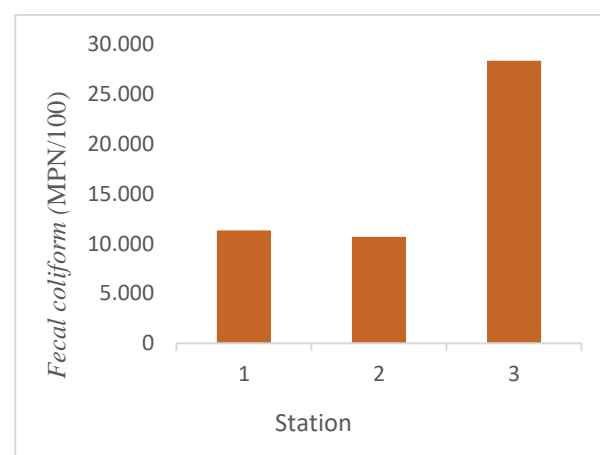


Figure 12. Average Fecal Coliform

Table 4. Water Quality Status Data

No.	Station Point	IP value	Category
1.	1	3,8	Lightly polluted
2.	2	3,3	Lightly polluted
3.	3	4,2	Lightly polluted

This research shows that water quality based on IP is categorized as lightly polluted at all observation stations because the results were ≤ 5.0 (PERMEN-LHK No. 27 of 2021). The

Pollution Index (IP) measurement results show that the highest IP value is at Station 3, while the lowest IP value is at Station 2. The high IP value at Station 3, which is called lightly polluted, is caused by several parameters that exceed class II quality standards, namely BOD ranges from 5.6 to 5.8 mg/L, total phosphate ranges from 0.7 to 0.8 mg/L, total nitrogen ranges from 5 to 18 mg/L, and *Fecal coli* ranges from 10,666 to 28,333 MPN/100 mL. Likewise, the pollution index value in Buatan Lake is not much different from Lake Toba in North Sumatera, which is also in the lightly polluted category. However, Lake Toba is dominated by nutrient content that has exceeded the standard, such as nitrate, nitrate, and ammonia (Silaban and Silallahi 2021). The increase in IP value at Station 3 was caused by floating net activities (KJA), which could indirectly cause an increase nutrient in the lake. Hamblin and Gale (2002), reported that one of the major pollutants generated from aquaculture is nitrogen.

The level of pollution in this Buatan Lake is lower than other sources of fresh water in Pekanbaru City, namely rivers. The research results of Yuliati *et al.* (2023) show that tributaries in Pekanbaru City experience light pollution, such as the Sibam River and Air Hitam River, with a pollution index ranging from 1.75 to 3.57. Both rivers are polluted mainly from organic matter with high BOD indicators and low DO levels. Thus, it is necessary to control efforts such as using multilevel floating net cages so that the remaining feed can be utilized by detritifera fish. In addition, pollution control is carried out by treating waste before it is discharged into the lake.

Conclusion

The existing condition of the Buatan Lake in this study is polluted, as indicated by the parameters BOD, total phosphate, total nitrogen, and fecal coli, which have passed class II quality standards based on Government Regulation Number 22 of 2021. The water quality status of the Buatan lake is based on the Pollution Index (IP) in this study, which is

included in the lightly polluted category. Based on the results of the research that has been carried out, the government or management of the Buatan Lake is advised to take steps to improve the water quality of the lake. It is necessary to carry out routine cleaning and water quality management of activities around the Rumbai Pesisir Buatan Lake, such as waste from tourism activities, wastewater for residential areas, and KJA activities in the Rumbai Pesisir Buatan Lake.

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