Water Quality of Lake Rawapening Central Java Based on A Study of Various Water Quality Parameters

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Abstract. An approach that can describe the overall water quality of Lake Rawapening at a given time and location is based on some water quality parameters. The scope of the study includes temperature, degree of acidity (pH), dissolved oxygen content in water (DO), conductivity, and water turbidity. The samples of the physico-chemical parameters of Lake Rawapening's water were carried out in situ using the Horiba Water Cheaker after first calibrating it with pH 4. The measurement results were then compared with Government Regulation No. 22 of 2021 to determine the water quality. The aim of this research is to analyze the water quality of Lake Rawapening in general. This water quality information can be used by decision-makers to manage Lake Rawapening water properly and correctly. Water quality sampling is carried out using purposive random sampling, which is a technique that is determined deliberately based on considerations. Sampling of the physico-chemical parameters of Lake Rawapening water was carried out in situ. The results of measuring the dissolved oxygen of Lake Rawapening water varied between 3.97 mg/L and 9.89 mg/L. This shows that Lake Rawapening water still meets class III and class II water quality standards. The pH value of the water ranges from 07.10 to 07.40 and still meets water quality standards. The TDS (total dissolved solid) value ranges from 0.13 mg/L to 0.20 mg/L. The water turbidity value ranges between 77.97 NTU and 426.47 NTU, and the electrical conductivity (EC) value is in the range of 0.19 mS/cm and 0.29 mS/cm.

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1 Introduction

A lake is a basin on land that is filled with water. Lakes are often associated with rivers, or sometimes seen as part of a widening river, so that lakes have inlet and outlet streams. But in reality not all lakes are related to rivers. Many lakes are water traps that have no inflow or outflow. Not all lakes are permanent, they can be flooded in the rainy season but dry up in the dry season [1]. These inland waters have major functions both ecologically and socioeconomically. Ecologically the lake functions as a place to carry out the ecological cycle of water components and the aquatic life in it. The existence of the lake is very influential on the condition of the ecosystem around it, and vice versa the condition of the lake will also be affected by the state of the ecosystem around it. Socioeconomically the existence of the lake is directly related to the lives of the people around it. The lake functions to provide environmental services, comfort, education, socio-ecology, spiritual services, culture, society, economy, community resilience and also has an entertainment function [3]. The water that fills Lake Rawapening comes from various scattered springs and rivers that flow into the lake. The rivers that contribute to supplying water are the Muncul River, Pentung River, Panjang River, Galeh River, Torong River, Legi River, Rengas River, Parat River, and Praginan River. The existence of all these rivers supply around 60% of Lake Rawapening's water. Muncul is the largest river that supplies water, which is about 20% of the volume of Rawapening water. The watershed in the Rawapening area has an area of 25,079 hectares covering 72 villages with a slope from 0^o to 45^o on Mount Merbabu and Mount Telomoyo [1]. The utilization of Lake Rawapening is not only for fishing activities, both capture and cultivation, but also for irrigation, duck farming, peat mining, hydroelectric power and tourism. The production of cultured fish in the Rawapening area is 1,535.9 tons/year. The power plant that utilizes the Rawapening water body can generate 222.504 million Kwh. Technically, irrigation covers 1,265.09 hectares of rice fields [5].

The neolimnological condition of Rawapening that experienced physical eutrophication can be seen from the abundant population of water hyacinth (*Eichhornia crassipes*) which is growing rapidly. In 2005, it was observed that water hyacinth covered the waters up to 65% or more, up to 70%, in the dry season [4]. It is necessary to continuously monitor the water quality of Lake Rawapening on various water quality parameters as an effort to maintain and preserve the existence of the lake. Currently, various data processing methods have been applied so that the data obtained in various studies regarding lake quality can be displayed into more communicative and easy-to-use information. The existence of water quality data and information that is continuously updated can certainly be used as a basis for determining policies in the management of Lake Rawapening. The water quality index (Water Quality Index, WQI) is a method that expresses water quality in a simple way that can respond to changes in the basic characteristics of water and then converts complex water quality parameter data into easy-to-understand information [8].

In research on the water quality of Lake Rawapening in Central Java, the scope of the study was used as a limitation of the scope of the study including: temperature, degree of acidity (pH), dissolved oxygen content in water (DO), conductivity and water turbidity. The aim of this research is to analyze the water quality of Lake Rawapening in general. This water quality information can be used for decision makers to manage Lake Rawapening water properly and correctly [8].

2 Methodology

The research was carried out in the Lake Rawapening area which is administratively located in Semarang Regency, Central Java Province. The research began in the first week of May 2020 and ended in March 2021. Three research stations were determined because they had different environmental characteristics. Site I is located in the Rowoboni Village area, Banyubiru District with coordinates 7°18'31"S 110°25'25"E which is a tourism area as well as a business center for freshwater fish farming using cages. Site II is located in the Bejalen Village area, Ambarawa District with coordinates 7°16'32.0"S 110°25'05.5"E which is naturally far from aquaculture, agriculture and tourism activities. Meanwhile, Site III is located in Asinan Village, Bawen District with coordinates 7°16'04 "S 110°26'50" E, which is the upstream of the Tuntang River, which is a peat mining area. The sampling locations are presented in Fig 1.

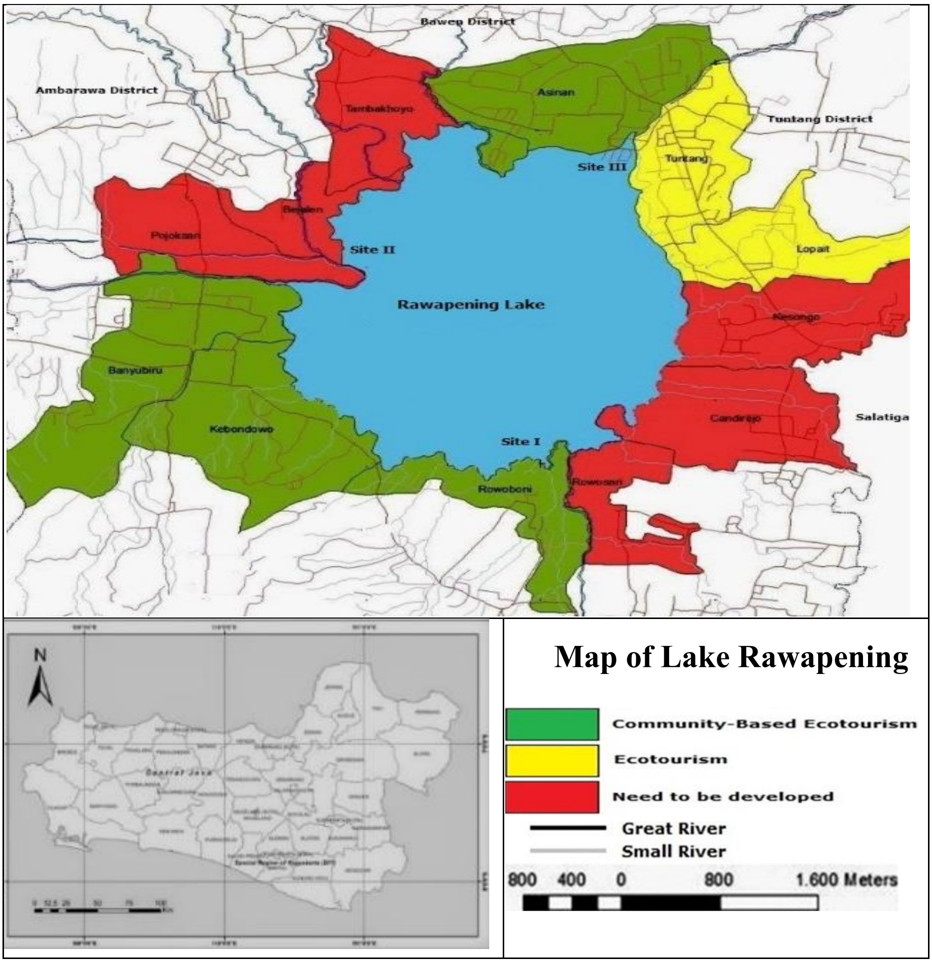

Fig. 1. Map of Lake Rawapening Water Quality Sampling

Sampling of water quality was carried out by purposive random sampling, a technique that was determined deliberately based on the considerations. Samples of the physico-chemical parameters of Lake Rawapening water were carried out in situ using the Horiba Water Cheaker by first calibrating it with pH 4. The probe part of the water checker was inserted into the water until the change in the number on the tool stopped, so that the screen would display the pH measurement results, temperature, and turbidity. Measurement of dissolved oxygen content in water by dipping the Horiba Water Checker probe into lake water, the results will be displayed on the device screen. Likewise, with the parameters of pH, TDS, conductivity, and turbidity. Measurements were taken three times at the same GPS-validated location: morning (07:30–08:00 AM), afternoon (12:30–01:00 PM), and night (07:00–07:30 PM). The water depth in the measurements was the same at all research stations, namely at a depth of 1 m in order to obtain data from the same water layer. All measurement results are recorded in the tabulation of water quality data which is then analyzed descriptively qualitatively, which describes the existing conditions analytically and synthesizes them integrally. The results of water quality measurements in this study were compared with water quality standards in accordance with Government Regulation No. 22 of 2021 [9].

3 Result

Sampling of water quality parameters was carried out in a time series for four weeks to determine the trend of changes in water quality in Lake Rawapening from time to time. Water quality parameters measured during the research process include temperature, dissolved oxygen content in water (DO), degree of acidity (pH), Total Dissolved Solid (TDS), conductivity and water turbidity. The results of the measurement of the water quality of Lake Rawapening are shown in Table 1 and Table 2.

Table 1. Concentration (mg/L) of Total Phosphorus Average and Total Nitrogen Average in Lake Rawapening

Site	Total Phosphorus Average (mg/L)	Total Nitrogen Average (mg/L)
Site I	0.156	1.120
Site II	0.068	1.680
Site III	0.011	1.120

Table 2. Results of Measurement of Lake Rawapening Water Quality Parameters

Parameter	Site	Morning	Afternoon	Night	Class Based on Government Regulation Number 22 of 2021	Explanation
Temperature (°C)	Site I	28.24	32.13	29.47	Deviation 3	Deviation from natural state
	Site II	28.17	32.39	27.72	Deviation 3	
	Site III	27.76	31.65	28.31	Deviation 5	
Dissolved Oxygen (DO, mg/L)	Site I	5.75	6.83	7.20	6	Minimum threshold value
	Site II	3.97	8.20	8.89	4	
	Site III	6.19	8.62	7.15	3	
pH	Site I	7.17	7.30	7.10	6–9	If naturally outside the range, determined by scientific justification
	Site II	7.36	7.40	7.16	6–9	
	Site III	7.16	7.25	7.26	6–9	
Total Dissolved Solids (TDS, mg/L)	Site I	0.15	0.17	0.13	1000	–
	Site II	0.20	0.15	0.19	1000	
	Site III	0.17	0.15	0.15	1000	

Parameter	Site	Morning	Afternoon	Night	Class Based on Government Regulation Number 22 of 2021	Explanation
Electrical Conductivity (EC, mS/cm)	Site I	0.19	0.26	0.20	–	–
	Site II	0.29	0.22	0.23	–	
	Site III	0.26	0.25	0.23	–	
Turbidity (NTU)	Site I	127.70	156.80	77.97	–	–
	Site II	426.47	257.83	160.65	–	
	Site III	183.13	180.80	96.87	–	

4 Discussion

The water quality of Lake Rawapening is influenced by polluting materials that enter the water body from various sources. Sources of pollution can come from river flows, domestic waste from the lake area community, tourism activities, agriculture and aquaculture. The quality of water in Lake Rawapening will determine the rate of processing and the level of water productivity that can be produced. Water quality will be useful in determining the standard of living and living of aquatic biota, the availability of feed, the level of water fertility and the ability of water productivity. In accordance with its function and role, the water quality shown through the assessment of each variable will have a feasibility limit and water fertility indicator for water productivity, especially aquaculture activities.

Measurements of the average phosphorus and average total nitrogen show that Lake Rawapening is eutrophic to hypereutrophic (Table 2). Household waste and agricultural activities that enter water bodies are the main contributors to the air pollution process, apart from fishing activities. The eutrophication conditions that occurred in Lake Rawapening were similar to those that affected the Batujai Reservoir, as described in the research of Rahim and Soeprobowati [7].

Temperature is one of the water quality parameters that has an important influence in the waters of the lake/reservoir. The temperature at all research stations in general is still in accordance with water quality standards in all classes. Class III water quality standard In accordance with Government Regulation Number 22 of 2021, the water temperature has a standard deviation of 3. Deviation 3 in the water quality standard can be interpreted as + 3°C from the normal temperature of the water. This means that if the normal temperature of class III water is 29°C, then the criteria for class III water quality standards provide water temperature limits in the range of 26 - 32°C. Water temperature measurements were carried out directly at the research site using the Horiba Water Checker at a depth of 1 m at different times, namely morning, afternoon and evening.

The results of measuring the temperature of Lake Rawapening in time series ranged from 27.76 - 32.39°C. The highest temperature during the day measurement ranged from 31.65 - 32.13°C during the day followed by the time of night taking, which ranged from 28.31 - 29.47°C and the lowest was in the morning, which was around 27.76 - 228.24°C at night. The temperature range is higher during the day because the measurement is in full sunlight, especially when sampling is already in the summer. While the lowest temperature was obtained during the morning measurement because one night there was no sun exposure, so the water temperature in the morning was still cold, even though there was morning sun exposure, but it was not able to increase the thermal conditions in the water. Water temperature measured at night (19:00–19:30 PM) was slightly lower than during the day, reflecting reduced solar radiation after sunset. This shows that the water temperature has decreased thermally but not significantly so that it is still higher than the water temperature in the morning measurement. The thermal level of Lake Rawapening according to Government Regulation No. 22 of 2021 is still suitable for aquaculture (Class II and Class III), with a deviation of 3 and a good water temperature tolerance for optimal growth for some freshwater fish such as tilapia and carp is 28°C.

The high and low water temperatures have a mutually influencing relationship to pH and oxygen. The three physical parameters of the waters can be an indication of the dynamics in the waters, the potential for high and low productivity and the occurrence of chemical evolution in the waters [12]. The important role of temperature in the waters is to be one of the determining factors for ecological processes in water bodies. The vertical temperature profile also plays an important role in determining the concentration of heat, the thermocline layer and the mixing of water masses in the waters.

Temperature has a direct influence on the process of photosynthesis and also physiological processes in animals (degrees of production and metabolism processes) related to how to eat and their growth rate [14]. The rise and fall of temperature is influenced by the depth of the water and the level of brightness. In shallow waters that have penetration of sunlight can increase the temperature of the water body. The brightness of water depends on the level of turbidity and the color of the water. The brightness value itself is strongly influenced by weather conditions and the time of measurement. Waters that can be penetrated by sunlight to the bottom provide the carrying capacity for aquatic plants to carry out the photosynthesis process properly.

Dissolved oxygen (DO) concentrations in Lake Rawapening ranged from 3.97 to 9.89 mg/L across all sampling periods. Based on this value, it shows that the water of Lake Rawapening still meets the water quality standards for class III and class II. The DO parameter of Lake Rawapening water when compared with class I water quality standards also still meets because only in the morning measurement only low values are obtained, namely 3.97 mg/L at station II and 5.75 mg/L at station I. DO levels The water of Lake Rawapening is considered good for freshwater aquaculture activities because it meets the threshold set by Government Regulation No. 22 of 2021 [6].

The difference in DO measurement time showed different results, in the morning measurement the lowest DO levels were obtained, which ranged from 3.97 - 6.9 mg/L with an average of 5.3 mg/L. The highest DO levels were obtained during daytime measurements, which ranged from 6.88 - 8.62 mg/L with an average of 7.89 mg/L. While the measurements at night ranged from 7.15 - 8.89 mg/L with an average of 7.74 mg/L and the difference was 0.15 mg/L lower than the daytime measurements. The high and low concentrations of DO in the waters are influenced by the increase in water temperature [14]. It is expected that dissolved oxygen (DO) levels are higher during the day compared to measurements taken in the morning or at night, due to increased photosynthetic activity. While the DO measurements made at night are in second place, the result proves that the water temperature has decreased thermally but not significantly so that it is still higher than the water temperature in the morning.

The pH measurements of Lake Rawapening recorded a highest value of 7.40 at Station II during the day, while the lowest value was 7.10 at Station I at night. According to Government Regulation No. 22/2021, the pH range of 7.10–7.40 at all stations and times meets the water quality standards for Class I–III (6.0–9.0). Most aquatic biota are sensitive to the dynamics of changes in water pH and tend to like pH values ranging from 7 to 8.5 [15]. A pH value that is too low (acidic) which is 8 can affect the value of the toxicity of chemical compounds. Water has a dangerous toxicity when the pH value is low and under anaerobic conditions. The high and low pH values are also influenced by the oxygen concentration at the bottom of the water. Low oxygen levels at the bottom of the water will slow down the process of decomposition of organic matter which causes the degree of acidity of water with a low pH value. The impact is the formation of toxic compounds (H2S, NH3) that are harmful to life in the waters.

When the oxygen concentration increases, the sulfur will be oxidized to ions such as sulfate which causes a decrease in the formation of hydrogen sulfide. The pH value in the waters greatly determines the change in sulfur (H2S, HS-, S2-). An increase in the pH value of water can cause the percentage of hydrogen sulfide to decrease [3]. Waters with a high pH (alkaline) atmosphere >10 increase the amount of toxic non-ionized ammonia. So we can understand that water with a pH value that is too acidic and too alkaline can kill living things in the waters.

The results of the measurement of the water quality parameters of Lake Rawapening show that the TDS (Total Dissolved Solid) value ranges from 0.13 - 0.20 mg/L. Station II has the highest TDS with 0.18 mg/L. Next is station III with an average TDS value of 0.156 mg/L and the lowest is at station I with a TDS value of 0.15 mg/L. The TDS of Lake Rawapening water comes from anthropogenic processes derived from organic materials.

Based on observations in the Lake Rawapening area, TDS comes from household domestic waste pollution, aquaculture activities in floating net cages, agriculture and tourism. Meanwhile, the Total Suspended Solid (TSS) in Lake Rawapening is composed of fine sand, mud and micro-organisms. TDS and TSS values in waters are strongly influenced by waste entering water bodies through water flow and rainwater runoff which causes TDS and TSS values to be higher in the rainy season than summer. Sedimentation that occurs in the waters is one of the determining factors for the high and low values of TDS and TSS of water. In Lake Rawapening, the sedimentation rate is closely related to the rate of land erosion as well as the rate of sedimentation due to the presence of water hyacinth in water bodies and in the Rawapening sub-watershed.

The rate of erosion that occurs in the Sub-watershed Rawapening is 1,767.08 tons/Ha. The sub-watersheds with the largest erosion rates include the Legi sub-watersheds, Parat sub-watersheds and Ringis sub-watersheds with erosion rates of 4,230.51 tons/ha in Legi sub-watersheds, 2,863, 62 to/ha in Parat sub-watershed and 2,560.83 ton/ha in Ringis sub-watershed. Meanwhile, the total sedimentation originating from erosion and weathering of water hyacinth in Lake Rawapening is estimated at 4,111,109.10 tons . The high level of erosion in the Lake Rawapening area can be seen from the physical characteristics of river water entering the water body which is brownish in color as an indicator that it has carried soil particles.

The value of the water turbidity of Lake Rawapening ranges from 77.97 - 426.47 NTU. The highest turbidity was found in measurements at station II, which ranged from 160.65 - 426.47 NTU, with the highest value in the morning measurement, which was 426.47 NTU. The lowest turbidity is at station I with values ranging from 77.97 - 156.80 NTU. Furthermore, at station III with a turbidity value of 96.87 - 183.13 NTU. Turbidity itself is a condition of blurring of the liquid that occurs due to the presence of particles (suspended solids) which are generally invisible to the eye. Water turbidity greatly affects the penetration of sunlight into the lake's water body, thus affecting the photosynthetic reaction. Materials in the form of non-toxic solids such as clay can interfere with the organs of vision, body surface and also gills, especially in fish. This condition can lead to changes in the behavior of aquatic biota, for example in fish that reject cloudy water, eating disorders and increasing efforts to find shelter [3].

An increase in turbidity of 5 NTU in the waters resulted in a decrease in primary productivity of up to 75%. Aquatic biota affected by the increasing turbidity in Lake Rawapening include Nilem fish (Osteochilus vittatus) whose population is decreasing. The decline in the Nilem fish population is due to the character of the species that grows well in clear waters, but the current condition of Lake Rawapening's water is cloudy.

The value of Electrical Conductivity (EC) is in the range of 0.19 - 0.29 mS/cm. The lowest EC value was obtained from measurements at station I, which ranged from 0.19 - 0.26 mS/cm with an average of 0.21 mS/cm. Meanwhile, at station II and station III, the EC value was obtained with the same average of 0.25 mS/cm. The level of ions in the solution according to, is influenced by the solids dissolved in it. The higher the amount of dissolved solids in the water, the higher the possibility of the number of ions present, so the conductivity value will be greater. A higher EC value is an indicator of worsening conditions in fresh water, for example the taste of water becomes brackish to salty. Meanwhile, the lower the EC value of the water, the more difficult it will be to deliver the current so that the water quality is getting better. According to WHO standards, the maximum EC value for drinking water is 1500 mS/cm.

5 Conclusion

The water quality of Lake Rawapening as a result of the measurement of temperature, DO, pH, TDS and conductivity parameters still meets the good criteria according to the water quality standard (BMA) stipulated in Government Regulation Number 22 of 2021.

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