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Water Quality Analysis Based on Chemical and Physical Parameters in the Acai River, Jayapura City

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Abstract. The Acai River functions as a primary channel located in the middle of Abepura City, which ends downstream at Yotefa Bay. The presence of various anthropogenic activities can provide a pollution burden to the environment, one of which is the decline in river water quality. This study aims to determine the water quality of the Acai River in Jayapura City. The study was conducted by collecting data through surveys and taking river water samples at six points. The parameters studied included temperature, water color, pH, TDS, DHL, BOD, and COD. The results of the study showed that the concentrations that exceeded the class II water quality standard limits, namely the BOD and COD concentrations at stations 1, 2, 3, 4, 5, and 6 exceeded the quality standard limits. Based on the Pollution Index value, at stations 1, 2, 3 the conditions were lightly polluted, while the conditions at stations 4, 5, 6 were classified as moderately polluted. It can be concluded that from upstream to downstream the water quality of the Acai River has increased in its water quality parameters

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1. Introduction

Water quality criteria are a standard basis for the requirements of water quality that can be utilized. Water quality standards are regulations prepared by a country or a region concerned. Water quality can be determined by conducting certain tests on the water. The tests carried out are chemical, physical, biological, or appearance tests (odor and color). Water quality management is an effort to maintain water so that the desired water quality is achieved according to its intended use to ensure that the water condition remains in its natural condition.

The Acai River functions as a primary channel located in the middle of Abepura City, the downstream of which ends at Yotefa Bay. Garbage is a sight in the Acai River, Abepura District, Jayapura City, Papua, which is visible before our eyes. On average, the garbage is dominated by used plastic bottles or garbage that is difficult to dissolve in water. During the rainy season, the volume of garbage increases two-fold, caused by garbage originating from drainage channels from housing that flow into the Acai River, all carried by the strong current in the drainage channels. This is exacerbated by the many tofu factories and animal cages that discharge their wastewater into drainage channels directly into the Acai River. During the rainy season, the riverbanks/Acai River often experience flooding.

In addition, waste that is dumped into the river will cause the quality of river water to decline, and can even cause diseases caused by an unclean or unhealthy environment. In addition, there is also shallowing of the river due to soil deposits eroded by water caused by flooding. Pollution of the Acai River can also cause pollution to the sea water of Yotefa Bay.

2. The Methods

This research is a qualitative descriptive research. The researcher describes the situation of the research location according to the actual conditions. The data collected is the water quality of the Acai River, Abepura, Jayapura City, Papua Province. Figure 1 shows the water sampling stations carried out at three (6) points that have the potential to be exposed to pollution.

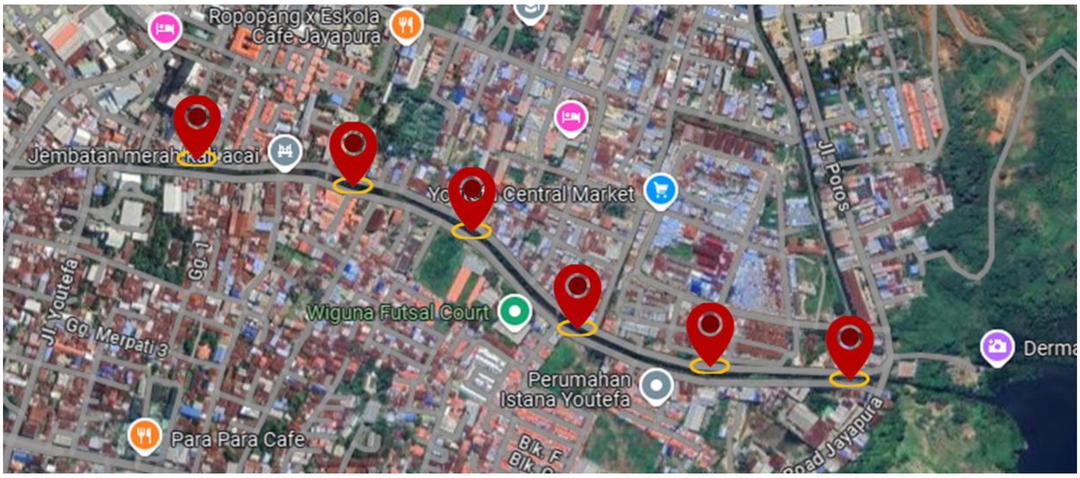

Figure 1. Research location.

The data collection method is through observation and documentation. This observation method is used to take river water samples and observe the behavior of the local community. The research was conducted from March to August 2024. The sampling time was around 08.00 am. This time was chosen because people have started to do a lot of their activities. Sampling using purposive sampling technique. By using purposive sampling, researchers can determine the right sample to be used as a research target.

The research instruments are observation sheets and cameras for data collection through observation. In addition, various materials and equipment are needed for river water sample analysis. The equipment is a sample bottle, spectrophotometer, filter paper, thermometer, aluminum foil, cool box, and GPS. The materials used are river water, distilled water, 90% acetone. Water sampling at each station uses a special 1000 cc jerrycan. The water quality parameters tested from river water samples for the physical and chemical aspects of water. The physical parameters include temperature and water color. Furthermore, the chemical parameters include pH, BOD, and COD.

The data were analyzed using three methods, namely data reduction, data presentation, and drawing conclusions based on the Miles and Hiberman model (2014). Meanwhile, water samples were analyzed by the Advanced Physics Laboratory of FMIPA and the Chemistry Education Laboratory. The water quality standards used are based on the Government Regulation of the Republic of Indonesia (PP RI) No. 22 of 2021 concerning the Implementation of Environmental Protection and Management (PP RI, 2021).

3. Result and Discussion

Acai River water is a surface water body. Based on Government Regulation No. 22 of 2021, the water quality standards for surface water bodies use class II water quality standards (PP RI, 2021). The definition of class II water is water that can be used for water recreation infrastructure/facilities, freshwater fish farming, livestock, irrigation of crops, and/or other uses. The results of laboratory analysis for water samples are listed in Table 1.

Table 1. Results of physical and chemical parameter measurements in the Acai River

Parameter	Unit	BM 2	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Temperature	(°C)	Deviation 3	29, 0	29.5	29.6	28.9	29.4	29.0
pH	-	6.0 – 9.0	6.9	7.0	6.6	7.1	6.5	7.1
Color	TCU	50	24	37	45	55	58	58
Smell	-	-	No smell	No smell	Smell	No smell	Strong smell	No smell
TDS	(mg/L)	1,000	377	400	436	394	692	456
DHL	(ms/m)	200	0.52	0.56	0.61	0.54	0.96	0.64
Saturation	-	-	76	59	29	72	38	72
DO	(mg/L)	4	4.78	4.14	5.14	5.08	5.44	5.69
BOD 5	(mg/L)	3	3.06	3.11	4.03	4.26	4.75	4.85
COD	(mg/LO2)	25	26	29	35	36.8	37.5	39

Table 1 displays the results of physical and chemical parameter measurements at three research stations shows that the water quality largely exceeds the class II quality standard, meaning its quality is poor. This indicates that the water has been polluted.

The temperature in the Acai River did not differ significantly at each station where at station 1 the temperature was 29 °C, station 2 was 29.5 °C, station 3 was 29.6 °C, station 4 was 28.9 °C, station 5 was 29.4 °C and station 6 was 29 °C. The temperatures measured were almost the same due to the inaccuracy of the equipment used in the field. The temperature conditions were still within the water quality standard threshold based on PP No. 22 of 2021, namely deviation 3, which means that if the normal water temperature is 27 °C, the Class II criteria limit the water temperature to a range of 24–30 °C. According to Masykur et al. (2018), water temperature affects the life of the biota in it. Therefore, because the temperature in local waters is still below the standard quality limit, it means that the temperature of the river water can still support life in the waters.

At stations 1 to 6, the temperature is almost stable with a difference of 0.5 °C at each station, this is possible due to similar geographical conditions. Based on observations, the research location in Kali Acai has the same width and depth so that the temperature can be maintained and tends to be stable. On the riverbank, some are still covered by trees so that the water temperature does not increase. In addition, indications of river water waste do not greatly affect the temperature of the water at each Kali Acai station.

The results of laboratory analysis on chemical parameters, namely the degree of acidity (pH), show that the pH concentration score at each station, although the river water is polluted, is still below the established water quality standards. The results of the pH analysis at 6 observation stations were 6.6–7.1. The highest pH value was obtained at stations 4 and 6, namely 7.1, and the lowest value was obtained at station 3, namely 6.6. Based on the data, the pH value is still below the water quality standard value regulated in PP No. 22 of 2021, namely 6.0-9.0. With this pH range at each water observation station in the Acai River, microorganisms that decompose waste contamination can live. According to Astuti et al. (2017), what affects the pH value in water is the presence of household waste, industrial waste, and photosynthesis. Thus, pollution at the research location in the Acai River has not increased the pH value to exceed the water quality standard limit.

Based on the results of the color parameter analysis, the color score at each station has not exceeded the predetermined threshold. This is indicated by the river water which is still clear and also greenish in color. The color score at stations 1 to 3 ranges from 24 - 45 TCU, below the water quality standard value in PP No. 22 of 2021, which is 50 TCU. Meanwhile, the color score at stations 4 to 6 ranges from 55 - 58 TCU, which is above the water quality standard value in PP No. 22 of 2021, which is 50 TCU. The different colors of river water are influenced by the presence of dissolved materials in the water and also the influence of turbidity due to the entry of organic waste and the presence of microorganisms such as algae and phytoplankton in the water. In addition, according to Hudiyah & Saptomo (2019), rainy weather can also affect the increase in water color, due to sedimentation and soil erosion in the river body. Therefore, because this study was conducted in the dry season, the rainy weather factor did not have a significant effect.

Based on the results of the TDS test by Gravimetry, the TDS levels from station 1 to station 6 are around 377 (mg/L) to 456 (mg/L). The TDS levels in Kali Acai are below the standard class 2 value of 1000 (mg/L). This TDS value could be caused by soil runoff and rock weathering. A lower TDS value indicates that the water has good quality and is slightly contaminated by minerals or dissolved solids. A low TDS value can also indicate that the water may lack essential minerals needed by the body.

The results of electrical conductivity measurements at 6 sampling stations show that the lowest DHL value is at station 5, which is 0.96 ms/m. While the DHL value obtained at station 6 is 0m52 ms/m. The DHL value will increase along with the increase in TDS content in the irrigation water. Research by Desiandi et al. (2010) stated something similar that the higher the TDS content, the higher the DHL value in the water. According to Effendi (2003), TDS is usually caused by inorganic materials in the form of ions that are commonly found in waters where the amount of ions or salts dissolved in water will greatly affect the ability of water as an electrical conductor. Therefore, the more ions in a body of water, the greater the DHL value in the water.

DO is the amount of dissolved oxygen in water. The higher the DO content, the better the water quality. Based on the results of laboratory tests on chemical parameters, namely DO, the DO values at the six stations ranged from 3.06 mg/L – 4.85 mg/L. Based on the water quality standard in PP No. 22 of 2021, the DO parameter has a value of > 4 for class II water category. The DO values at stations 1 – 6 do not meet the water quality standard because they are above the threshold for oxygen requirements in the waters that have been set. The high DO values at stations 1,2,3,4,5 and 6 are caused by the photosynthesis process by aquatic plants such as phytoplankton which produce oxygen in the waters. According to Panggabean (2017), phytoplankton are able to produce dissolved oxygen during the photosynthesis process, where solar energy absorbed by chlorophyll is used to break down water molecules, reduce NADP to NADPH and form oxygen gas.

Biochemical Oxygen Demand (BOD5) is a term often used to indicate the amount of oxygen needed to decompose organic matter aerobically. Based on the results of laboratory tests on chemical parameters, namely BOD, the BOD 5 value at the six stations ranged from 1.75 mg/l to 4.66 mg/l. The high BOD values at stations 1,2,4 and 6 indicate the presence of organic pollutants that are decomposed by bacteria biologically. The presence of residential areas around the river is thought to provide a load of organic pollution such as food waste, urine, washing water and so on that are dumped into the river. BOD in waters comes from organic materials that are composed by microorganisms aerobically. According to Salmin (2005), in aerobic conditions, the role of oxygen is to oxidize organic and inorganic materials with the end result being nutrients that can provide fertility to the waters. If a body of water has a high level of fertility, algae blooming will occur, algae blooming causes sunlight to be blocked from entering the bottom of the waters, thus disrupting the photosynthesis process carried out by aquatic plants such as phytoplankton. If the photosynthesis process in water is disrupted, the dissolved oxygen levels in the water are low, thus disrupting the respiration process and the decomposition process of organic and inorganic materials in the water. According to Djoharam (2018), the high BOD value indicates the lower water quality. This is because the higher the BOD value, the more dissolved oxygen is needed by decomposing microbes for the decomposition process of organic materials and causes the DO value to decrease. The decrease in oxygen content in waters causes aquatic biota to die due to the lack of oxygen in the waters. According to Daroini (2020), high BOD content can reduce the fish population in waters.

Chemical Oxygen Demand (COD) is a term used to describe the total amount of dissolved oxygen needed to chemically oxidize organic matter, both biodegradable and non-biodegradable. Based on the results of laboratory tests on chemical parameters, namely COD, the COD values from the three stations ranged from 26 mg/l to 39 mg/l. The COD values at stations 1,2,3,4,5, and 6 exceeded the water quality standards set by PP No. 22 of 2021, which is 50 mg/l for class II water category. The high COD value is thought to be due to community activities around the river such as bathing and washing. The presence of chemical substances in detergents and soaps such as surfactants, sodium, sulfonates and so on which are difficult to degrade by bacteria cannot be degraded biologically so that the decomposition process is through a chemical process, this chemical process requires more oxygen than usual. According to Suheriyanto (2013), high COD levels indicate that the amount of organic waste that does not undergo rapid biological decomposition based on BOD5 will accumulate in larger amounts, requiring a larger amount of oxygen to decompose the waste through chemical processes. Meanwhile, high COD values are also thought to be caused by the collision of waste around rivers such as plastic, diapers, and other waste materials. Waste content generally consists of organic and inorganic substances that are difficult to degrade by microorganisms so that the processing process usually occurs anaerobically. According to Fitri et al., (2016), one of the treatments for waste with high organic content is anaerobic processing.

According to Sandi (2017), high COD concentrations indicate a higher level of pollution in a body of water. The higher the COD, the lower the dissolved oxygen content in the water (Wicheisa, 2018). Low oxygen in waters can directly affect the life of aquatic biota in it because oxygen is needed for the respiration, growth, and reproduction processes of aquatic biota. According to Sugianti (2018), most fish in several polluted waters die not because of the direct toxicity of waste materials but because of a lack of oxygen in the waters due to being used for the degradation process of organic matter by microorganisms.

Water quality is not only reviewed from BOD and COD which indicate the level of water pollution, but can also use the water quality method regulated in the Regulation of the Minister of Environment and Forestry No. 27 of 2021 concerning the Environmental Quality Index, namely the Water Pollution Index (KLHK, 2021). This water pollution index is useful for determining the level of pollution relative to the permitted water quality parameters. The following is the Pollution Index value in the Acai River in Table 2.

Table 2. Pollution index values based on physicochemical parameters in the Acai River

Station	Pollution Index (PI) Value	Information
Station 1	3.21	Lightly Contaminated
Station 2	3.86	Lightly Contaminated
Station 3	4.75	Lightly Contaminated
Station 4	5.13	Moderately Polluted
Station 5	6.21	Moderately Polluted
Station 6	7.38	Moderately Polluted

It can be seen that the Pollution Index (PI) value of the Acai River is polluted. At station points 1, 2 and 3, the conditions are slightly polluted because the PI value is <5. While at station points 3, 4, and 6, the river water quality is moderately polluted, because the PI value is already >5. The PI value category at each observation station states that the water of the Acai River has decreased in water quality due to the presence of both organic and inorganic pollutant compounds. The Pollution Index value is used in this study, because according to Effendi (2016), this index is useful for providing quick initial assessment results on water quality status. Likewise, according to Popovic et al. (2016) that the water pollution index can provide a single assessment score, a useful tool for integrating assessment results based on different quality elements. The results of the Pollution Index value at each station also indirectly support evidence that the decline in water quality as reviewed from the BOD and COD concentrations is due to waste pollution in the waters of the Acai River. Domestic waste from households and also food industry waste such as cafes located on the banks of the river is one of the sources of pollution in the Ciliwung River water in this area. According to Brankov et al. (2012), the increase in the value of organic pollution indicators such as BOD is due to uncontrolled domestic wastewater discharge. The results of this study indicate that waste from community activities has a direct impact on river water quality. As stated by Hasan et al. (2019) that water, which is a limited resource, has been threatened by human factors. Therefore, actions to raise public awareness through counseling need to be carried out periodically and strict legal sanctions must be applied to violators.

Conclusion

This research was conducted at the Acai River, Abepura District, Jayapura City, Papua. The study was conducted through five physical and chemical parameters of water, namely temperature, water color, pH, TDS, DHL, Saturation, BOD 5 and COD. The color concentration that exceeds the class II water threshold is the concentration at stations 1 to 3 which ranges from 24 - 45 TCU, below the water quality standard in PP No. 22 of 2021. The DO concentration at stations 1 to 6 does not meet the water quality standard because it is below the oxygen requirement threshold in the waters that have been set. The concentration that exceeds the class II water threshold is the BOD concentration at stations 1, 2, 3, 4, 5, and 6. The COD value at stations 1, 2, 3, 4, 5, and 6 exceeds the water quality standard determined by PP No. 22 of 2021, which is 50 mg/l for the class II water category. The water quality standard used is Government Regulation of the Republic of Indonesia No. 22 of 2021 concerning the Implementation of Environmental Protection and Management.

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