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A Study on the Quality of Mako-mako River Water as Clean and Raw Water Source in Yembekiri Village

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Abstract: This study aims to determine the water quality of the Mako-Mako River based on physical, chemical, and microorganism parameters, as well as the effect of metal and microorganism levels on the color of the water and sediment. Water, sediment, and plankton samples were collected using purposive sampling at three locations: upstream, middle, and downstream. The concentrations of Fe and Mn in water and sediment were analyzed using AAS, while plankton identification was performed using a binocular microscope. The results of the water quality analysis of the Mako-Mako River show that the parameters of temperature, TDS, TSS, and Mn are still below the water quality standard for class 1, except for the Fe and total coliform parameters, whose concentrations have exceeded the standard. The metal content of Fe in the sediment is high and affects the color of the Mako-Mako River sediment, which ranges from reddish-brown to dark brown (deep). The presence of plankton, with a low abundance and diversity index, did not affect the color of the river water or the sediment of the Mako-Mako River. Therefore, a processing treatment is needed to use the Mako-Mako River water as a source of clean and raw water.

Keywords: Mako-mako river; Plankton; Sediment; Water quality

Introduction

Access to clean water remains a major problem for people living in various regions in Indonesia, including West Papua, in environments with marginal raw water, such as brackish water and carbonate rocks. In general, sources of clean water come from groundwater and river water. River water is surface water that comes from rainwater or springs that appear on the ground with various shapes and sizes and can flow from upstream to downstream. The quality of surface water is affected by natural and anthropogenic factors (Akhtar et al., 2021; Khatri & Tyagi, 2014; Puckett, 1995), which cause colored water. The color of the water is divided into two, apparent colors are the colors caused by particles such as soil, sand, sediment, and others that cause turbidity, metal dispersion of Fe, Mn, and microorganisms (Algae) such as Cyanobacteria (Blue- Green Algae) groups such as Oscillatoria sp, Trichodesmium erythraeum, nitrate groups for example Nitrisomonas sp, iron bacteria such as Crenothrix and Sphaerotillus, and sulfur bacteria such as Chromatium and Thiobacillus. Whereas the true color is the color caused by the decomposition of organic substances such as humus, lignin, tannin, and other organic acids.

The Mako-mako River is one of the watersheds located in Yembekiri Village, Rumberpon District, Teluk Wondama Regency. The river has a distance of about 600 m from residential areas which can be reached on foot. The length of the river is ± 3 km and a width of about 1-2 meters with a depth of 25 - 30 cm. Until now, the local community has not used the river as a source of clean water. This is because, along the river flow, there are reddish-brown rocks that cause the river water to appear reddish-brown, which is presumably due to the dissolved metal content, especially Fe and Mn metals, besides the presence of certain types of plankton that affect the color of the river water.

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Drinking water contaminated with different chemicals and heavy metals is released from different natural and anthropogenic sources (Rapant & Krčmová, 2007). The contamination of water resources has important repercussions for the environment and human health (Emmanuel et al., 2009). Utilization of water directly from shallow wells and surface water as a source of clean water has the potential to cause gastrointestinal and parasitic diseases, as well as malnutrition caused by the consumption of water contaminated by pathogenic microbes and high levels of dissolved heavy metals in water will accumulate in the body and adversely affect human health. High concentrations of iron (Fe) and manganese (Mn) can accumulate in the liver and kidneys. Chronic exposure may lead to Fe and Mn poisoning, resulting in nervous system disorders and hyperreflexia (Ye et al., 2017). In addition, long-term exposure to elevated groundwater manganese can result in Parkinson's disease. It causes neurotoxicity by increasing oxidative stress and also disturbing neurotransmitter metabolism (Erikson et al., 2004). This study aims to examine the potential of the Mako-mako River as a source of clean and raw water for the people of Yembekiri Village, Rumberpon District, Teluk Wondama Regency.

Method

The sampling equipment used are polyethylene bottles, pH meters, cool boxes, plastic bags, DO meters, TDS meters, GPS (GARMIN brand), and hand refractometers. Destruction and analysis equipment is a set of reflux apparatus, mortar, an analytical balance, Whatman 41 filter paper, an oven, and an Atomic Absorption Spectrophotometer (SSA Flame Brand AA-6300 and 80 mesh sieve). The materials used are samples of water, sediment, nitric acid (HNO3), and perchloric acid $HClO_4$.

Sampling of Water and Sediment from Mako-Mako River

The sampling was carried out by purposive sampling method, sampling was carried out at three location points, namely the upstream part at coordinates S: 10 50' 39" and E: 1340 9' 19", the middle part at coordinates S: 10 50' 37" and E: 1340 9' 17" and downstream at coordinates S: 10 50' 36" and E: 1340 9' 12". The volume of water samples taken was ± 1000 mL and put into a labeled sample bottle, added with a few drops of HNO3 (up to pH <2), and stored in an ice box. Sediment and plankton samples were taken at the same location as the water sampling location. Sediment samples were taken with a shovel from the left and right sides of the river using a random sampling method, then put into a plastic that has been labeled and stored in an ice box. Plankton samples were collected using a 5-liter plastic bucket, which was poured into a 20-meter plankton net over 10 repetitions. The plankton collected in the net were transferred to a sample bottle, and 3-4 drops of 4% Lugol's solution were added.

Analysis Method

The analysis of the quality of Mako-mako River water in this study includes physical and chemical parameters of water with the analytical method presented in Table 1. The measurement results are then compared with Class II quality standards based on Government Regulation Number 22 of 2021 concerning Water Quality Management and Water Pollution Control.

Table 1. Parameters of Water Quality Study and Analysis Method

Water quality parameter	Unit of measurement	Method
Temperature	^oC	SNI 06-6989.23-2005
TSS	mg/L	SNI 06-6989.3-2004
TDS	mg/L	SNI 06-6989.14-2004
pH	-	SNI 06-6989.11-004
Fe	mg/L	SNI -6989.4-2009
Mn	mg/L	SNI -6989.5-2009
Total coliform	MPN/100ml	APHA, 2012, 9222-B

Measurement of Fe and Mn levels in the sediment of the Mako-mako River refers to the SNI method, 2004 section 7. The plankton identification method refers to the method of Verlecar et al. (2004), the abundance of plankton according to the Sachlan method and the determination of the Diversity Index refers to Moore (1991).

Result and Discussion

This study examined the physical and chemical parameters of Mako-mako River water, including temperature, TDS, and TSS as physical parameters, and pH, Mn, and Fe as chemical parameters, as shown Table 2.

The concentration of TSS in the Mako-mako River in the upstream and the middle parts is <5 mg/L or the water quality is still categorized as good if compared to the class I water quality standard based on PP 22 of 2021, which is 40 mg/L. The condition of the upper and middle river bodies which are dominated by river stones and sandy sediments and the relatively low current movement affects the TSS levels at these locations. The low TSS value is thought to be caused by several factors, including the lack of human activity around the waters and calm water conditions. The calm waters allowed the solid substances suspended in them to mostly settle into sediments at the bottom. The condition of the downstream river which is dominated by clay and sand-type sediments affects the TSS content in the downstream part of the river. The TSS concentration downstream increased to 29.10 mg/L but remains below the Class I water quality standard of 40 mg/L (PP 22 of 2021). This shows a decrease in water quality from upstream to downstream of the river (Putro, 2017; Supardiono et al., 2023).

Table 2. Water Quality Result of Mako-mako River

Water quality parameter	Unit of measurement	Location			Class I of River Water Quality Standard
		upstream	middle	downstream	
Temperature	°C	28.20	28.60	29.10	Dev 3
TSS	mg/L	<5	<5	37	40
TDS	mg/L	<10	<10	67.46	1000
pH	-	8.53	7.17	7.58	6-9
Fe	mg/L	0.94	0.51	0.89	0.30
Mn	mg/L	0.01	0.03	0.02	0.10
Total coliform	MPN/100ml	<2400	<2400	<2400	1000

The concentration of dissolved Mn in Mako-mako River water ranges from 0.01 mg/L to 0.03 mg/L and is still below the Class I river water quality standard of 0.10 mg/L. The concentration of dissolved Fe in the Mako-mako River water ranges from 0.51 mg/L to 0.94 mg/L, exceeding the Class I river water quality standard of 0.30 mg/L. The high concentration of dissolved Fe in the water is thought to come from sediments and river rocks in the river. Iron levels > 1.0 mg/L are considered harmful to aquatic organisms. Water intended for drinking should have an iron (Fe) content of less than 0.3 mg/L (Moore, 1991). Heavy metals tend to accumulate in the food chain through the biomagnification process (Mangallo et al., 2018; Yousif et al., 2021). Manganese is one of the most abundant elements in the earth's crust; it usually occurs together with iron and is widely distributed in soil, sedimentary rocks, and water. The most abundant compounds of manganese are sulfide, oxide, carbonate, and silicate.

The presence of metals in the Mako-mako River is more dominantly influenced by natural factors, as evidenced by the high density of plants along the river and the decomposition of organic matter, which affect both organic matter and metal content in the water. The formation and complexing of Fe in water is generally carried out by microorganisms. Additionally, iron (Fe) and manganese (Mn) can naturally enter water bodies through various processes, including rainfall, erosion, decomposition of organic materials around the water, and sedimentation, where they mix with sediments and mud at the water's bottom (Liew et al., 2020; Zhai et al., 2021).

The aquatic environment is highly susceptible to pollution from harmful pathogenic microorganisms, which can enter through various sources such as residential areas, agriculture, and animal husbandry (Pandey et al., 2014). Escherichia coli, a type of coliform bacteria commonly found in human and animal feces, is often used as an indicator of water contamination (Odonkor & Ampofo, 2013). Based on the water quality analysis of the Mako-mako River, total coliform levels at all observation locations exceeded the Class I river water quality standard. This shows that the quality of the river water is relatively low. Therefore, to be used as a source of raw water, it needs to be treated. High levels of total coliform can come from animal waste in the surrounding area.

Concentration of Fe and Mn in Sediments of Mako-mako River

The concentrations of Fe in the Mako-mako River sediments were 2782.92 mg/kg upstream, 2848.46 mg/kg midstream, and 2024.50 mg/kg downstream. The permissible Fe concentration in sediment is below 17.00 mg/kg. High Fe concentrations give the Mako-mako River sediment a reddish-brown to dark brown color. The concentration of Mn in the Mako-mako River sediments was 56.22 mg/kg upstream, 70.18 mg/kg midstream, and 8.36 mg/kg downstream. The results of the analysis indicate that the concentration of Mn in the sediments of the Mako-mako River is still below the quality standard for Mn, as determined by the National Sediment Quality Survey (NSQS), which is 120.77–284.77 mg/kg. The Mn concentration in the Mako-mako River sediments remains below this NSQS standard.

The presence of Fe and Mn in the sediment of the Mako-mako River was higher than their dissolved concentrations in river water. Generally, heavy metals can accumulate in sediments as they bind to organic and inorganic compounds through adsorption and the formation of complex compounds (Mangallo & Mufidah, 2022; Pan et al., 2022). The heavy metals that accumulate in the sediment depend on the type of sediment, based on the amount of heavy metal content in the sediment type mud > sandy mud > sandy (Korzeniewski & Neugebauer, 1991).

Plankton Types and Abundance in the Mako-mako River

In addition to water quality, it is also necessary to assess biological parameters through the abundance of phytoplankton in the water body. Plankton, especially phytoplankton, has a particularly important role in the food chain of aquatic ecosystems and is often used as an indicator of stability, fertility, and water quality. Phytoplankton can serve as an ecological parameter of aquatic fertility, describing the condition of a water body (Richardson, 2008). The results of the plankton analysis in the Mako-mako River, including the identified species and their abundance, are presented in Table 3. The analysis identified 8 (eight) plankton species, of which only 3 (three) were classified as phytoplankton (found at the upstream location) and zooplankton (found at the middle and downstream locations of the river), while the other 5 (five) species remain unidentified.

Table 3. Types and Amounts of Plankton in the Mako-mako River

Location	Species	Number of individuals	Total individuals
Up stream	Closteriopsis longisimma	1	5
	X1 X2	4	
Middle	Pelagothuria natatrix	1	79
	Y1 Y2	78	
Downstream	Squatinella mutica tridentate	2	6
	Z	4	
Total			90

The types of plankton found in the waters of the Mako-mako River are relatively few. This can be caused by various factors, including the influence of environmental conditions, climate, and time of sampling. Abundance is a measure of the number of individuals per unit volume of water, which is generally expressed in cells per unit volume. In general, the abundance of phytoplankton is closely linked to the fertility or productivity of a water body. When phytoplankton abundance is high, the water tends to have high productivity (Rizky et al., 2013). The results of the measurement of plankton abundance and diversity index in the Mako-mako River are presented in Table 4.

Table 4. The abundance and diversity index of plankton in the Mako-mako River

Location	Abundance (ind/L)	Diversity index of plankton
Upstream	2.00	0.15
Middle	31.65	0.12
Downstream	2.40	0.17
Total	36.05	0.44

Plankton observed at each location belong to different classes. The phytoplankton species *Closteriopsis longissimi* (found upstream) belongs to the Bacillariophyceae class, while zooplankton from the river's middle section are classified under the Holothuroidea class. In the downstream location, zooplankton from the Rotifera class were identified. Plankton obtained from the upper reaches of the river amounted to 5 individuals, with an abundance of 2.00 ind/L. At the mid-river location, the number of plankton obtained was 79 individuals, with an abundance of 31.65 ind/L, while at the downstream location, the number of plankton obtained was 6 individuals, with an abundance of 2.40 ind/L. Waters with an abundance of plankton ranging from 0 to 2.00 ind/L are considered low fertility or oligotrophic, while mesotrophic waters have a phytoplankton abundance range of 2,000 to 15,000 ind/L. These mesotrophic waters are a phase in which oligotrophic waters begin to transition into eutrophic waters, leading to nutrient enrichment. The total plankton diversity index value in the Mako-Mako River is 0.44, indicating that the diversity of plankton in the Mako-Mako River is low, in accordance with the classification of plankton community conditions based on H'. If $H' < 2.30$, it is classified as low diversity, if $2.30 < H' < 6.91$, it is classified as moderate diversity, and if $H' > 6.91$, it is classified as high diversity. The presence of plankton in the waters of the Mako-Mako River, despite its low abundance, indicates that plankton does not significantly affect the color of the river water.

The relationship between the concentration of Fe in the Mako-Mako River water and plankton abundance shows that the higher the concentration of Fe in the river, the lower the abundance of plankton. The addition of $Fe2+$ at concentrations of 0.1 to 0.6 ppm in C. vulgaris phytoplankton cells is more of a nutrient for plankton growth. The addition of metal ions $Fe2+$ at a concentration of 0.8 – 2.0 ppm can be toxic to plankton growth (Rizky et al., 2013).

Conclusion

The results of the water quality analysis of the Mako-Mako River show that the parameters of temperature, TDS, TSS, and Mn are still below the water quality standard, except for the Fe and total coliform parameters, whose concentrations have exceeded the water quality standard. The metal content of Fe in the Mako-mako River sediment is high and affects the color of the Mako-mako River sediment, which ranges from reddish-brown to dark brown (deep). The presence of plankton, with a low level of abundance and diversity index, did not affect the color of the river water or the sediment. Therefore, to use Mako-Mako River water as a source of raw water, it must undergo a processing treatment.

Author Contributions

Conceived, designed the experiments, and wrote the manuscript by Bertha Mangallo; performed the experiments by Devi Oktaviani. The authors read and approved the final manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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