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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 of the Mako-mako river. The method of sampling water, sediment and plankton by purposive sampling at three locations, namely the upstream, middle and downstream of the river. The concentrations of Fe and Mn in water and sediment were analyzed using AAS, while the identification of plankton using a binocular microscope. The results of the analysis of the water quality 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 water quality standard. The metal content of Fe in sediment is high and affects the color of the Mako-mako river sediment which is 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 of the Mako-mako river. So that to use the Mako-mako river water as a source of raw water, clean water needs to go through a processing process.

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 those in environments with marginal raw water, such as brackish water and carbonate rocks. In general, sources of clean water come from ground water 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 (Puckett, 1995; Khatri & Tyagi, 2014; Akhtar et al., 2021), which cause colored water. The color in 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 in color, which is presumably due to the dissolved metal content, especially Fe and Mn metals as well as the presence of certain types of plankton that causes the color of the river water.

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Drinking water contaminated with different chemicals and heavy metals, released from different natural and anthropogenic sources (Rapant & Krčmová, 2007). The contamination of water resources, has important repercussions to 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 associated with 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 Fe and Mn can accumulate in the liver and kidneys and in chronic conditions occur Fe and Mn poisoning and cause nervous system disorders and hyperreflection (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 raw water and clean water for the people of Yembekiri Village, Rumberpon District, Teluk Wondama Regency.

Method

The sampling equipment used were polyethylene bottles, pH meters, cool boxes, plastic bags, DO meters, TDS meters, GPS (GARMIN brand), hand refractometers. Destruction and analysis equipment is a set of reflux apparatus, mortar, analytical balance, Whatman 41 filter paper, oven, and Atomic Absorption Spectrophotometer (SSA Flame Brand AA-6300 and 80 mesh sieve). The materials used are samples of water, sediment, nitric acid (HNO_3) 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 HNO_3 (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 labelled and stored in an ice box. Plankton samples were taken using a 5 liter plastic bucket and poured into a 20 m plankton net for 10 repetitions. The plankton samples that were accommodated in the plankton net were transferred to a sample bottle and 3-4 drops of Lugol 4% were added.

Analysis Method

The testing 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 with quality standards referring to class 1 of water quality standard on Government Regulation Number 22 of 2021 concerning Administration, Protection and management of the environment.

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 the Moore, James W.

Result and Discussion

The physical and chemical parameters of Mako-mako river waters observed in this study were temperature, TDS and TSS as physical parameters, and pH, Mn and Fe as chemical parameters which are presented in 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 resulted in the solid substances suspended in the waters having mostly settled into sediments at the bottom of the waters. 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 concentration of TSS in the downstream increase is 29.10 mg/L but are still below the TSS quality standard compared to the class I water quality standard based on PP 22 of 2021, which is 40 mg/L. 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 – 0.03 mg/L and is still below the class 1 river water quality standard, which is 0.10 mg/L. The concentration of dissolved Fe in the Mako-mako river water ranges from 0.51 mg/L – 0.94 mg/L or has exceeded the quality standard for Fe concentration for class I river water, which is 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 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 sulphide, oxide, carbonate and silicate.

The presence of metals in the Mako-mako river is more dominantly influenced by natural factors. This can be seen that along the Mako-mako river flow is filled with plants with a fairly high density which also undergoes decomposition of organic matter, thus affecting the levels of organic matter and metal content in the water, generally the formation and complexing of Fe in water is carried out by microorganisms. In addition, naturally Fe and Mn metals can enter water bodies through several events, namely rain and erosion, decomposition of organic materials found around the waters and sedimentation to the bottom of the water and mixed with sediment and mud (Liew et al., 2020; Zhai et al., 2021).

The aquatic environment is easily polluted by harmful pathogenic microorganisms that enter from various sources such as settlements, agriculture and animal husbandry (Pandey et al., 2014). Bacteria that are commonly used as indicators of contamination of a water body are bacteria belonging to Escherichia coli which is one of the bacteria classified as coliforms and lives normally in human and animal feces (Odonkor & Ampofo, 2013). Based on the analysis of the water quality of the Mako-mako river, the total coliform levels in observation locations indicated that the total coli content had exceeded the quality standard for class I river water. This shows that the quality of the river water is relatively low, so that to be used as a source of raw water, clean water needs to go through a processing process. High levels of total coliform can come from animal waste that lives around river.

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

The concentration of Fe in the sediments of the Mako-mako river at the upstream, middle and downstream of the river were 2782.92 mg/kg, 2848.46 mg/kg, and 2024.50 mg/kg, respectively. The permissible concentration of Fe in sediment is below 17.00 mg/kg. The high concentration of Fe in the sediment affects the color of the Mako-mako river sediment which is reddish brown to dark brown (deep). The concentration of Mn in the sediment of the Mako-mako river in the upstream, middle and downstream of the river was 56.22 mg/kg, 70.18 mg/kg, and 8.36 mg/kg, respectively. 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 heavy metal Mn in sediments that has been determined based on the National Sediment Quality Survey (NSQS), which is 120.77 – 284.77 mg/kg.

The presence of Fe and Mn metals in the sediment of the Mako-mako river was higher than dissolved in river water. Generally, heavy metals can accumulate in sediments because they can be bound to organic and inorganic compounds through adsorption events and the formation of complex compounds (Mangallo & Mufidah, 2022; Pan et al., 2022). Basically 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 the biological parameters through the abundance of phytoplankton contained in the water body. Plankton, especially phytoplankton, has a particular important role in the food chain in aquatic ecosystems and is often used as indicators of stability, fertility and water quality. Phytoplankton can play a role as one of the ecological parameters, aquatic fertility, in describing the condition of a water body (Richardson, 2008). The results of the analysis of plankton in the Mako-mako river, obtained types (species) and the amount of plankton are presented in table 3.

The results of the plankton analysis obtained 8 (eight) species, of which only 3 (three) species were identified into phytoplankton (upstream location) and zooplankton (middle and downstream locations of the river) while 5 (five) species the other plankton species are unknown.

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

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

The type of plankton found in the waters of the Mako-mako river is relatively small, 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 generally expressed in cells per unit volume. In general, the abundance of phytoplankton is closely linked to fertility or productivity of a waterbody. When the phytoplankton abundance is high, the water tend to have high productivity (Rizky et al., 2013). The results of measuring the abundance and diversity index of plankton 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 found at each location come from different classes. The type of phytoplankton Closteriopsis longisimma (upstream location) is plankton class Bacillariophyceae, in the middle location of the river found zooplankton class Holothuroidea while in the downstream location of the river zooplankton class Rotifera was found. Plankton obtained in 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 for 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 0-2.00 ind/L are waters with low fertility or oligotrophic and the fertility of mesotrophic waters has an abundance range of phytoplankton 2000-15000 ind/L. These mesotrophic waters are water phases which initially are oligotrophic waters begin to enter the eutrophic waters phase, so that during this phase nutrient enrichment occurs. The total index value of plankton diversity in the Mako-mako river is 0.44, which indicates that the diversity of plankton in the Mako-mako river is low or small, in accordance with the classification of plankton community conditions based on H'. If $H' < 2.30$ classified as low diversity (small), if $2.30 < H' < 6.91$ classified as moderate diversity, and if $H' > 6.91$ classified as high diversity. The presence of plankton in the waters of the Mako-mako river with low abundance indicates that the presence of plankton does not affect the color of the Mako-mako river water.

The relationship between the concentration of Fe in the Mako-mako river water and the abundance of plankton shows that the higher the concentration of Fe metal in the river water, the smaller the abundance of plankton in the river. The addition of Fe^{2+} at concentrations of 0.1 to 0.6 ppm in C. vulgaris phytoplankton cells is more of a nutrient for plankton growth. While the addition of metal ions Fe^{2+} at a concentration of 0.8 – 2.0 ppm can be toxic to plankton growth (Rizky et al., 2013).

Conclusion

The results of the analysis of the water quality of the Mako-mako river show that parameters of the 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 is 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 and the sediment of the Mako-mako river. So to use Mako-mako river water as a source of raw water, clean water needs to go through a processing process.

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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