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Water Quality Analysis and Water Pollution Effect from Upstream to Downstream of Brantas River - East Java

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Abstract

Brantas River is the largest river in East Java, flowing from the city of Batu upstream until downstream in Surabaya and Sidoarjo. This river plays a crucial role as a vital natural resource that supports the various needs of the surrounding communities. This study serves as a preliminary investigation with the primary aim of assessing the water quality in three different zones of the Brantas River: the upper, middle, and downstream sites. Additionally, this research includes a review to identify the organisms exposed to water pollution in the Brantas River. The study was conducted from November 2020 to April 2023, utilizing an exploratory observational method at 19 observation stations. The data obtained was subsequently analyzed using a descriptive approach. Various parameters were observed, including pH (a measure of acidity or alkalinity), hardness (the concentration of calcium and magnesium ions), alkalinity (the capacity of water to neutralize acids), nitrate, nitrite, fluoride, and heavy metals such as lead (Pb), copper (Cu), and iron (Fe). The research findings indicate that in several upstream areas of the Brantas River, there were elevated hardness, nitrate, lead (Pb), and iron (Fe) that exceeded the established water quality standards. In the middle section of the river, water quality was generally satisfactory, although a few locations exhibited slightly elevated levels of lead (Pb). Meanwhile, all locations downstream of the Brantas River demonstrated water quality that exceeded the prescribed standards. After a literature review, it was discovered that various biota in the Brantas River have been exposed to pollutants, including fish species and plants like Ipomea aquatica and Eichhornia crassipes. Therefore, it is necessary and urgent to improve water management and monitoring plants and biota in the Brantas River to preserve organisms in aquatic and terrestrial ecosystems.

Keywords: Brantas river, pollution, water quality

INTRODUCTION

The Brantas River is the second-largest river on the island of Java, located between 110°30' E to 112°55' E longitude and 7°01' S to 8°15' S latitude. According to Regulation of the Minister of Public Works and Public Housing (Permen PU) No. 4/2015, the Brantas River has a length of approximately 320 kilometers. It covers an area of roughly 14,103 square kilometers, constituting approximately 25% of the total area of East Java Province or around 9% of the entire island of Java. The Brantas River traverses 11 regencies and 4 cities. It originates in the Brantas. Source, within the slopes of Mount Arjuno-Welirang. From there, the water flows through Batu, Malang, Blitar, Tulungagung, Kediri, Jombang, and Mojokerto. Upon reaching Mojokerto Regency, the Brantas River divides into two main branches: the Surabaya River, flowing toward Surabaya, and the Porong River, leading to Sidoarjo [1]. The existence of the Brantas River is a vital natural resource for the riverside community [2].

Brantas River water is mainly used for various purposes, including human consumption, agriculture, fisheries, and industry. The river also provides other benefits in the form of freshwater ecosystems that support a variety of biota. According to the Regulation of the Minister of Public Works and Public Housing regarding the Pattern of Management of Water Resources in the Brantas River Basin in 2020, by the year 2015, there were 18,166 million people residing in this

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river basin, which was counted as 46.7% of the total of East Java Population. Furthermore, the Brantas River significantly supports East Java's status as the national rice granary. In 2015, the rice production's total reached 1.69 million tons, representing 2.24% of Indonesia's total rice production.

Unfortunately, this river, which has a crucial role, is facing severe challenges threatening its water quality and ecosystem. This is because the quality of the Brantas River directly impacts the river ecosystem and all forms of life in it. River conditions that are not well maintained can cause water pollution that endangers the organisms that live in it. This pollution can come from various sources, including industrial waste, agriculture, settlements, and other human activities. Previous studies have reported that the Brantas River is polluted by multiple pollutants, including domestic and industrial waste [3]. Furthermore, the results of the analysis of heavy metal levels in the Brantas River showed average values of Pb (2.63), Cd (1.09), Cu (0.74), Ni (0.40), Fe (0.26), Cr (0.10); and Mn (0.02) [4].

Furthermore, accumulating these hazardous substances in water can disrupt the health of river ecosystems, including the organisms that live in the river. Heavy metals can affect the histological structure of fish tissues and organs and decrease fish size, weight, and total length [5]. Moreover, surfactants in detergents can cause foam that covers the surface of the water, reducing the diffusion of oxygen from the air and decreasing the dissolved oxygen in the water, which can harm aquatic organisms [6]. Heavy metals are also able to accumulate in the organs of fish, causing mortality and making them weak, anemic, and vulnerable to diseases. Furthermore, heavy metal pollution can cause structural changes in the organs of fish at microscopic cellular and organ levels, leading to alterations in the function systems [7]. Furthermore, phosphate, nitrate, nitrite, and sulfide are all compounds that can negatively impact the environment and ecosystem of rivers, mainly when found at high levels. Excess amounts of these compounds can cause significant water quality problems, accelerate eutrophication, cause dramatic increases in aquatic plant growth, and change the types of plants and animals that live in the stream [8].

This study aims to conduct a preliminary investigation focusing on assessing the water quality in three different Brantas River zones, including the upper, middle, and downstream sites. Additionally, the research aims to conduct a review to identify the biota exposed to pollution in the Brantas River.

MATERIAL AND METHOD

This study used an observational method with a descriptive explorative approach. The Brantas River, East Java, Indonesia, was explored from November 2020 until April 2023. Water quality measurements were carried out from the upstream to downstream areas of the Brantas River Basin. Water sampling was taken at multiple locations, with 19 site points 8 sites upstream (points 1-8), 3 sites in the middle (points 9-11), and 8 sites downstream (points 12-19).

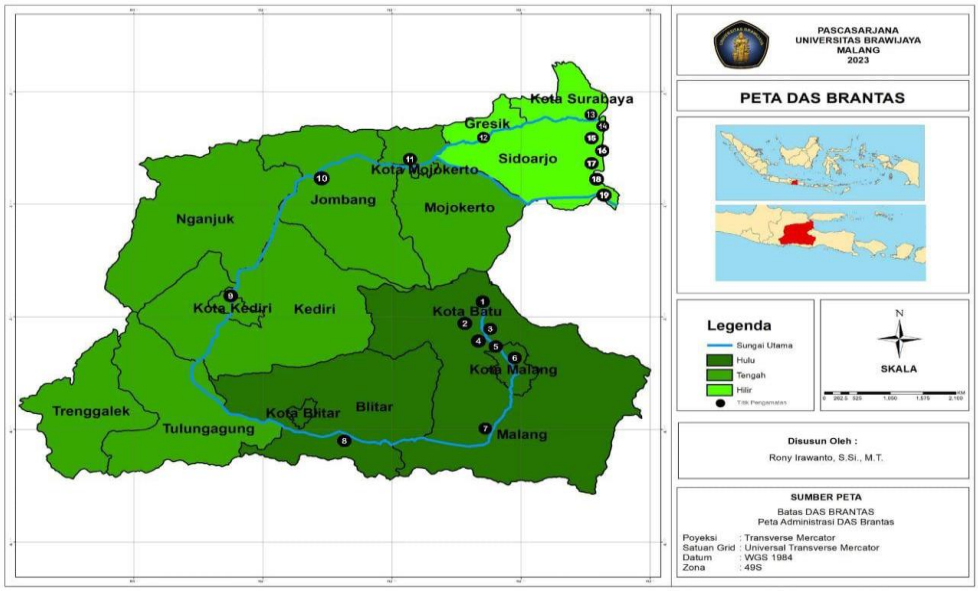

Figure 1. Location of point sampling Brantas Ri

The location name from upstream to downstream is S01. Sumber Brantas (Batu), S02. Cuban Talun (Batu), S03. Pendem (Batu), S04. Sengkaling (Malang), S05. Tlogomas (Malang), S06. Muharto (Malang), S07. Kepanjen (Malang), S08. Kasembon (Blitar), S09. Taman Brantas (Kediri), S10. Megaluh (Jombang), S11. Hayam Wuruk (Mojokerto), S12. Driyorejo (Gresik). S13. Wonorejo (Surabaya), S14. Gunung Anyar (Surabaya), S15. Gunung Anyar Tambak (Surabaya), S16. Sedati (Sidoarjo), S17. Gisik Cemendi (Sidoarjo), S18. Kalanganyar (Sidoarjo), S19. Porong (Sidoarjo). The site location selection was based on the mainstream of Brantas River, which passes through every city and district in East Java, as depicted in Figure 1.

Data Analysis

Water quality tests are carried out using the water test kit instrument. The utilization of this instrument is considered sufficient to serve as an initial presumptive test of water quality in the Brantas River. The parameters tested in this study include pH, Hardness, Total Alkalinity, Lead, Copper, Iron, Chromium, Mercury, Nitrate, Nitrite, Fluoride, Iodine, Sulfite, Free Bromine, Bromine, Free Chlorine, Total Chlorine, Residual Chlorine, Cyanuric Acid, and Carbonate Root. Then, to conduct a review to identify the biota that have been exposed to pollution in the Brantas River, we use a literature review method based on previous research. The data was then compared, presented in subsequent figures and tables, and analyzed using a descriptive qualitative method.

RESULT AND DISCUSSION

Water Quality Analysis on Brantas

Water quality was measured by dividing it based on the upstream, middle, and downstream areas of the Brantas River. Sampling point location numbers 1-8 upstream, 9-10 middle, and 11-19 downstream. The results of water quality sampling can be seen in Table 1. The Brantas River in this research divided three regencies or cities for one part of the mainstream. Batu, Malang, and Blitar are upstream; Kediri, Jombang, and Mojokerto are midstream; Gresik, Surabaya, and Sidoarjo are downstream. The Batu water spring (Sumber Brantas) flows through Malang, Blitar, Kediri, Jombang, and Mojokerto. The river has two main branch streams: the Surabaya River and the Porong River. The Surabaya River passes Gresik and flows toward urban Surabaya to the estuary of the big city. The Porong River, from Mokokerto to Sidoarjo, flows straight towards the sea.

Table 1 Water Quality Results for the Upstream, Middle and Downstream of Brantas River.

Parameter	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19
pH	6,5	6,5	7,8	7,2	7,2	7	7	7	7	7	7,5	7,6	7,6	7,2	7	7	7,5	8,4	7,2
Hardness	100	100	425	425	250	100	100	100	100	100	100	425	425	425	100	250	250	425	425
Total Alkalinity	40	40	120	120	120	180	80	80	80	80	80	120	120	120	180	80	80	180	120
Lead	0	0	50	50	50	20	50	50	50	50	20	50	50	20	50	20	20	20	50
Copper	1	1	1	1	1	1	1	1	1	1	1	10	30	10	1	1	1	10	10
Iron	0	0	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chromium	-	-	2	2	2	-	-	-	-	-	-	2	2	2	-	-	-	2	2
Mercury	-	-	0	0	0	-	-	-	-	-	-	0	0	0	-	-	-	0	0
Nitrate	0	0	250	250	250	250	50	50	25	25	10	250	250	250	50	100	100	250	100
Nitrite	0	0	20	40	40	20	20	20	5	5	1	80	80	80	10	20	20	80	40
Fluoride	25	25	25	25	25	25	25	25	25	25	25	50	50	50	25	25	25	50	25
Iodine	0	0	-	-	-	0	0	0	0	0	0	-	-	-	0	0	0	-	-
Sulfite	-	-	10	10	0	-	-	-	-	-	-	10	10	10	-	-	-	10	10
Free Bromine	0	0	-	-	-	0,5	0,5	0,5	0,5	0,5	0	-	-	-	0	3	0,5	-	-
Bromine	-	-	0	0	0	-	-	-	-	-	-	0	0	0	-	-	-	0	0
Free Chlorine	0	0	-	-	-	0,5	0,5	0,5	0,5	0,5	0	-	-	-	0	3	0,5	-	-
Total Chlorine	0	0	-	-	-	0,5	0,5	0,5	0,5	0,5	0	-	-	-	0,5	0,5	0,5	-	-
Residual Chlorine	-	-	0	0	0	-	-	-	-	-	-	0	0	0	-	-	-	0	0
Cyanuric Acid	0	0	-	-	-	0	0	0	0	0	0	-	-	-	30	30	30	-	-
Carbonate Root	0	0	-	-	-	20	0	0	20	20	0	-	-	-	20	20	20	-	-

From Table 1 above, the main parameters can be grouped into three parts: physical, such as pH, hardness, and alkalinity; heavy metals (Pb, Cu, Fe, Cr, Hg); and organic components. Upstream of the Brantas River, some hills and mountains have many forest and water catchment areas, so the condition is still good; it only changes slightly when entering residential and agricultural areas.

Some upstream areas in Malang were elevated hardness, nitrate, lead (Pb), and iron (Fe), which exceeded the established water quality standards. In the middle section of the river, water quality was generally satisfactory, although a few locations exhibited slightly elevated levels of heavy metals such as lead (Pb). Meanwhile, all locations downstream of the Brantas River demonstrated water quality that exceeded the prescribed standards.

Water Pollution Effect on Organisms

The previous study shows that varying pollution levels in different zones of the Brantas River, with the upper areas experiencing elevated levels of pollutants, including heavy metals copper (Cu), cadmium (Cd), mercury (Hg), lead (Pb), and iron (Fe). The results of previous studies on water pollution effects on organisms can be seen in Table 2. These pollution levels have significantly impacted the microorganisms inhabiting the Brantas River. Various biota, including *Barbonymus gonionotus*, *Scylla serrata*, *Sulcospira testudinaria* and aquatic plants like *Ipomea aquatica* and *Eichhornia crassipes* have been exposed to pollutants.

Figure 1. Water Pollution Effect in Organisms from Brantas River.

No	Organism	Locations	Types and Levels	References
1	*Ipomoea aquatica*	Prambon River	Heavy metal copper (Cu) 0.02 mg/L	[9]
2	*Eichhornia crassipes* and *Ipomoea aquatica*	Buntung River	Heavy metal cadmium (Cd) 0.03 mg/L	[10]
3	*Ipomoea aquatica*	Prambon River	Heavy metal cadmium (Cd) 0.03 mg/L	[11]
4	*Neritona labiosa*	Sadar River	Heavy metal lead (Pb) 4.03 mg/L	[12]
5	*Ipomoea aquatica*	Brantas River Mojokerto	Heavy metal cadmium (Cd) 0.24 mg/L	[13]
6	*Eichhornia crassipes* and *Ipomoea aquatica*	Brantas River Mojokerto	Heavy metal lead (Pb) 0.07 mg/L	[14]
7	*Barbonymus gonionotus*	Brantas River Mojokerto	Heavy metal cadmium (Cd) 0.11 mg/L	[15]
8	*Rice*	Jombang	Heavy metals Pb 2.28 mg/L; Fe 39.95 mg/L; Cr 2.73 mg/L; Cu 2.81 mg/L; Co 1.45 mg/L; Mn 16.07 mg/L; 15.73 mg/L	[16]
9	*Sulcospira testudinaria*	Brantas River	Heavy metals Pb 0.001 to 0.005 mg/L, and Cd from 0.005 to 0.03 mg/L	[17]
10	*Scylla serrata*	Mouth of Brantas River	Heavy metals Cd 0.185 ± 0.025; Pb 0.270 ± 0.039; Zn 7.685 ± 0.988; Cu 5.627 ± 1.567; Hg 0.012 ± 0.001; Zn 0.327 ± 0.041	[18]

Table 2 above shows that several previous studies have analyzed heavy metal content in organisms in the Brantas River. The organisms include plants, fish, crabs, and shellfish. Plants, fish, crabs, and clams found in rivers can contain heavy metals due to pollution from various sources such as domestic sewage, urban run-off, industrial effluents, farm wastes, and chemicals used in agriculture. The heavy metals can enter the bodies of plants, fish, crabs, and clams through various pathways, such as root absorption, ingesting contaminated sediment, and consuming contaminated food [19]–[22]. Once the heavy metals enter the bodies of these organisms, they can accumulate in their organs and tissues, negatively impacting their physiology and health [23].

Furthermore, the type of pollutant found in each organism was heavy metals. It indicates that heavy metals are a type of pollutant that is widely seen and pollutes the environment. Heavy metals in rivers can come from various sources, including natural and anthropogenic activities such as rock weathering, mining, agriculture, industrial activities, domestic sewage, atmospheric deposition, and water-rock interaction [19], [24], [25]. In this study, we found that some of the heavy metals that have

contaminated the Brantas River are copper (Cu), cadmium (Cd), and lead (Pb). Moreover, these heavy metals can also accumulate in surrounding organisms, which is not a good thing. The heavy metals accumulate in the organs of shells, fish, and crabs, causing damage to their vital organs and tissues. So, it can cause changes in the physiology of shells, fish, and crabs, including their growth, reproduction, and behavior. Because Heavy metals can cause changes in the gene expression of shells, fish, and crabs [26]–[28].

The plant species that accumulate a lot of heavy metals in the Brantas River are Ipomoea aquatica and Eichhornia crassipes, which indicates that both plants are categorized as hyperaccumulator plants. Hyperaccumulator plants can grow in soil or water with very high concentrations of metals, absorbing these metals through their roots and concentrating extremely high levels in their tissues [29]. The ability of *Eichhornia crassipes* and *Ipomoea aquatica* to accumulate heavy metals in their tissues makes them useful as biomonitors in assessing heavy metal pollution in rivers. However, the accumulation of heavy metals in these plants can have negative impacts on their physiology and health, affecting their growth, reproduction, and behavior [20].

CONCLUSION

The research findings indicate that in several upstream areas of the Brantas River, there were elevated hardness, nitrate, lead (Pb), and iron (Fe) that exceeded the established water quality standards. In the middle section of the river, water quality was generally satisfactory, although a few locations exhibited slightly elevated levels of lead (Pb). Meanwhile, all locations downstream of the Brantas River demonstrated water quality that exceeded the prescribed standards. After a literature review, it was discovered that various biota in the Brantas River have been exposed to pollutants, including fish species and plants like Ipomea aquatica and Eichhornia crassipes. Therefore, it is necessary and urgent to improve water management and monitoring plants and biota in the Brantas River to preserve organisms in aquatic and terrestrial ecosystems.

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