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Study on the Water Quality of Kali Jagir River Surabaya Reviewed from the Cadmium (Cd) and Lead (Pb) Content

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ABSTRACT

The Kali Jagir River in Surabaya has the potential to receive domestic and industrial wastewater resulting from the activities in Surabaya city and serves as a raw water source for PDAM Surabaya. The chemical content of wastewater can include heavy metals such as Cd and Pb. This study aimed to analyze the water quality of the Kali Jagir River in Surabaya in terms of cadmium (Cd) and lead (Pb) content in 2022. The type of research is observational with a cross-sectional approach. The research object is the water of the Kali Jagir River in Surabaya, which was taken from the upstream, midstream, and downstream sections of the river with 3 replications. Data analysis was conducted to determine the water quality of the Kali Jagir River by comparing it with the Class I Water Quality Standards based on the Government Regulation of the Republic of Indonesia Number 82 of 2001. The average cadmium (Cd) content in the upstream, midstream, and downstream sections of the Kali Jagir River was 0.0005 mg/L. The average lead (Pb) content in the upstream, midstream, and downstream sections of the Kali Jagir River was <0.010 mg/L, <0.010 mg/L, and <0.012 mg/L, respectively. The cadmium (Cd) and lead (Pb) content in the upstream, midstream, and downstream sections of the Kali Jagir River comply with the Class I water quality standards. Future research is suggested to examine sediments and biota to assess the presence of heavy metals.

Keywords: River Water, Heavy Metals, Cadmium (Cd), Lead (Pb)

INTRODUCTION

One of the most crucial environmental components for daily life is water. Water needs serious attention (Pahruddin, 2017). Pollutant sources are divided into three categories: industrial, household, and waste from metropolitan areas and shopping districts. Water pollution occurs due to waste from various activities and inadequate urban wastewater treatment facilities (Mawaddati, 2021).

Heavy metals are one of the most dangerous pollutants, especially for living organisms. Generally, heavy metals are toxic to living organisms, although some are needed in small amounts (Nurul, 2021). Heavy metals at high concentrations can cause environmental damage, increase bioaccumulation, and enhance the toxicity of these metals. If heavy metal compounds in water bodies exceed certain concentrations, they can cause the death of aquatic biota (Jais et al., 2020). Heavy metals are also hazardous to human health, inhibiting enzyme function and disrupting body metabolism (Yuni, 2020).

Direct exposure to heavy metals in water at high concentrations can cause several diseases, including skin infections, digestive tract damage, lung damage, kidney failure, cardiovascular disorders, and gastrointestinal disease symptoms (Azizah, 2022). Rivers also host activities from upstream to downstream, such as the Kali Jagir River in Surabaya, one of the city's largest waterways (Laili, 2021). The Kali Jagir River is one of the main raw water sources for PDAM Surya Sembada Surabaya, supplying water to almost the entire population of Surabaya. Population growth drives an increasing demand for clean water from PDAM. The utilization of river water can reduce water quality to meet standards due to industrial, agricultural, and residential activities that can introduce pollutants into the water body (Mawaddati, 2021).

According to the research conducted by I. Mawaddati (2021), there has been a decline in the water quality of the Kali Jagir River due to domestic and industrial wastewater discharges. The Kali Jagir River is used as a direct dumping ground for waste by the surrounding community, necessitating further research using other parameters to determine more detailed river water quality, such as heavy metals.

The study aims to determine the amount of heavy metals, Lead (Pb) and Cadmium (Cd). The numerous effluents entering the river from industries such as steel, battery, and batik factories potentially cause high cadmium and lead content in the Kali Jagir River in Surabaya. The researchers also want to determine the lead and cadmium content daily. Heavy metals Cd and Pb are toxic pollutants. Lead and cadmium are heavy metals

that are difficult to degrade and can persist long in water, accumulating in sediments. Heavy metals accumulated in the human body can cause poisoning, as cadmium and lead are non-essential heavy metals for living organisms (Adhani and Husaini, 2017).

Research on river water quality has become a primary focus over the past few decades due to its impact on human health and the environment. The Kali Jagir River in Surabaya is a significant river that must be monitored for water quality, especially concerning heavy metal content such as Cadmium (Cd) and Lead (Pb).

Cadmium and lead are heavy metals often found in river water and can originate from various sources, including industrial waste, household waste, and mining activities. These two metals are known to be toxic and have significant adverse effects on human health and ecosystems (Tamele and Loureiro, 2020).

Cadmium, for instance, can cause kidney damage, bone diseases, and cancer if it accumulates in the human body (Ying & Fang, 2020). Lead, on the other hand, is known to damage the nervous system, especially in children, and cause cardiovascular and hematological problems (Rice et al., 2014).

Additionally, research shows that pollution control techniques such as chemical precipitation can be used to reduce the concentration of heavy metals in wastewater before it is discharged into rivers. This method involves chemical reactions that precipitate heavy metals into insoluble forms, making it easier to separate them from the water (Koul et al., 2022).

This study aims to analyze the water quality of the Kali Jagir River in Surabaya, focusing on cadmium and lead content throughout 2022. The results of this study are expected to provide an overview of the pollution levels and the control efforts needed to protect public health and environmental sustainability.

RESEARCH METHODS

This qualitative research uses a descriptive observational method and a cross-sectional approach. The research object is the water of the Kali Jagir River in Surabaya, 2022. The sampling process was carried out from upstream to downstream by determining sampling points using a purposive sampling technique, divided into 2 segments: segment A and segment B, with 3 station locations (upstream, midstream, and downstream).

The sampling procedure used the grab sampling method (instantaneous), with sample collection repeated three times over three consecutive days to obtain valid (representative) samples. The environmental samples were collected in bottles filled with 1,500 ml. The test parameters examined in the Kali Jagir River water were cadmium and lead. The river water quality analysis was reviewed based on the cadmium (Cd) and lead (Pb) content.

RESULTS AND DISCUSSION

The following table shows the water flow rate of the Kali Jagir River in Surabaya:

Table 1.
Measurement Results of the Flow Rate of the Kali Jagir River Surabaya

Description	Station		
	1	2	3
Distance between points (Km)	0	2,8	6,6
River Width (m)	50,2	45	50
Depth (m)	4,1	4,3	4
Cross-Sectional Area (m^2)	164	176,3	184
Velocity (m/s)	0,5	0,57	0,67
Flow Rate (m^3/dtk)	82	100,49	123,28

Based on the calculations, the water flow rate at station 1 was 82 m^3/s. At station 2, the flow rate was 100.49 m^3/s, and at station 3, it was 123.28 m^3/s.

The temperature measurements of the Kali Jagir River water in Surabaya, conducted at upstream points 1, 2, and 3, showed an average temperature of 28.1°C. Temperature measurements in the midstream and downstream sections showed an average of 28°C.

The pH measurements, conducted directly in the field, showed that the average pH at upstream points 1, 2, and 3 was 5.4. The average pH at midstream points 1, 2, and 3 was 5.6, and at downstream points 1, 2, and 3, it was 5.5.

The measurement of Cadmium (Cd) content was carried out in the water of the Jagir River in Surabaya, with the results shown in Table 2.

Table 2.
Cadmium (Cd) Content Parameters in the Kali Jagir River Water in Surabaya

Station	Cadmium (Cd) Content	Average	Class I Water Quality Standard
Upstream 1	0,0005 mg/L	**0,0005 mg/L**	0,01 mg/L
Upstream 2	0,0005 mg/L		
Upstream 3	0,0005 mg/L		
Midstream 1	0,0005 mg/L	**0,0005 mg/L**	
Midstream 2	0,0005 mg/L		
Midstream 3	0,0005 mg/L		
Downstream 1	0,0005 mg/L	**0,0005 mg/L**	
Downstream 2	0,0005 mg/L		
Downstream 3	0,0005 mg/L		

The average results of cadmium content measurements carried out upstream, middle, and downstream were 0.0005 mg/L.

Measurements of Lead (Pb) content carried out in Kali Jagir River water in Surabaya are in Table 3.

Table 3.
Lead (Pb) Content Parameters in the Kali Jagir River Water in Surabaya

Station	Lead (Pb) Content	Average	Class I Water Quality Standard
Upstream 1	< 0,010 mg/L	**< 0,013 mg/L**	0,03 mg/L
Upstream 2	< 0,010 mg/L		
Upstream 3	0,018 mg/L		
Midstream 1	< 0,010 mg/L	**< 0,010 mg/L**	
Midstream 2	< 0,010 mg/L		
Midstream 3	< 0,010 mg/L		
Downstream 1	< 0,010 mg/L	**< 0,010 mg/L**	
Downstream 2	< 0,010 mg/L		
Downstream 3	< 0,010 mg/L		

The average lead (Pb) content measured at upstream points 1, 2, and 3 was <0.013 mg/L. The average lead content measured at midstream and downstream points was <0.010 mg/L.

Water discharge measurement in the Kali Jagir River was conducted using the floating method (Mawaddati, 2021). Based on the calculation results of the water discharge in Table 1, it is shown that this study used a discharge of 5 – 150 m³/second in the flow of the Kali Jagir River in Surabaya. Thus, sampling was done at each station with two sample collections or duplicates at points 1/3 and 2/3, then combined into one container. This sampling aims to obtain an average concentration value, thereby increasing the accuracy of the data obtained for each river water test parameter (Mawaddati, 2021). Furthermore, the larger the water discharge downstream, the higher the water discharge due to effluents along the river.

Based on temperature measurements at the three points, the results showed that each location had a temperature of 28°C, which meets the criteria and is suitable according to Class I water quality standards as per PP No. 82 of 2001. The water quality standard for Class I water states that normal water temperature has a deviation of 3 from the ambient air temperature. Therefore, the normal water temperature is 25°C, so the water temperature standard for Class I is in the range of 22°C – 28°C (Rosana, 2021). Based on the average temperature measurement results in the field, the Kali Jagir River, as the study area, has met the clean water requirements for the surrounding community. The intensity of sunlight exposure and the surrounding air temperature can affect the water temperature in the river (Taek, Kolo, and Ledheng, 2018).

The pH value set in the Class I water quality standard according to Government Regulation No. 82 of 2001 is 6 - 9, with a pH of 7 being neutral. The pH of the Kali Jagir River in Surabaya is still considered normal or meets the Class I water quality standard, with pH values of 6 on the first day in the midstream and downstream sections and on the second day. However, four other locations on different days showed that the pH results did not meet the Class I water quality standard, with pH values <6. These locations include the upstream section on the first day and the upstream, midstream, and downstream sections on the third day. Based on these field research results, it is concluded that the flow of the Kali Jagir River in Surabaya is still somewhat unstable. The pH content can also change due to several biological factors, such as photosynthesis and respiration of living organisms, as well as temperature fluctuations in the flow (Farida, Abdullah, and Priyati, 2017).

Cadmium (Cd) is a silvery-white metal resembling aluminum and is resistant to corrosion and heat (Yuniar, 2020). Cadmium is used in electrolysis and as a pigment in the paint, enamel, and plastic industries. Cadmium is also found in alloy industries, zinc refining, pesticides, and other applications (Jannah, 2021). This study examined the river flow and obtained data from Table 2, showing that the average cadmium content in the upstream, middle, and downstream sections is 0.0005 mg/L. Table 2 shows a comparison between the average cadmium content in the Kali Jagir River water and the Class I water quality standard, which is below the Class I water quality criteria standard according to PP No. 82 of 2001, meaning it meets the requirements or that cadmium is present in small amounts in the Kali Jagir River water.

The factor influencing the river water meeting the standards is related to the river's current speed. River flow is divided into two types: uniform and non-uniform flow (Hadijah, 2022). This factor can have an impact because the wider the river, the greater the water discharge, which affects the cadmium content, leading to natural dilution. In this case, physical processes in the water, such as mixing and sedimentation, can also occur, influenced by the current speed and water depth (Sari, Kirana, and Guntur, 2017). The waste found in the river mostly comes from domestic waste, including canned and plastic packaging. One source of cadmium pollution also comes from batteries, cable wire scraps, and other electronic items. Additionally, other pollution can come from household drainage. Cadmium is toxic to all organisms and can enter the human body in various ways. High concentrations of cadmium exposure can cause health issues, including bone complications and cancer (Handayani, Martono, and Harini, 2022).

Lead is one of the toxic heavy metals (Nasution and Sihombing, 2017). Lead is a non-essential heavy metal, meaning it has no function in the human body and can cause poisoning (Permata, Purwiyanto, and Diansyah, 2018). Suppose lead is ingested or inhaled over a long period. In that case, it can cause B2 category health problems, including neurotoxicity, hearing disorders, hemoglobin synthesis disorders, developmental disorders, hypertension, reproductive disorders in men, and an increased risk of cancer, such as kidney tumors

(Dwipayanti et al., 2021). Data in Table 3 explains that the lead content in the Kali Jagir River meets the standards or is classified as good. Comparing the lead content data in the Kali Jagir River water with the Class I water quality standard according to Government Regulation No. 82 of 2001 shows that it meets the requirements, meaning lead is present in small amounts in the Kali Jagir River flow.

Lead (Pb) is a metal with accumulative properties (Sukowati, 2018). Lead in riverwater has the potential to settle at the riverbed due to its high atomic weight, causing it to precipitate into the sediment more quickly (Nadia, Rudiyanti, and Haeruddin, 2018). Lead is closely linked to various human activities around the Kali Jagir River in Surabaya, a densely populated area with heavy motor vehicle traffic. The compound TEL (Tetraethyl Lead) is an anti-knock agent found in gasoline. Lead emissions from motor vehicle combustion are released as gases that rainwater carries into water bodies, increasing lead concentrations in the water (Aprilia, 2021).

Liquid waste from numerous workshops around the river, including used oil, battery water, solvents, paint, and cleaning fluids, also contributes to lead pollution. Other sources of lead pollution include its use in ceramics manufacturing, paint, industrial emissions, batteries, cables, insecticides, explosives, soldering in jewelry industries, and cosmetics (Aprilia, 2021). Lead in water can settle as sediment, and heavy metals in sediment are generally higher than in water. Aquatic biota, such as fish, shrimp, and shellfish, can become contaminated by high lead levels in sediment, posing health risks if consumed (Jannah, 2021).

Heavy metals are hazardous pollutants because they cannot be broken down and will accumulate in the environment, even settling at the bottom of water bodies, forming complex compounds with organic and inorganic materials through adsorption and combination (Warni, Karina, and Nurfadillah, 2017). The accumulation of heavy metals in sediment is influenced by various factors, including temperature, salinity, and the nature of the metals themselves, which are difficult to degrade (Sukowati, 2018). The transfer of toxic substances into organisms occurs through four processes: absorption, distribution, metabolism, and excretion, starting from their entry into environmental compartments. In addition to industrial waste, heavy metals like lead (Pb) and cadmium (Cd) also originate from household waste and agricultural activities (Azizah and Maslahat, 2021).

CONCLUSION

The water quality of the Kali Jagir River in Surabaya complies with Class I Water Quality Standards. The calculated flow rates at the Kali Jagir River in Surabaya are 82 m^3/s at station 1, 100.49 m^3/s at station 2, and 123.28 m^3/s at station 3, based on cross-sectional area and flow velocity. The average water temperature of the Kali Jagir River at the upstream, middle, and downstream sections is 28.1°C, 28°C, and 28°C, respectively. The average pH of the Kali Jagir River water in the upstream section is 5.4, the middle section is 5.6, and the downstream section is 5.5. The average cadmium (Cd) content in the Kali Jagir River at the upstream, middle, and downstream sections is 0.0005 mg/L. The average lead (Pb) content in the Kali Jagir River at the upstream, middle, and downstream sections is < 0.013 mg/L, < 0.010 mg/L, and < 0.010 mg/L, respectively.

RECOMMENDATIONS

Based on the research findings on the water quality study of the Kali Jagir River in Surabaya in terms of cadmium (Cd) and lead (Pb) content in 2022, the researchers provide the following recommendations. For the community as users of the Kali Jagir River, it is advisable to use water that has undergone physical and chemical treatment processes to avoid health issues. For the relevant authorities managing the Kali Jagir River in Surabaya, it is recommended that water quality monitoring and supervision be conducted at least every six months in accordance with PP No. 82 of 2001 on Water Quality Management and Water Pollution Control.

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