Potential health disaster risks due to Ciliwung River Water quality in DKI Jakarta

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Abstract. DKI Jakarta is one of the provinces with the highest flood risk in Indonesia. 13 rivers divide Jakarta from upstream to downstream, one of which is the Ciliwung River. However, at this time, the Ciliwung River was asked to be one of the dirtiest rivers in the world. The purpose of this study was to determine the levels of physical parameters (TSS), chemical parameters (BOD, COD, Total Phosphate), and microbiological parameters (Total Coliform, Fecal Coliform) in the Ciliwung River, along with the potential health disaster risks from various parameters studied based on literature review. The method used is descriptive quantitative with secondary data sources in the form of monitoring data on the water quality of the Ciliwung River, which was carried out for four periods in April, June, July and August at 21 points spread along with upstream to downstream. The results showed that the physical, chemical and microbiological parameters had passed the specified standard thresholds and had the potential for a public health disaster due to exposure to organic compounds and microorganisms in the Ciliwung River. Further efforts related to disaster need to be carried out in a Penta helix manner so that disaster risk reduction efforts can be carried out as a whole.

1. Introduction
Pollution can come from natural events, and it can also come from the consequences of daily human activities [1]. In general, the accumulation of various human activities can produce waste containing heavy metals, which can cause river water pollution problems and become a risk factor for chronic diseases and negative health impacts [2,3].

Toxic heavy metals (toxic metals) can enter the body through direct or indirect interactions with food, respiration, and skin penetration [4–6]. Heavy metals are non-degradable by organisms in the environment, so these heavy metals accumulate in environmental ecosystems that settle on the riverbed to form complex compounds with organic and inorganic materials by absorption and combination. Aquatic biota that lives in rivers contaminated with heavy metals can accumulate these heavy metals in their body tissues through the bioaccumulation process [7–9].

Based on the 2020 Indonesian Disaster Risk Index, DKI Jakarta Province has a high potential for flood disasters due to overflowing river water [10]. The lack of water catchment areas, high rainfall, and the overflow of the Ciliwung River are some of the leading causes of flooding in DKI Jakarta [11,12].

The Ciliwung River is the largest river in Java that crosses the DKI Jakarta area and often causes floods every year in the downstream area. The characteristics of this river tend to overflow in the rainy season but dry in the dry season [13,14].
The potential risk of health disasters due to pollution of domestic and industrial waste in the Ciliwung River is a threat and challenge for flood disaster risk management programs in DKI Jakarta. Therefore, the study of potential health disaster risks due to the water quality of the Ciliwung River in DKI Jakarta becomes significant as part of reducing disaster risk that can afflict the community.

This paper aims to describe the levels of physical parameters (Total Suspended Solids), chemical parameters (Biological Oxygen Demand, Chemical Oxygen Demand, and Total Phosphate), and microbiological parameters (Total Coliform and Fecal Coliform) in the Ciliwung River and their comparison to standard quality. Water-based on the Regulation of the Governor of DKI Jakarta Province Number 582 of 1995, but also analyzes the potential risk of health disasters to humans from various parameters of heavy metals based on literature studies. The significance of this research is essential to be carried out immediately considering the annual flood cycle that afflicts DKI Jakarta. The analysis of potential health disasters on heavy metal content in the Ciliwung River in DKI Jakarta is a database and input material for better water resource management in DKI Jakarta.

2. Research methodology

This research is a research concept processed quantitatively (using secondary number data) with a descriptive approach as an analytical tool in answering research problems. Secondary data sources are obtained from direct observation and research, but the data sources are obtained from observations and analyses that previous researchers have carried out. The study started with the search for water quality data on OpenDataJakarta to describe the heavy metal content in the Ciliwung River in Jakarta [15]. The qualification of the Ciliwung River water quality data source is the result of measurements of the Ciliwung River in 4 periods (April, June, July, and August) at 21 points spread upstream to downstream (Figure 1).

![Figure 1. Locations for monitoring the water quality of the Ciliwung River in DKI Jakarta Province.](image-url)
In addition, this paper also uses other secondary data in the form of government laws and regulations, scientific reports, books, and journals related to the potential health disaster risk on the parameters of heavy metals contained in the Ciliwung River in Jakarta.

3. Results and discussion

3.1. Ciliwung River water quality in DKI Jakarta

The Ciliwung River is one of the largest rivers on Java, which passes through the capital city of DKI Jakarta. This river stretches from upstream, located in the Bogor area, which includes Mount Gede, Mount Pangrango, and Cisarua, to the downstream extent on the north coast of DKI Jakarta. The length of the main flow of this river is ± 120 km with a watershed area (DAS) of 387 km² [16]. Geographically, the watershed of the Ciliwung River is located between 6°05' - 6°50' south latitude and 106°40' - 107°00' east longitude.

Water is closely tied to local ecological conditions [16]. Based on the Regulation of the Governor of DKI Jakarta Province Number 582 of 1995, water according to its designation is classified into Category A; namely, water that can be directly used as drinking water without prior treatment, with a maximum concentration of organic substances (permanganate number) 10 mg/l or equivalent to Maximum target concentration of Biological Oxygen Demand is five mg/l, Category B is water that can be used as raw water for drinking water, with a target concentration of maximum Biological Oxygen Demand 10 mg/l, Category C is water that can be used for fishery and livestock purposes, with an ultimate target concentration of Biological Oxygen Demand is 20 mg/l, Category D is water that can be used for agricultural purposes and can be used for urban businesses, hydropower industry, with a target concentration of maximum Biological Oxygen Demand 20 mg/l. The designation of the Ciliwung River and its tributaries are classified B, C, and D.

Based on the results of measurements carried out by the DKI Jakarta Environment Agency on the water quality of the Ciliwung River at 21 monitoring points in 2019, it shows that the water quality of the Ciliwung River does not meet the water quality standards according to Government Regulation No. 82 of 2001 concerning Water Quality Management and Water Pollution Control. The results of laboratory testing of the water quality of the Ciliwung River based on physical parameters in the form of the concentration of Total Suspended Solids (TSS) at 21 sample locations can be seen in Figure 2.

Figure 2. Ciliwung River Water Quality Measurement Results Based on Physical Parameters (Total Suspended Solids) Ciliwung River in DKI Jakarta Province.

The measurement results in Figure 2 show fluctuations in the concentration of Total Suspended Solids (TSS) in the Ciliwung River, with the enormous changes seen in period one at monitoring points
1, 2A, 2B, 2C, 3, 3B, 4, 5, 29A, and 29 E. Periods 1 which occurs from April to May is a transitional period between the two main seasons, namely between the rainy season and the dry season. There was still rainfall intensity in period 1 (April – May), resulting in river water carrying solids from upstream to downstream, so Total Suspended Solids (TSS) levels in this period were very high at some monitoring points. This result is inversely proportional to the measurement results in the dry season period (Periods 2, 3, and 4). The results of this measurement follow the characteristics of rivers in DKI Jakarta Province, where the rivers tend to be dry during the dry season, so those little solids are carried by the currents of the Ciliwung River in DKI Jakarta.

The results of measuring the water quality of the Ciliwung River based on chemical parameters in the form of concentrations of Biological Oxygen Demand, Chemical Oxygen Demand, and Total Phosphate at 21 sample locations can be seen in Figures 3, 4, and 5.

![Graph 3](image3.png)

**Figure 3.** Ciliwung River Water Quality Measurement Results Based on Chemical Parameters (Biological Oxygen Demand) in DKI Jakarta Province.

![Graph 4](image4.png)

**Figure 4.** Ciliwung River Water Quality Measurement Results Based on Chemical Parameters (Chemical Oxygen Demand) in DKI Jakarta Province.
Figure 5. Ciliwung River Water Quality Measurement Results Based on Chemical Parameters (Total Phosphate) in DKI Jakarta Province.

Based on Figures 3, 4, and 5, the results of measuring the water quality of the Ciliwung River on the parameters of Total Phosphate, Biological Oxygen Demand, and Chemical Oxygen Demand indicate that these parameters have exceeded the quality standards set in almost all monitoring points, except monitoring points 1, 2, 2A, 2B, 2C, and 3. The high values of Biological Oxygen Demand and Chemical Oxygen Demand in river water indicate that the organic compound content of river water is high enough that the quality of river water has decreased significantly. The ratio between Biological Oxygen Demand and Chemical Oxygen Demand in river water shows the source of pollutants that enter the river flow. Biological Oxygen Demand and Chemical Oxygen Demand ratio for Ciliwung River water are in the range of 0.5 – 0.6. This shows that the source of the pollutant comes from the direct disposal of industrial waste.

In addition, the Ciliwung River was also identified as experiencing contamination from domestic waste. This can be seen at monitoring points 3B, 4, 5, and 6 (downstream), which are pretty high in the Total Phosphate parameter due to domestic waste from community settlements living along the banks of the Ciliwung River. Total Phosphate content generally comes from people's domestic activities, such as bathing and washing using soap and detergent. Soaps and detergents are one of the reasons for the high Total Phosphate parameter because they contain high levels of Nitrogen (N) and Phosphorus (P) [17].

Another identification shows that the Total Phosphate parameter can also be sourced from soil erosion due to the denitrification process by microorganisms so that the content of ammonia and Total Phosphate can increase in the soil. Soil erosion due to rainwater causes ammonia and total phosphate contained in the soil to be carried to the river [18–20].

The results of measuring the water quality of the Ciliwung River based on microbiological parameters in the form of concentrations of Total Coliform and Fecal Coliform at 21 monitoring points can be seen in Figures 6 and 7.
The results of the measurement of biological parameters in the form of Total Coliform and Fecal Coliform in Figures 6 and 7 indicate that all samples of Ciliwung River water during the 4 test periods have exceeded the specified quality standard. This identification of microbiological pollution suggests the presence of domestic waste that enters the river water. The household waste was identified as a result of open defecation [21–23] along the banks of the Ciliwung River. Therefore, the high concentration of Total Coliform and Fecal Coliform due to open defecation is one of the causes of the high biological parameters in the Ciliwung River.

3.2. Potential Health Disaster Risks Due to Ciliwung River Water Quality in DKI Jakarta

Environmental pollution by heavy metals is a crucial environmental problem and a challenge for achieving sustainable development goals. However, heavy metals and providing benefits for human life can also be toxic to human health and can disrupt the balance of the ecosystem. Based on the point of view of toxicology, heavy metals can be divided into essential heavy metals and non-essential heavy metals. Essential heavy metals include essential elements needed by living things in specific doses or amounts, such as copper (Cu), selenium (Se), iron (Fe), and zinc (Zn) needed to maintain body metabolism. On the other hand, non-essential heavy metals (microelements) have no function in the body. They are even very dangerous to cause poisoning in humans, such as lead (PB), mercury (Hg), arsenic (As), and cadmium (Cd) [24–26].

Heavy metals are one of the water pollutants. The presence of these metals is hazardous, even in small amounts. Heavy metals that pollute river flows can cause poisoning to humans directly, such as...
use for drinking, bathing, and other direct services [27,28], as well as indirect uses, such as the use of river water for agricultural purposes, utilization of marine life, and so on [29,30].

3.2.1. **Total Suspended Solids (TSS)**. Total Suspended Solids are solids present in a solution but are not dissolved, can cause the solution to become cloudy, and cannot directly settle to the bottom of the solution. The impact of Total Suspended Solids on water quality can lead to a decrease in water quality. This condition can cause a disturbance, damage, and danger to all living things that depend on water resources. Total Suspended Solids cause turbidity and reduce the light that can enter the water. Therefore, the benefits of water can be diminished, and organisms that need light will die. The death of these organisms will disrupt the aquatic ecosystem [22,31–33]. In addition, if this amount of suspended matter settles, then the formation of mud can significantly disrupt the flow in the channel. As a result, silting occurs, meaning that there is a potential for indirect health disaster.

3.2.2. **Biological Oxygen Demand (BOD)**. Biological Oxygen Demand is the amount of dissolved oxygen needed by microorganisms to break down organic matter in water. Consumption of river water containing Biological Oxygen Demand as drinking water can cause health problems, such as digestive disorders and skin irritation [34–36].

3.2.3. **Chemical Oxygen Demand (COD)**. Chemical Oxygen Demand is the amount of oxygen needed to oxidize the waste materials in the water through a chemical reaction. The high parameter of Chemical Oxygen Demand in waters indicates a tendency for heavy metal content in water and sediment to be high because Chemical Oxygen Demand is a non-biodegradable organic matter content that is generally sourced from industrial waste [37,38].

3.2.4. **Total Phosphate**. Phosphate content in water does not have a direct impact on humans or animals. Still, if consumed continuously, it will affect digestive problems and increase the potential for chronic kidney disease [39–41].

3.2.5. **Total Coliform**. A total Coliform is a group of bacteria that is used as an indicator of the presence of sewage pollution. The total coliform present in the food or drink indicates the possibility of enteropathogenic and toxigenic microbes harmful to health. Total Coliform bacteria can cause diarrhea, dysentery, cholera, and other digestive tract diseases [42–44].

3.2.6. **Fecal Coliform**. Naturally, Fecal Coliform bacteria are found in humans, as well as warm-blooded animals. The discovery of these bacteria in river water indicates contamination by human or animal waste which may contain other bacteria, viruses, or disease-causing organisms. This is why Fecal Coliform bacteria are often used as an indicator of water pollution because Fecal Coliform bacteria in the water are a warning of disease-causing microorganisms. The most common diseases caused by fecal coliform bacteria are urinary tract infections, infections of the brain's lining, and hemolytic uremic syndrome [45–47].

4. **Conclusion**

In general, this study concludes that the water quality of the Ciliwung River in DKI Jakarta, from upstream to downstream, has been of poor quality, both in terms of physical, chemical, and biological parameters. The high physical parameters (TSS), chemical parameters (BOD, COD, and Total Phosphate), and microbiological parameters (Total Coliform and Fecal Coliform) of the Ciliwung River at the beginning of entering the DKI Jakarta area indicate that pollution occurs not only in the DKI Jakarta area but also in also upstream of the Ciliwung River in Bogor and Depok, West Java. Therefore, the handling of potential health disaster risks due to the water quality of the Ciliwung River needs to be handled Penta helix.
Pollution characteristics in the Ciliwung River are predicted to continue to increase every year. This is based on the high physical, chemical, and biological parameters along the banks of the Ciliwung River area due to increased human activities (building houses and shops) along this river. Therefore, several steps need to be implemented, such as periodic testing of the water quality of the Ciliwung River in DKI Jakarta, policies related to anaerobic biofilters (septic tanks), increasing public awareness of the importance of protecting river ecosystems and the dangers of heavy metals on health, policy consistency in monitoring, warning and enforcement. In addition, law continuously to industrial, housing, and office managers who do not have a liquid waste disposal permit and other appropriate policy strategies in reducing health disaster risks due to the water quality of the Ciliwung River in DKI Jakarta.

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