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Assessment of heavy metal contamination in surface water: A case study from Kanke Dam, Ranchi

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ABSTRACT

Surface water heavy metal concentrations must be tracked in order to assess environmental quality and possible health hazards. The current study measured the concentrations of a few chosen heavy metals in surface water taken from Ranchi, eastern India's Kanke Dam. Arsenic (As), lead (Pb), nickel (Ni), cadmium (Cd), and mercury (Hg) were measured in water samples using conventional analytical techniques in accordance with IS 3025. Pb was found at a low quantity of 0.002 mg L^{-1}, whereas As, Ni, Cd, and Hg were below the detection limit (<0.001 mg L^{-1}), according to the results. The acceptable limits set forth by IS 10500:2012 drinking water regulations were fulfilled by all measured heavy metals. The low quantities found point to little anthropogenic impact and show that there is now no major heavy metal contamination in the water body. In addition to highlighting the necessity of routine monitoring to identify long-term changes and possible buildup in sediments and aquatic animals, the study offers baseline data on heavy metal status.

Key Words - Surface water quality, Environmental monitoring, Drinking water standards, Kanke Dam

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INTRODUCTION

Although freshwater supplies are essential for maintaining ecosystems and enabling human activity, rising human pressure has caused the quality of water to decline in many parts of the world. Heavy metals pose significant ecological and human health problems since they are non-biodegradable, persistent in the environment, and have the ability to bioaccumulate in aquatic creatures (Rai *et al.,* 2019; Singh, Singh, & Gupta, 2021). Metals like arsenic, cadmium, mercury, and lead need to be regularly monitored in surface water bodies because they are known to have harmful effects even at low quantities (WHO, 2017). Due to inputs from urban runoff, agricultural practices, atmospheric deposition, and natural rock weathering, surface waters-such as lakes, reservoirs, and dams-are particularly susceptible to heavy metal contamination (Tripathi, Singh, & Chandra, 2018; Chaturvedi, Shrivastava, & Tripathi, 2019). Numerous studies have shown the significant influence of local land-use patterns, hydrological conditions, and geochemical processes such sediment adsorption and dilution on the concentration of heavy metals in surface water (Duhan *et al.*, 2019; Maiti & Chowdhury, 2020). As a result, the evaluation of heavy metals in freshwater systems is frequently employed as a gauge of anthropogenic stress and environmental quality. Concerns over the quality of surface water resources have grown in the Indian context due to the country's fast urbanization and population expansion. Depending on local industrialization and urban influence, several studies conducted in lakes and reservoirs throughout India have found varying degrees of heavy metal contamination, from undetectable to elevated concentrations (Amina & Raghavan, 2017; Singh, Sharma, & Singh, 2018; Kumar & Dhanjal, 2020). The significance of site-specific monitoring is shown by the fact that, although some freshwater bodies in relatively less industrialized areas have metal concentrations below regulatory norms, others indicate contamination levels above allowable limits.

There are many freshwater reservoirs in eastern India, especially the state of Jharkhand, which are crucial for irrigation, drinking water, and fisheries. There is still a dearth of systematic data on the heavy metal status of many of these water bodies, despite their socioeconomic importance. A significant freshwater reservoir that provides water for residential and recreational uses is Kanke Dam, which is located close to Ranchi. However, as the surrounding areas become more urbanized, the water quality must be regularly assessed to guarantee public health and environmental safety. In this regard, the current study uses standard analytical techniques to determine the concentrations of specific harmful heavy metals in the surface water of Kanke Dam, including arsenic (As), lead (Pb), nickel (Ni), cadmium (Cd), and mercury (Hg). The present level of heavy metal contamination was assessed by comparing the results to national drinking water standards (IS 10500:2012). In addition to contributing to existing initiatives for sustainable management and long-term monitoring of freshwater resources in eastern India, the study offers baseline data on heavy metal levels in the reservoir.

MATERIALS & METHODS

Samples of surface water were taken from Kanke Dam, a freshwater reservoir used for agriculture and domestic usage, located at latitude 23.4300°N and longitude 85.3200°E, respectively. High-density polyethylene (HDPE) bottles that had been previously cleaned were used for sampling in accordance with conventional protocols. To preserve the dissolved metals, samples were acidified with ultrapure nitric acid to a pH of less than two as soon as they were collected. They were then chilled and brought to the lab. In accordance with conventional procedures, materials were digested in the lab using nitric acid after being filtered to eliminate suspended particles. Following the Indian Standard procedures outlined in IS 3025 (Part II) for the analysis of water and wastewater, the levels of arsenic, cadmium, lead, nickel, and mercury were measured. Atomic Absorption Spectrophotometry (AAS) was used for metal analysis, and analytical blanks and approved standard solutions were used for calibration. The use of analytical-grade chemicals, acid-washed glassware, replicate analyses, and routine equipment calibration were all part of the quality assurance and control procedures. In order to assess heavy metal pollution, the measured amounts were compared with national and international drinking water quality standards. Results that fell below the method detection limits were reported as below detection limit (BDL).

RESULTS & DISCUSSION

Table 1. Heavy metal concentration in surface water sample of Kanke Dam, Ranchi

Sl. No.	Parameter	Unit (mg L^{-1})	Concentration	Permissible limit* (mg L^{-1})	Analytical method
1	Arsenic (As)	mg L^{-1}	BDL (DL-0.001)	0.01	IS 3025 (Part II): 2004
2	Lead (Pb)	mg L^{-1}	0.002	0.01	IS 3025 (Part II): 2004
3	Nickel (Ni)	mg L^{-1}	BDL(DL-0.001)	0.02	IS 3025 (Part II): 2004
4	Cadmium (Cd)	mg L^{-1}	BDL(DL-0.001)	0.003	IS 3025 (Part II): 2004
5	Mercury (Hg)	mg L^{-1}	BDL(DL-0.001)	0.001	IS 3025 (Part II): 2004

Table 1 summarizes the amounts of specific hazardous heavy metals in the surface water sample. Of the parameters that were examined, the levels of arsenic (As), nickel (Ni), cadmium (Cd), and mercury (Hg) were found to be below the analytical methods' detection limit (BDL < 0.001 mg L^{-1}). These metals' insignificant presence in the aquatic system during the sampling period is indicated by their non-detectable levels. The amount of lead (Pb) found was 0.002 mg L^{-1}, far less than the IS 10500:2012-recommended maximum allowable value of 0.01 mg L^{-1}. The low lead levels at the research site indicate little industrial or urban influence and little anthropogenic input.

All of the heavy metals that were detected fell under the national standards' allowable levels for drinking water. The analysis was carried out in accordance with IS 3025 (Part II): 2004 standard standards, guaranteeing data dependability and methodological consistency. The findings show that hazardous metal contamination has no discernible impact on the study area's surface water quality.

Arsenic and cadmium frequently remain below detectable levels in surface waters due to strong adsorption onto sediments and organic matter, which lowers their dissolved concentrations, according to earlier studies on reservoirs and lakes from eastern and central India (e.g., Singh *et al.*, 2018; Kumar and Sharma, 2020). Other researchers noted similar findings, emphasizing that mercury is rarely found in surface waterways unless it is impacted by mining operations or industrial discharge. The current study's lack of mercury lends more credence to the idea that point-source pollution is comparatively absent from the studied area. The low concentration of lead (0.002 mg L^{-1}) found here is in line with previous findings from water bodies around cities, where lead is typically ascribed to diffuse sources such surface runoff, air deposition, and vehicle emissions rather than direct industrial inputs. Lead contents in lakes without significant industrial inflow have been shown to be significantly below drinking water standards in studies by Verma *et al.* (2019) and Mishra *et al.* (2021). There was no anthropogenic stress during the sampling period, as evidenced by the measured lead level in this study being much lower than the IS 10500:2012 standard. Similar findings have been extensively documented in freshwater bodies throughout India, where low dissolved metal concentrations are the consequence of efficient dilution processes and little industrial activity (Amina & Raghavan, 2017; Singh *et al.,* 2018; Maiti & Chowdhury, 2020). The present study's non-detectable levels of cadmium and arsenic are in line with previous research that found that these metals frequently stay below detection limits in surface waters because of their strong adsorption onto organic matter and sediments (Duhan *et al.,* 2019; Chaturvedi *et al.,* 2019). In aquatic systems, these geochemical controls are essential for reducing the mobility and bioavailability of hazardous metals. Similarly, the lack of mercury in the current investigation suggests low point-source pollution, as it is rarely found in surface waters unless it is impacted by mining or industrial effluents (Khan *et al.,* 2018; Mani & Ramasamy, 2017).

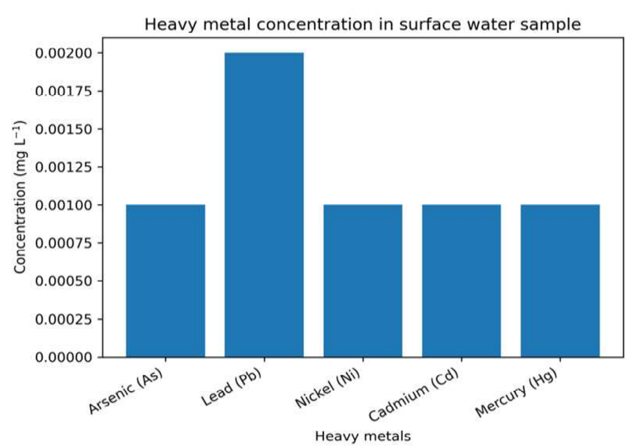

Fig.1- Graph showing heavy metal concentration in surface water sample of Kanke Dam

CONCLUSION

The analysis of surface water revealed that arsenic, nickel, cadmium, and mercury were below the detection limit, while lead was detected at a low concentration within permissible limits. These results indicate minimal heavy metal contamination and limited anthropogenic influence at the study site during the sampling period. However, regular monitoring is recommended to assess long-term accumulation and ensure sustainable water quality management.

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