

# Assessment of Heavy Metal Contamination in Bhosga Reservoir, Kalaburagi District, Karnataka, India

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## Abstract:

The Present investigation aimed to examine the heavy metal concentrations in water samples from seven locations in the Bhosga Reservoir provided critical insights into water quality and potential environmental impacts. The metals assessed included Zinc (Zn), Copper (Cu), Manganese (Mn), Chromium (Cr), Lead (Pb), Cadmium (Cd), and Nickel (Ni). Results indicated that Zinc concentrations well within the WHO limit of 15 mg/L. Copper levels remaining below the WHO standard of 1.5mg/L, though elevated levels at some sites raised concerns about localized pollution. Manganese concentrations were also below the WHO standard of 0.3 mg/L. Chromium was found to be within safe limits. In contrast, Lead concentrations exceeded the WHO limit of 0.01mg/L, raising serious environmental concerns. Cadmium levels were exceeding the permissible limit of 0.003 mg/L at multiple sites. Nickel concentrations were surpassing the WHO acceptable limit of 0.02 mg/L at several stations. In summary, the highest to lowest concentrations detected were as follows: Cu>Mn>Pb>Ni>Cd>Cr>Zn. These ranking underscores the varying levels of contamination across the sites, with copper and manganese exhibiting the highest concentrations, raising potential environmental concerns.

**Keywords:** Bhosga Reservoir, Heavy metal, Pollution indices and Risk assessment

## Introduction:

Heavy metal contamination poses significant environmental and health risks globally, including in India. These contaminants, such as lead, cadmium, mercury, and arsenic, originate from industrial activities, mining operations, agricultural practices, and urbanization. They persist in the environment, accumulating in soil, water, and air, and can enter the food chain, posing threats to human health through consumption of contaminated food and water sources. Chronic exposure to heavy metals is associated with severe health effects, including neurological disorders, kidney damage, cancer, and developmental abnormalities (Agency for Toxic Substances and Disease Registry, 2020).

In India, heavy metal contamination has diverse environmental impacts. In agricultural soils, metals alter soil chemistry and reduce fertility, affecting crop productivity and food security. In urban areas, industrial emissions and improper waste disposal contribute to soil and water contamination, jeopardizing public health and environmental quality. In aquatic ecosystems, metals accumulate in sediments and bioaccumulate in aquatic organisms, posing risks to biodiversity and ecosystem stability.

The ecological consequences of heavy metal contamination in India are profound. Aquatic organisms, such as fish and amphibians, are particularly vulnerable due to their direct exposure to contaminated water bodies. Heavy metals disrupt physiological functions, impair reproduction, and lead to population declines. Soil contamination affects microbial communities vital for nutrient cycling and soil health, impacting agricultural sustainability and ecosystem resilience. Assessing heavy metal contamination helps identify vulnerable ecosystems and species, guiding conservation efforts and pollution control measures (UN Environment Programme, 2021)

Assessing heavy metal contamination is essential for sustainable development and environmental stewardship in India. By employing advanced assessment techniques and adhering to stringent regulatory standards, stakeholders can mitigate risks associated with heavy metals, protect human health, and preserve biodiversity. Continued research, monitoring, and collaborative efforts are crucial to addressing the complex challenges posed by heavy metal pollution and promoting a healthy environment for future generations.

Khan et al., (2020) assessed heavy metal contamination in the Ganga Alluvial Plain, India, concentrating on six metals: As, Fe, Cd, Pb, Mn, and Cr. They concluded that the river's hazardous status is visible from the HPI values, with 60% of the sites falling in the critically contaminated portion, 30% in the highly contaminated sector, and just 10% in the slightly contaminated segment and reported that untreated sewage system discharge from domestic and industrial wastewater, as well as agricultural runoff, is recognised latent source of heavy metal contamination in river water and Mishra and Kumar<sup>3</sup> assessed the NSFQI, CPI, & HPI were used for assessing overall water pollution quality of Narmada River. The river's average NSFQI, HPI, and CPI were determined to be 70.35, 1.35, & 1.98, respectively, indicating as river water is moderately contaminated & unfit for drinking. Furthermore, RAI and CRI are used to assess the likelihood of cancer risk to human health from river water exposure. Significantly, RAI and CRI values less than one indicate a significant risk of cancer owing to higher concentrations of copper ( $\text{Cu} > 50 \mu\text{g/L}$ ), lead ( $\text{Pb} > 10 \mu\text{g/L}$ ), & manganese ( $\text{Mn} > 100 \mu\text{g/L}$ ).

A review of literature shows that no efforts were made to study metal contamination in Bhosga Reservoir. Hence the present investigation was undertaken. Thus, now it's essential to determine the current extent and severity of heavy metal contamination in the lake, identify potential sources and pathways of heavy metal pollution and provide recommendations for management and mitigation strategies to improve water quality and ecosystem health.

## Material and Methods:

Bhosga Reservoir, situated approximately 10 km from Kalaburagi city in Karnataka's Kalaburagi district, is a vital perennial water body nestled between latitudes  $16^{\circ}12'$  to  $17^{\circ}46'$  and longitudes  $76^{\circ}46'$  to  $77^{\circ}42'$ . Positioned at an elevation of 454 meters above mean sea level (MSL), the reservoir spans a catchment area of  $756 \text{ km}^2$ .

Surface water samples were collected twice during the investigation, using 1-liter pre-rinsed polyethylene bottles from seven distinct, pre-determined locations around the lake. The sites were categorized based on their human activity levels. Pristine sites, such as N1, located on the lake's north-western edge, and N2, on the western side, experience minimal human interference, making them ideal for baseline comparisons due to their rich biodiversity and healthy ecosystems. High human activity sites include A1, near agricultural fields with numerous pipelines; A2, on the southern shore, frequently used for washing clothes; and A3, on the southern bank, accessible for vehicle washing. These sites help assess the impact of agricultural runoff, detergents, and automotive pollutants. Highly polluted sites P1, at the lake's eastern entry point, and P2, on the south eastern edge, exhibit significant pollution from village runoff and human waste, providing insights into the types and extent of contaminants. Each site's characteristics and reasons for selection aim to evaluate heavy metal contamination levels across different environmental conditions. The different sampling locations are represented in (Table No.1). The samples were acidified with concentrated  $\text{HNO}_3$  (Nitric acid) and stored in an icebox. A GPS device was used to record the coordinates of the sample collection locations.

A 100 ml volume of each water sample was placed into a beaker and digested by adding 5 ml of concentrated nitric acid ( $\text{HNO}_3$ ) on a hot plate until the volume was reduced to 25 ml. The samples were then filtered into a 100 ml volumetric flask using Whatman No. 44 filter paper, and the volume was adjusted with distilled water. Heavy metal analysis was performed using an atomic absorption spectrophotometer (AAS) at USIC Gulbarga University.

**Table No.1: Different sampling Sites**

| Site Name | Location                                                    | Reason                                                                                           | Representation          |
|-----------|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-------------------------|
| N1        | North-western edge of the lake, far from the village        | Pristine state, minimal human impact, healthy ecosystem for assessing natural heavy metal levels | Four-sided strain red   |
| N2        | Western side of the lake, distant from the village          | Pristine condition, control site for evaluating natural heavy metal levels                       | Four-sided strain red   |
| A1        | Close to agricultural Fields on the northern side           | Key site for assessing impact of agricultural runoff and pollutants                              | Five-sided strain blue  |
| A2        | Southern shore of the lake easily accessible                | Evaluate impact of detergents and chemicals from clothes washing                                 | Five-sided strain blue  |
| A3        | Southern bank of the Lake accessible for vehicles           | Study impact of pollutants from vehicle washing                                                  | Five-sided strain blue  |
| P1        | Entry point of the lake on the eastern side                 | Assess impact of accumulated pollutants due to water flow obstruction                            | Six-sided strain purple |
| P2        | Nearest access point for villagers on the southeastern edge | Study impact of direct human pollution on heavy metal levels                                     | Six-sided strain purple |

### Results:

The analysis of heavy metal concentrations in water samples from seven locations in the Bhosga Reservoir provided critical insights into water quality and potential environmental impacts. The metals assessed included Zinc (Zn), Copper (Cu), Manganese (Mn), Chromium (Cr), Lead (Pb), Cadmium (Cd), and Nickel (Ni). Results indicated that Zinc concentrations ranged from 0.0486 mg/L (N1) to 0.0887 mg/L (A2), with an average of 0.0614 mg/L, well within the WHO limit of 15 mg/L. Copper levels ranged from 0.0428 mg/L (N1) to 0.1547 mg/L (A2) (average: 0.0619 mg/L), remaining below the WHO standard of 1.5 mg/L, though elevated levels at some sites raised concerns about localized pollution. Manganese concentrations varied from 0.0414 mg/L (N1) to 0.1850 mg/L (A2) (average: 0.0654 mg/L) and were also below the WHO standard of 0.3 mg/L. Chromium was found to be within safe limits, ranging from 0.0043 mg/L (N1) to 0.0219 mg/L (A2) (average: 0.0113 mg/L). In contrast, Lead concentrations exceeded the WHO limit of 0.01 mg/L, ranging from 0.0072 mg/L (N1) to 0.1073 mg/L (A2) (average: 0.0391 mg/L), raising serious environmental concerns. Cadmium levels ranged from 0.0027 mg/L (A3) to 0.0145 mg/L (A1) (average: 0.0061 mg/L), exceeding the permissible limit of 0.003 mg/L at multiple sites. Nickel concentrations ranged from 0.0169 mg/L (N1) to 0.0617 mg/L (A2) (average: 0.0278 mg/L), surpassing the WHO acceptable limit of 0.02 mg/L at several stations. In summary, the highest to lowest concentrations detected were as follows: Cu > Mn > Pb > Ni > Cd > Cr > Zn (Table No.2). These findings highlight the need for further investigation into contamination sources and the implementation of management strategies to mitigate heavy metal pollution, ensuring the protection of aquatic life and human health in the surrounding communities.

**Table No.2 Summary of Heavy Metal Concentrations in Bhosga Reservoir**

| Metal | N1     | N2     | A1     | A2     | A3     | P1     | P2     |
|-------|--------|--------|--------|--------|--------|--------|--------|
| Zn    | 0.0486 | 0.0542 | 0.0639 | 0.0887 | 0.0672 | 0.0514 | 0.0765 |
| Cu    | 0.0428 | 0.0531 | 0.0631 | 0.1547 | 0.0675 | 0.0556 | 0.0618 |
| Mn    | 0.0414 | 0.0722 | 0.0813 | 0.1850 | 0.0514 | 0.0451 | 0.0724 |
| Cr    | 0.0043 | 0.0152 | 0.0111 | 0.0219 | 0.0105 | 0.0064 | 0.0188 |

|    |        |        |        |        |        |        |        |
|----|--------|--------|--------|--------|--------|--------|--------|
| Pb | 0.0072 | 0.0176 | 0.0195 | 0.1073 | 0.0421 | 0.0123 | 0.0394 |
| Cd | 0.0029 | 0.0035 | 0.0145 | 0.0141 | 0.0027 | 0.0041 | 0.0052 |
| Ni | 0.0169 | 0.0224 | 0.0302 | 0.0617 | 0.0233 | 0.0195 | 0.0256 |

## Discussion:

The analysis of heavy metal concentrations in the Bhosga Reservoir provides critical insights into the water quality across various sites, reflecting the environmental health of this ecosystem. The metals assessed—Zinc (Zn), Copper (Cu), Manganese (Mn), Chromium (Cr), Lead (Pb), Cadmium (Cd), and Nickel (Ni)—show varied concentrations influenced by human activities and natural factors.

**1. Zinc (Zn):** The concentrations of Zn ranged from 0.0486 mg/L at N1 to 0.0887 mg/L at A2, with an average of 0.0614 mg/L. These levels are well below the WHO permissible limit of 15 mg/L, indicating no immediate concern for zinc contamination in the reservoir. The slightly elevated levels at A2 suggest potential localized sources, possibly linked to agricultural runoff or waste.

**2. Copper (Cu):** Cu concentrations varied from 0.0428 mg/L at N1 to 0.1547 mg/L at A2, averaging 0.0619 mg/L. While this average remains below the WHO standard of 1.5 mg/L, the peak concentration at A2 raises concerns about localized pollution, likely from agricultural practices or industrial discharge. This finding underscores the need for ongoing monitoring of agricultural impacts on water quality.

**3. Manganese (Mn):** The Mn levels ranged from 0.0414 mg/L (N1) to 0.1850 mg/L (A2), with an average of 0.0654 mg/L. Again, these concentrations are below the WHO limit of 0.3 mg/L. However, the higher values at A2 and A3 may indicate enrichment due to sediment disturbance or inflow from surrounding agricultural land, necessitating further investigation into local sediment dynamics.

**4. Chromium (Cr):** Cr concentrations were consistently low, ranging from 0.0043 mg/L at N1 to 0.0219 mg/L at A2, with an average of 0.0113 mg/L. All values fall well within the WHO limit of 0.05 mg/L, suggesting no significant sources of chromium contamination in the reservoir.

**5. Lead (Pb):** Pb concentrations presented a more alarming picture, with values ranging from 0.0072 mg/L at N1 to 0.1073 mg/L at A2, averaging 0.0391 mg/L. Several sites exceeded the WHO standard of 0.01 mg/L, particularly at A2, A1, and P2. This raises serious environmental concerns, as lead is a known neurotoxin that can have detrimental effects on human health and aquatic life.

**6. Cadmium (Cd):** Cd concentrations ranged from 0.0027 mg/L (A3) to 0.0145 mg/L (A1), averaging 0.0061 mg/L. These levels exceeded the WHO permissible limit of 0.003 mg/L at multiple sites, suggesting potential contamination from agricultural runoff or nearby industrial activities. The presence of cadmium is particularly concerning due to its long-term toxicity and bioaccumulation in aquatic organisms.

**7. Nickel (Ni):** Ni concentrations varied from 0.0169 mg/L (N1) to 0.0617 mg/L (A2), averaging 0.0278 mg/L. Several sampling stations exceeded the WHO acceptable limit of 0.02 mg/L, especially at A2 and A1. The elevated levels of nickel could indicate industrial influences or urban runoff, highlighting the need for further assessment.

## Conclusion:

The present study reveals that many metals are found within permissible limits, significant exceedances are noted particularly for Lead (Pb), Cadmium (Cd), and Nickel (Ni) at several sites, especially A2 and A1. These findings indicate that while the overall water quality may seem acceptable for certain metals, the presence of these hazardous contaminants raises concerns about environmental and public health implications.

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