# Finding Heavy Metals in Drinking Water Along the Krishna River

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**Abstract: Access to clean and safe drinking water remains a critical concern in many developing regions, including parts of India. The Krishna River, a major water source in Andhra Pradesh, supports domestic, agricultural, and industrial activ- ities. However, increasing anthropogenic influences have raised concerns over the presence of heavy metal contaminants in its water. This study aims to assess the concentration of heavy metals such as Lead (Pb), Cadmium (Cd), Chromium (Cr), and Arsenic (As) in drinking water samples collected from various locations along the Krishna River. Standard analytical techniques, including Atomic Absorption Spectroscopy (AAS), were employed for metal detection. The results were compared with permissible limits set by the World Health Organization (WHO) and the Bureau of Indian Standards (BIS). Findings indicate the presence of potentially harmful concentrations of certain metals at specific sites, highlighting the urgent need for monitoring and remediation efforts. This research contributes to the understanding of regional water quality and supports policy recommendations for sustainable water management in Andhra Pradesh.**

***Keywords:*** *Heavy Metals, Drinking Water, Krishna River, Andhra Pradesh, Waterquality, Atomic Absorption Spectroscopy (AAS), Environmental Pollution, Public Health, Lead (Pb), Cad- Mium (Cd), Chromium (Cr), Arsenic (As).*

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## I. INTRODUCTION

Access to clean and safe drinking water is a fundamental human necessity and a key indicator of public health. How- ever, increasing industrialization, agricultural runoff, and urban expansion have significantly compromised water quality in many parts of the world, especially in developing countries like India [2], [14]. Heavy metals such as lead (Pb), arsenic (As), cadmium (Cd), chromium (Cr), and mercury (Hg) are among the most toxic and persistent pollutants in aquatic ecosystems. These metals not only pose serious health risks to humans but also disrupt aquatic life and ecological balance [5], [9], [16].

The Krishna River, one of the major rivers of peninsular India, serves as a life line for millions across Maharashtra, Karnataka, Telangana, and Andhra Pradesh. Despite its critical role in irrigation and drinking water supply, the river is increasingly vulnerable to contamination due to effluent discharges, sewage, and agricultural activities along its banks [12],[17].Previous studies on rivers such as the Yamuna and the Ganga have revealed alarming levels of heavy metal pollution, emphasizing the need for timely monitoring and mitigation [3], [10], [14].

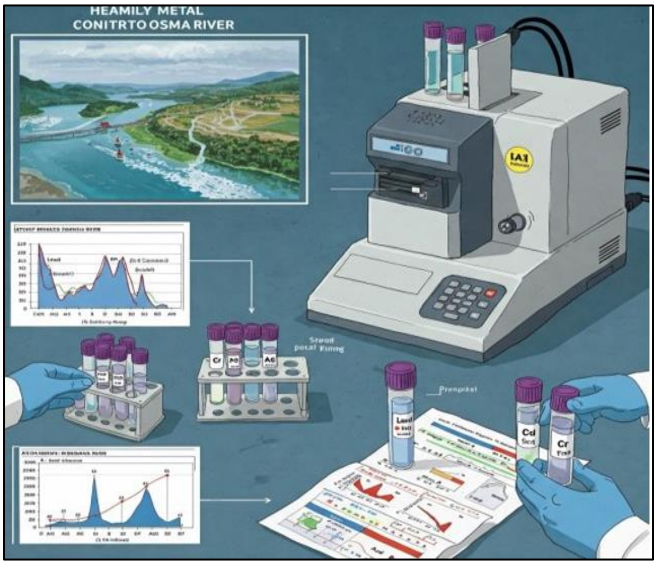


Fig 1 Studying Water Quality in Krishna River.

As illustrated in Figure 1, the Krishna River flows through several industrial and agricultural zones, making it highly susceptible to various sources of heavy metal pollution. This geographical context highlights the importance of studying water quality in its downstream regions.

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According to the Bureau of Indian Standards (BIS) and World Health Organization (WHO) guidelines, even trace amounts of certain heavy metals in drinking water can lead to chronic health issues, including neurological disorders, kidney damage, and carcinogenic effects [4], [19], [20]. These metals can bio accumulate in the human body overtime, making their Presence particularly hazardous [8], [13]. Unfortunately, com- prehensive data on heavy metal concentration in the Krishna River—especially in the downstream stretches flowing through Andhra Pradesh—remains scarce.


Fig 2 Krishna River Map.

In this study, we investigate the levels of heavy metals in drinking water sources along the Krishna River in Andhra Pradesh using standard procedures recommended by APHA and AWWA [1]. The findings aim to assess the current state of water quality, evaluate potential health risks, and recommend strategies for regular monitoring and pollution control. This work is critical for ensuring safe water for the population and promoting sustainable water management in the region. Figure 2 illustrates the geographical location of the Krishna River, which is central to this study. The map highlights the regions most affected by heavy metal contamination in Andhra Pradesh.

The remainder of the paper is organized as follows: Sec-tion 2 presents a review of the existing literature related to heavy metal contamination in Indian rivers. Section 3 outlines the methodology used for sample collection, analysis, and interpretation. Section 4 discusses the results obtained from laboratory analysis and compares them with established safety standards. Section 5 concludes the study by summarizing the findings and proposing recommendations for future research and policy interventions.

## II. LITERATURE REVIEW

The issue of heavy metal contamination in water sources has been extensively studied due to its serious environmental and health implications. According to APHA, AWWA, and WEF [1], standard methodologies for water analysis remain critical in identifying and quantifying toxic metals in drinking water. Studies conducted along major rivers in India have consistently indicated the presence of hazardous heavy metals beyond permissible limits.

Begum et al. [2] assessed the Cauvery River and found elevated levels of metals such as lead and cadmium, linking them to urban and industrial discharge.Similarly, Bhardwajet al.[3] employed environmetrics to analyze the Yamuna River, highlighting a concerning rise in metal concentrations due to anthropogenic activities.

Briffa et al. [5] provided a global perspective on heavy metal pollution and its toxico logical impact on humans, emphasizing that even low exposure levels can result in chronic health issues. The World Health Organization (WHO) has repeatedly addressed these concerns through guidelines on drinking water quality [**?**], [19], [20], stressing the dangers of arsenic, mercury, and other metals.

Kaushiketal.[10]and Khanetal.[11] further confirmed heavy metal accumulation in the Yamuna and Gomti rivers, respectively, attributing the sources to sewage, industrial waste, and agricultural runoff. The Central Water Commission (CWC) has published comprehensive reports detailing trace and toxic metals in Indian rivers, including the Krishna River basin, revealing widespread contamination [17], [18].

Masindi and Muedi [13] provided an in-depth look at the environmental behavior of heavy metals, their transport in water bodies, and bio accumulation in aquatic life. Dutta et al.

[7] Observed how riverfront developments further exacerbate pollution by disturbing natural sedimentation processes. Paul [14] reviewed the pollution of the Ganga River and noted a similar pattern of contamination driven by unchecked urban growth and in adequate waste management. Fergusson.

[8] and Jarup [9] discussed the long-term effects of heavy metal exposure, including developmental, neurological, and carcinogenic outcomes.

Singh et al. [16] and Sharma [15] highlighted how heavy metals affect not only human health but also disrupt aquatic ecosystems. Their work underlines the urgency of continuous monitoring and policy enforcement to mitigate such contami- nation.

Overall, these studies establish a clear need for region-specific assessments of heavy metal pollution. While the Krishna River has received limited focused attention

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compared to rivers like the Yamuna or Ganga, evidence suggests it faces similar threats from urbanization, industrialization, and agriculture.

## III. METHODOLOGY

In the present study, water samples were collected from various locations along the Krishna River in clean polyethylene containers. These samples were subsequently analyzed for the presence of heavy metals such as arsenic, cad- mium, chromium, copper, iron, lead, nickel, and zinc using Atomic Absorption Spectrophotometry (AAS). The analysis was carried out using an Agilent 240FS atomic absorption spectrophotometer. The measurements for most metals were performed using a Graphite Tube Analyzer (GTA) with argon gas, while iron was analyzed using flame operation involving air and acetylene gas. The analytical parameters, including wavelength, current, slit width, and the method used for each metal, are provided in Table I.

Table 1 The Wavelength, Current, Slit and Method Used for Chemical Analysis by AAS

| S.No. | Parameter | Wavelength (nm) | Current (mA) Recommended | Maximum | Slit (nm) | Method used for analysis |
|---|---|---|---|---|---|---|
| 1 | Arsenic (As) | 193.7 | 10 | 12 | 0.5 | By AAS with VGA |
| 2 | Cadmium (Cd) | 228.8 | 4 | 10 | 0.5 | By AAS with Graphite Tube Analyzer (GTA) |
| 3 | Chromium (Cr) | 357.9 | 7 | 15 | 0.2 | By AAS with Graphite Tube Analyzer (GTA) |
| 4 | Copper (Cu) | 324.8 | 4 | 10 | 0.5 | By AAS with VGA |
| 5 | Mercury (Hg) | 253.7 | 4 | 8 | 0.5 | By AAS with VGA |
| 6 | Iron (Fe) | 248.3 | 7 | 10 | 0.2 | By AAS with Flame |
| 7 | Lead (Pb) | 217.0 | 10 | 12 | 1.0 | By AAS with Graphite Tube Analyzer (GTA) |
| 8 | Nickel (Ni) | 232.0 | 4 | 10 | 0.2 | By AAS with Graphite Tube Analyzer (GTA) |
| 9 | Zinc (Zn) | 213.9 | 5 | 10 | 1.0 | By AAS with Graphite Tube Analyzer (GTA) |

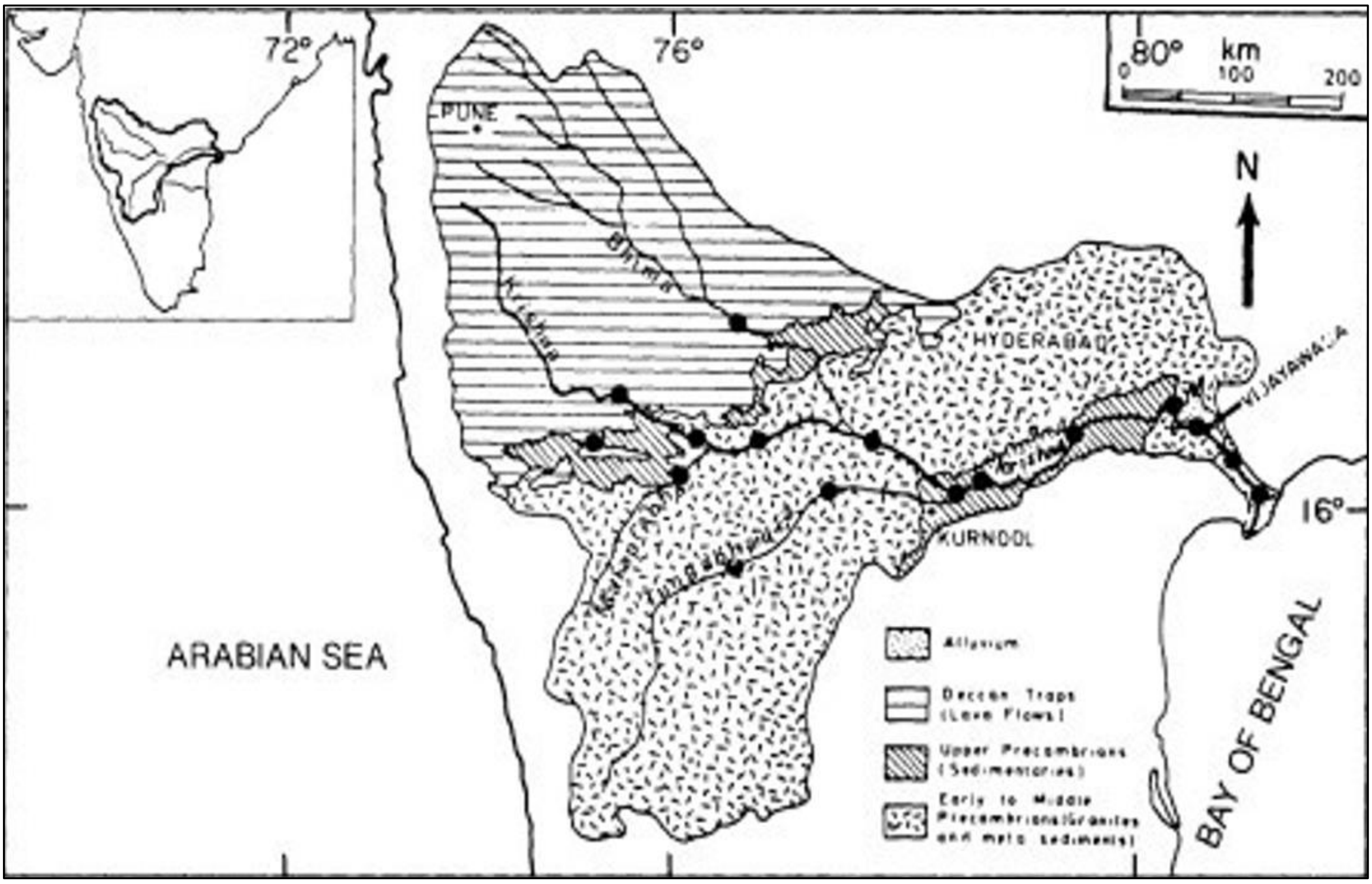


Fig 3 Krishna River GIS-Basedmap

➢ *Study Area*

The present study focuses on the detection and analysis of heavy metals in drinking water collected from various monitoring locations along the Krishna River, one of the major east-flowing rivers of peninsular India. Originating near Mahabaleshwar in Maharashtra, the Krishna River flows through the states of Maharashtra, Karnataka, Telangana, and Andhra Pradesh before draining into the Bay of Bengal.

Water samples were collected from **XX strategically se- lected stations** along the Krishna River covering upstream, midstream, and downstream regions to ensure comprehensive spatial representation. Sampling was conducted during the period from **August 2018 to December 2020**, encompassing both dry and wet seasons to capture seasonal variability.

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The selected sampling locations include sites near major urban settlements, industrial zones, agricultural regions, and relatively undisturbed upstream areas to assess anthropogenic impacts. The spatial distribution of these monitoring stations along the Krishna River is illustrated in the GIS-based map shown in Figure 3.

## IV. EXPERIMENTAL RESULTS

The concentration levels of trace and toxic heavy metals, namely Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Iron (Fe), Lead (Pb), Nickel (Ni), and Zinc (Zn), were analyzed in the water samples collected from different monitoring stations along the Krishna River using Atomic Absorption Spectrophotometry (AAS). The observed concentrations were compared against the permissible limits prescribed by the Bureau of Indian Standards (BIS) and the World Health Organization (WHO).

➢ *Heavy Metal Concentration Levels*

Figure 4 presents the average concentrations of the selected heavy metals at various locations along the river. It is observed that:

- **Iron (Fe)** and **Zinc (Zn)** showed the highest concentrations among all metals, with certain sites exceeding the WHO permissible limits.
- **Lead (Pb)** and **Cadmium (Cd)** levels were above safe limits in the downstream industrial zones.
- **Arsenic (As)** and **Mercury (Hg)** were detected in trace quantities but still raise concern due to their toxicity.

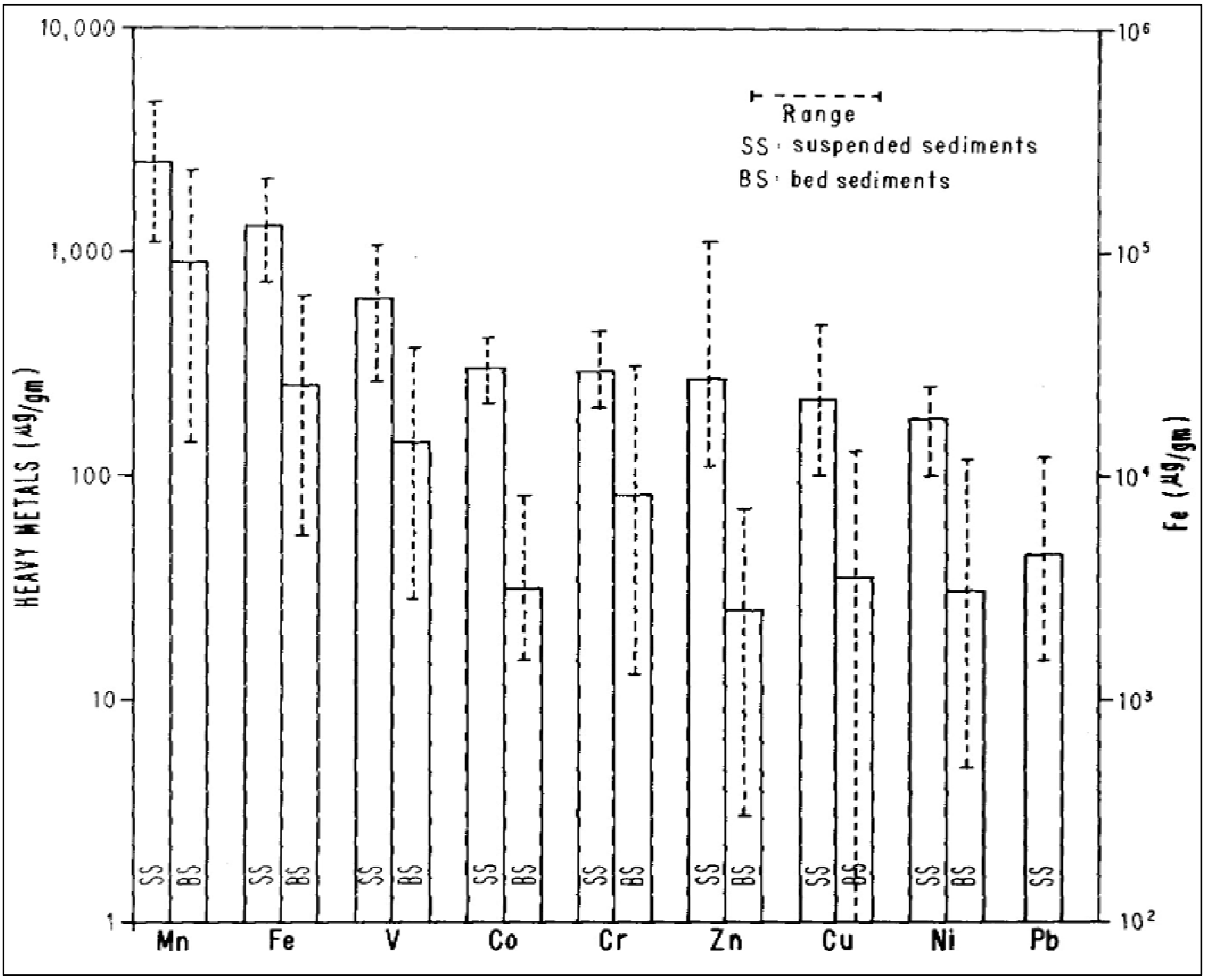


Fig 4 Average Concentration of Heavy Metals (mg/L) at Various Monitoring Stations Along the Krishna River

The spatial distribution of selected heavy metals was mapped using GIS as shown in Figure 5. High concentrations were observed downstream near urban and industrial clusters, indicating anthropogenic sources of pollution.

➢ *Comparison with Standards*

Table III summarizes the comparison between observed average concentrations and the permissible limits.

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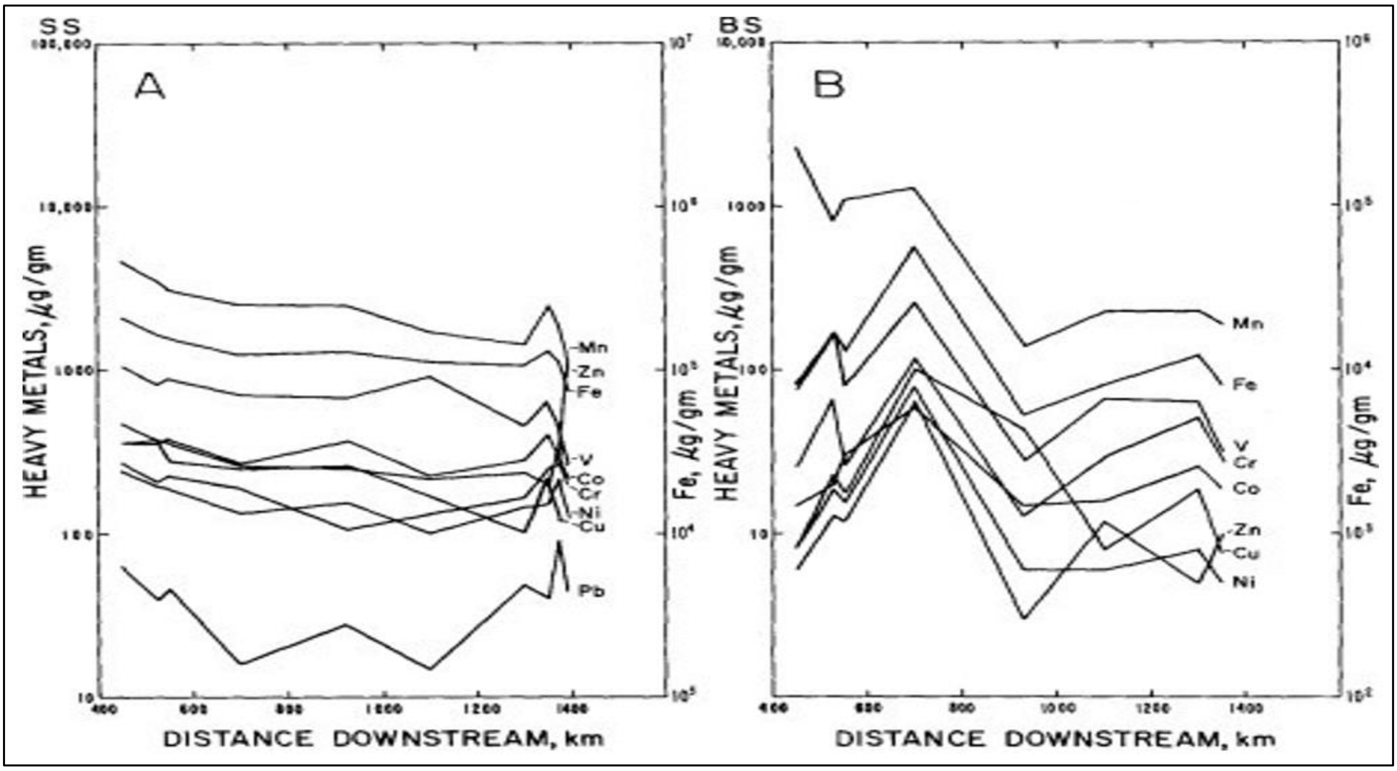


Fig 5 Downstream Variation in the Concentration of Fe, Mn, Cr, Co, Ni, Cu, Zn, V, and Pb in the Suspended (A) and Bed Sediments (B) of the Krishna River Basin

Table 2 Heavy Metal Fluxes in Suspended Sediments of Krishna, Major Rivers of the Indian Sub-Continent, and World Average. Units for Heavy Metals are in $\times 10^3$ tonnes/Year (Unless noted).

| **Location** | **Sediment Transport** ($\times 10^6$ t/yr) | **Fe** | **Mn** | **Cr** | **Co** | **Ni** | **Cu** | **Zn** | **V** | **Pb** |
|---|---|---|---|---|---|---|---|---|---|---|
| Krishna River | | | | | | | | | | |
| Kolhar | 0.5 | 0.11 | 2.31 | 0.18 | 0.18 | 0.12 | 0.24 | 0.14 | 0.53 | 0.03 |
| Sangam | 7.16 | 1.2 | 25.74 | 2.71 | 2.51 | 1.4 | 2.65 | 1.48 | 5.91 | 0.28 |
| Raichur | 14.86 | 1.87 | 37.73 | 3.88 | 3.98 | 2.01 | 3.73 | 2.87 | 10.46 | 0.24 |
| Kurnool | 16.86 | 2.19 | 42.93 | 4.27 | 6.39 | 2.65 | 4.43 | 1.8 | 11.68 | 0.47 |
| Srisailam | 11.26 | 1.26 | 19.38 | 2.47 | 2.57 | 1.16 | 1.96 | 1.5 | 10.48 | 0.17 |
| Vijayawada | 1.74 | 0.19 | 2.51 | 0.41 | 0.49 | 0.26 | 0.19 | 0.29 | 0.81 | 0.09 |
| Tributaries | | | | | | | | | | |
| Gataprabha | 0.19 | 0.04 | 0.85 | 0.08 | 0.08 | 0.05 | 0.09 | 0.05 | 0.13 | 0.02 |
| Malaprabha | 0.75 | 0.08 | 1.39 | 0.16 | 0.16 | 0.14 | 0.09 | 0.18 | 0.29 | 0.04 |
| Bhima | 5.31 | 0.64 | 12.6 | 1.35 | 1.48 | 0.71 | 1.34 | 0.87 | 3.68 | 0.09 |
| Tungabhadra | 0.85 | 0.09 | 2.04 | 0.24 | 0.21 | 0.15 | 0.09 | 0.14 | 0.33 | 0.02 |
| Mean (Krishna) | 4.11[b] | 0.54 | 10.45 | 1.21 | 1.25 | 0.73 | 0.91 | 1.12 | 2.59 | 0.19 |
| Other Rivers | | | | | | | | | | |
| Godavari | 170[c] | 9.71 | 181.9 | 21.42 | 7.99 | 8.67 | 13.94 | 9.18 | 50.49 | 1.87 |
| Cauvery | 0.71[a] | 0.04 | 0.92 | 0.11 | 0.07 | 0.11 | 0.04 | 0.36 | 0.21 | 0.03 |
| Ganges | 329[e] | 29.61 | 1135.05 | 86.86 | 73.37 | 45.07 | 82.91 | 604.05 | – | – |
| Brahmaputra | 597[f] | 65.31 | 2656.65 | 132.53 | 100.3 | 106.86 | 64.48 | 546.85 | – | – |
| Indian Average | 1212[d] | 35.15 | 733.26 | 105.44 | 37.57 | 44.84 | 33.94 | 19.39 | – | – |
| World Average | 13505[g] | 648.24 | 14180.25 | 1350.5 | 270.1 | 1215.45 | 1350.25 | 4726.75 | 2295.85 | 2025.75 |

**Sources:** A Rameshand Subramanian (1986); b Rameshand Subramanian (1988); c Bikshamand Subramanian (1988); d Subramanian (1978); e Abbasand Subramanian (1984); f Subramanian (1979); g Millimanand Meade (1983).

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Table 3 Comparison of Observed Heavy Metal Concentrations with BIS and WHO Standards(mg/L)

| Metal | Observed Avg. | BIS Limit | WHO Limit |
|---|---|---|---|
| Arsenic (As) | 0.01 | 0.01 | 0.01 |
| Cadmium (Cd) | 0.006 | 0.003 | 0.003 |
| Chromium (Cr) | 0.05 | 0.05 | 0.05 |
| Copper (Cu) | 0.2 | 0.05 | 2.0 |
| Mercury (Hg) | 0.001 | 0.001 | 0.001 |
| Iron (Fe) | 1.2 | 0.3 | 0.3 |
| Lead (Pb) | 0.02 | 0.01 | 0.01 |
| Nickel (Ni) | 0.04 | 0.02 | 0.07 |
| Zinc (Zn) | 4.5 | 5.0 | 3.0 |

Based on the annual sediment load in the Krishna River (RameshandSubramanian1986), the annual heavy metal flux was calculated at various stations Table II.

## V. CONCLUSION AND FUTURE SCOPE

➢ *Conclusion*

The present study highlights the presence and distribution of heavy metals in drinking water sources along the Krishna River, emphasizing the need for continuous monitoring and control measures. The experimental analysis revealed ele- vated concentrations of Iron (Fe), Zinc (Zn), Lead (Pb), and Cadmium (Cd) in several locations, particularly downstream, where anthropogenic influences such as industrial discharge, agricultural runoff, and urban sewage are prominent.

The comparison with BIS and WHO standards indicates that certain sampling sites exceed the permissible limits, posing potential health risks to the local population. These findings underscore the urgency for effective water quality management strategies and pollution control interventions across the Krishna River basin.

➢ *Future Scope:*

- Integrationo fremotesens in gand IoT-basedreal-timewa- terqua lity monitoringsystemscanenhancedataaccuracy and timeliness.
- Further studies can explore bioaccumulation effects of heavy metals in aquatic life and the food chain.
- Machine learning and AI-based predictive models maybe developed to forecast heavy metal pollution trends.
- Implementation of community-level water purification solutions can be investigated for high-risk zones.
- Policy-oriented research involving socio-economic im- pact assessment and regulatory frameworks can provide long-term mitigation strategies.

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