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# HEAVY METAL CONTAMINATION IN KOLLERU LAKE AND ITS LINK TO THE ELURU ILLNESS INCIDENT

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**ABSTRACT**

Kolleru Lake, a Ramsar wetland, faces severe heavy metal contamination from aquaculture, industry, and agriculture. This study assessed heavy metal (Pb, Hg, Cd, Cr, As) concentrations in water and sediments during pre-monsoon and post-monsoon periods in 2024, comparing them to WHO drinking water limits and ecological thresholds. Results showed that Pb, Hg, and Cd in water frequently exceeded WHO limits, while sediment concentrations were significantly higher, particularly for Pb. Although monsoon rainfall diluted water concentrations of some metals, others like Cr and As showed post-monsoon increases due to agricultural runoff. Elevated lead levels in water (2.8-3.5 times WHO limits) pose chronic health risks, particularly to children in downstream communities like Eluru. The persistent contamination in the lake, especially in sediments, suggests a continuous risk of public health crises similar to the 2020 Eluru illness outbreak, where lead-contaminated drinking water was implicated. The findings emphasize the urgent need for stringent effluent regulations, sediment remediation, and integrated watershed management to protect Kolleru Lake's ecological integrity, regional water security, and public health.

**Keywords:** Kolleru Lake, Heavy Metal Contamination, Eluru Illness, Lead, Water Quality, Sediment Pollution, Public Health, Environmental Monitoring, Wetland Management

## 1. INTRODUCTION

Kolleru Lake, a Ramsar-designated wetland of international importance situated between the Krishna and Godavari deltas, plays a crucial role in supporting diverse aquatic biodiversity and providing essential ecosystem services. These services include water storage, flood mitigation, and livelihood support for thousands of fishing households (Kolli et al., 2021). Despite its ecological significance, the lake has faced increasing heavy metal contamination over the past three decades due to rapid aquaculture expansion,

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industrialization, and agricultural intensification (Shivakrishna et al., 2020; Rao et al., 2020; Kolli et al., 2020).

In December 2020, Eluru town, located downstream of Kolleru's catchment area, experienced a mysterious illness characterized by neurological symptoms such as seizures, vomiting, and loss of consciousness, affecting over 400 people within three days (Mummadi et al., 2021). Investigations revealed the presence of heavy metals, particularly lead, in blood samples of those affected, although most tested heavy metals were within permissible limits except for a few samples (Mummadi et al., 2021). While organophosphorus pesticides were primarily identified as the probable cause, heavy metal contamination was also considered a potential contributing factor (Mummadi et al., 2021).

This paper aims to thoroughly examine the extent of heavy metal pollution in Kolleru Lake, analyze its potential links to the Eluru illness incident, identify the primary sources of this contamination, and assess seasonal patterns in contamination levels through comprehensive water and sediment sampling. Understanding these dynamics is crucial for developing effective mitigation strategies and safeguarding both ecological health and human well-being in the region.

## 2. LITERATURE REVIEW

### 2.1 Heavy Metal Pollution in Wetlands

Wetlands inherently function as natural sinks for heavy metals, effectively trapping them within their sediments, where these contaminants can persist for decades. This persistence leads to bioaccumulation in aquatic organisms (Rao et al., 2010), posing significant ecological and public health risks. Long-term exposure to toxic metals such as lead (Pb), mercury (Hg), and cadmium (Cd) is associated with severe health issues including neurological impairment, kidney dysfunction, and developmental disorders in humans (World Health Organization [WHO], 2017).

### 2.2 Heavy Metals in Kolleru Lake

Previous research on Kolleru Lake has consistently documented elevated concentrations of Pb, Hg, and Cd in both sediments and surface waters, often exceeding national and international safety thresholds for drinking water and aquaculture (Sharma, 2019; Nadh, 2020). Major anthropogenic sources contributing to the heavy metal inputs into the lake includes, Aquaculture effluents containing uneaten feed, antifouling agents, and waste by-products., Agricultural runoff carrying organophosphate pesticides and phosphate fertilizers contaminated with trace metals, Industrial discharges from nearby paper mills, electroplating units, and chemical processing plants, Urban sewage containing untreated domestic wastewater and pharmaceutical residues.

### 2.3 The December 2020 Eluru Illness

In December 2020, Eluru town, located downstream of Kolleru Lake's watershed, experienced a sudden outbreak of neurological illness. Clinical investigations by the Indian Council of Medical Research (ICMR) detected lead concentrations in drinking water that were above permissible limits (ICMR, 2021). Possible contamination pathways included the leaching of heavy metals from agricultural inputs and industrial effluents into the groundwater and surface water sources that supply Eluru's municipal system.

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## 3. METHODOLOGY

### 3.1 Study Area

Sampling for this study was systematically carried out across three distinct hydrological zones within Kolleru Lake. These zones were selected to represent the varying influences on the lake's water quality and ecological conditions. Upstream inflow points at the Budameru and Tammileru rivers, which serve as major channels for freshwater and pollutant inputs. Mid-lake aquaculture zones, characterized by intensive fish and prawn farming operations.Downstream outlet near the Eluru canal, which drains towards Eluru town and adjacent agricultural areas.

### 3.2 Sampling and Analysis

Field sampling of both water and sediment was conducted during two distinct seasonal windows to capture variations in heavy metal concentrations: pre-monsoon (May 2024) and post-monsoon (October 2024). The parameters measured included heavy metals (Lead (Pb), Mercury (Hg), Cadmium (Cd), Chromium (Cr), and Arsenic (As)), physicochemical variables (pH, dissolved oxygen (DO), and electrical conductivity (EC)), and sediment characteristics (organic matter content). Analytical methods adhered to internationally accepted protocols to ensure data reliability. Water digestion procedures were performed according to Standard Methods for the Examination of Water and Wastewater (American Public Health Association [APHA], 2017), and heavy metal quantification was carried out using Atomic Absorption Spectroscopy (AAS), a highly sensitive technique for trace metal detection (APHA, 2017). Quality control measures, including triplicate sampling, reagent blanks, and analysis of certified reference materials, were implemented to ensure the reliability and reproducibility of the data.

## 4. RESULTS

### 4.1 Heavy Metal Concentrations

Heavy metal concentrations in the water and sediments of Kolleru Lake were assessed for both the pre-monsoon (May 2024) and post-monsoon (October 2024) seasons. The measured values were compared with WHO drinking water limits (WHO, 2017) to evaluate potential human health risks.

**Table 1 – Heavy Metal Concentrations in Kolleru Lake Water and Sediments**

| Heavy Metal | WHO Limit (Water, mg/L) | Pre-Monsoon Water (mg/L) | Post-Monsoon Water (mg/L) | Pre-Monsoon Sediment (mg/kg) | Post-Monsoon Sediment (mg/kg) | SD (Water) | SD (Sediment) | p-value | Significance |
|---|---|---|---|---|---|---|---|---|---|
| Pb | 0.01 | 0.035 | 0.028 | 45.6 | 42.1 | 0.004 | 1.25 | 0.032 | Significant |
| Hg | 0.006 | 0.012 | 0.009 | 1.8 | 1.6 | 0.0012 | 0.09 | 0.041 | Significant |
| Cd | 0.003 | 0.0045 | 0.0031 | 2.3 | 2.0 | 0.0008 | 0.12 | 0.058 | Not Significant |
| Cr | 0.05 | 0.041 | 0.049 | 12.5 | 13.2 | 0.0021 | 0.31 | 0.046 | Significant |
| As | 0.01 | 0.0098 | 0.011 | 5.6 | 6.3 | 0.0009 | 0.28 | 0.052 | Not Significant |

- *SD values represent variability between triplicate sample measurements and p-values ≤ 0.05 were considered statistically significant or not significant*

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The results show that Pb, Hg, and Cd in water exceeded WHO limits during the pre-monsoon period, and Pb remained above limits in the post-monsoon period. Cr and As remained within permissible water quality limits but showed a slight post-monsoon increase. Sediment concentrations were significantly higher than water concentrations for all metals, with Pb showing the highest sediment contamination.

## 5. DISCUSSION

### 5.1 Seasonal Variation

The observed seasonal pattern indicates that heavy rainfall during the monsoon period led to reduced concentrations of Pb, Hg, and Cd in the water column. This reduction is primarily attributable to dilution effects and increased water exchange (Rao et al., 2010). Conversely, Cr and As concentrations rose slightly post-monsoon, likely due to surface runoff from agricultural fields containing fertilizers and pesticides contaminated with these metals, as well as soil leaching during intense rainfall events. Such seasonal dynamics have been previously reported in tropical wetland systems, where hydrological flushing temporarily reduces certain contaminants while mobilizing others from catchment soils (Sharma, 2019).

### 5.2 Public Health Implications

Lead concentrations in water during both seasons were 2.8–3.5 times higher than WHO (2017) permissible limits, posing a chronic risk to human health. This risk is particularly significant for children in downstream areas such as Eluru, where lead exposure is unequivocally linked to irreversible neurotoxicity, reduced IQ, and developmental delays (WHO, 2017). The persistence of elevated Pb levels strongly suggests continuous contamination sources, possibly stemming from industrial effluents and legacy deposits in sediments that can resuspend during hydrological events (Nadh, 2020).

### 5.3 Ecological Risk

Sediment concentrations of Pb (42–46 mg/kg) and Cd (2–2.3 mg/kg) are well above ecological safety thresholds for benthic organisms (Seshavatharam et al., 2024). These metals can readily bioaccumulate in fish species such as Labeo rohita (Rohu) and Channa striata (Murrel), which are widely consumed by local communities, thereby transferring contamination through the food chain. Chronic sediment contamination also poses a severe threat to aquatic biodiversity, especially filter-feeding species that exhibit high sensitivity to metal toxicity.

### 5.4 Link to the December 2020 Eluru Illness

The December 2020 neurological outbreak in Eluru was partially attributed to Pb-contaminated drinking water, with Pb levels surpassing WHO limits in several tested samples (Mummadi et al., 2021). Although organophosphate pesticide contamination was also implicated, heavy metal toxicity could have exacerbated the severity of symptoms. The current 2024 findings suggest that Pb contamination levels remain significantly high in Kolleru's ecosystem, particularly in the sediments, supporting the hypothesis that episodic spikes during low-flow, dry season conditions could still trigger similar public health crises if not adequately addressed.

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## 6. CONCLUSION

The present study unequivocally highlights that Kolleru Lake remains under persistent and significant heavy metal stress, particularly from lead (Pb) and mercury (Hg), both of which exceeded WHO (2017) drinking water limits in multiple sampling periods. While post-monsoon hydrological flushing temporarily reduced concentrations of Pb, Hg, and cadmium (Cd) in the water column, sediment analyses confirm that these metals remain entrenched in the lake's benthic layer at ecologically hazardous levels. The presence of such long-lived pollutants not only poses chronic threats to aquatic biodiversity (Seshavatharam et al., 2024) but also sustains a latent risk of episodic contamination events, similar to the December 2020 Eluru neurological illness outbreak (Mummadi et al., 2021).

Given the catchment-wide nature of pollutant inputs, which include aquaculture effluents, industrial discharges, agricultural runoff, and untreated urban sewage (Nadh, 2020), Kolleru's contamination is not an isolated phenomenon but rather a systemic issue rooted in inadequate watershed management and enforcement gaps. Without targeted interventions—such as strict regulation of effluent discharge, comprehensive sediment remediation to address historical contamination, and integrated watershed-based pollution control strategies—the lake's ecological integrity will continue to degrade, with severe implications for regional water security, biodiversity conservation, and public health. Addressing these multifaceted challenges requires a coordinated and sustained effort from all stakeholders.

## 7. RECOMMENDATIONS

### 7.1 Enforce Zero-Discharge Policies for Aquaculture and Industry

The Andhra Pradesh Pollution Control Board (APPCB) must mandate closed-loop water treatment systems for aquaculture and industrial units, with strict penalties for violations. This is critical to prevent untreated effluents—rich in heavy metals, feed residues, and pesticides—from entering the lake (Sharma, 2019).

### 7.2 Implement Seasonal Health Monitoring for Communities Dependent on Kolleru Water

Public health agencies should conduct biannual medical screenings in downstream communities such as Eluru, with a focus on blood lead levels (BLL) in children. This data should be linked to seasonal pollution trends to enable early-warning systems (WHO, 2017).

### 7.3 Restore Riparian Buffer Zones to Reduce Runoff

Establish vegetated buffer strips along inflow rivers (Budameru and Tammileru) and lake margins to filter sediments, pesticides, and heavy metals before they enter the main water body. Similar restoration measures in other wetlands have shown measurable reductions in non-point source pollution (Rao et al., 2010).

### 7.4 Conduct Annual Heavy Metal Audits with Public Reporting

A centralized, publicly accessible database of water and sediment quality metrics should be maintained. Independent annual audits would enhance transparency and build trust among local communities, researchers, and policymakers.

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### 7.5 Strengthen Inter-Agency Coordination for Pollution Control

Currently, jurisdiction over Kolleru Lake's management is fragmented between fisheries, irrigation, forest, pollution control, and health departments. A joint task force with shared funding and legal authority is necessary to address the lake's pollution holistically.

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