Vidhyabharti International Ibterdisciplinary Research Journal

A LITERATURE REVIEW ON SOURCES OF HEAVY METALS POLLUTION OF INDIAN WATER BODIES AND THEIR IMPACT ON THE AQUATIC LIFE

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ABSTRACT

The fast population growth, industrialization, and new agricultural practises have destroyed India's water resources. Acute and chronic toxicity of heavy metals pollute aquatic environments. For numerous reasons, heavy metals can alter the trophic status of aquatic environments. Also a major health issue. Indian sediments in inland water systems are poisoned by heavy metals. It also addresses pollution sources. Various thresholds for sediment contamination were evaluated. Separate from natural factors, unmanaged manmade activities have deteriorated the environment in India. It is vital to raise public awareness of these issues and establish preventive and corrective measures. The country cannot afford high-tech remediation, thus prevention must be emphasised. Concerns about poverty, crowding, and malnutrition must be addressed through indigenous mitigation and remediation studies.

***Keywords**: Heavy metal, environment, aquatic life, Indian water bodies.*

1. Introduction

Recent threats to freshwater ecosystems include industrial pollution, agriculture, and waste management (Meijide et al., 2018). Precipitation and temperature have changed, influencing daily operations including reproduction and feeding. Ecosystems affected by invasive species (Schmeller et al., 2018). Water species and functions must be maintained globally, as must major pollution sources and fates (Liu et al., 2018; Zhao et al., 2018). We can conserve anthropogenic activity in freshwater aquatic species (Sumon et al., 2018a). Insights from natural processes can help design freshwater (Schmeller et al., 2018). Its main goal is to study pollution's effects on freshwater organisms.

India's ecological situation is deteriorating due to urbanisation, population expansion, industry, and other factors. Ecological conservation and energy efficiency are current socioeconomic problems Industrialization and agricultural development are important for human survival, but they must be done properly.

In aquatic ecosystems, household and municipal waste degrades more rapidly. India collects and processes fewer than 6 billion litres of waste water daily. 120,000 tonnes of MSW are generated everyday, however only 70% is collected and managed. Large concentrations of nonbiodegradable components, such heavy metals, raise the risk of bioaccumulation and biomagnification (Malik et al., 2010). Ocean pollution accounts for 59% of India's major annual environmental costs, while aquatic resources are declining at a 2%-3% annual rate. People put the stress on city water resources, causing them to deplete faster. This affects the local aquatic ecosystems. Cities harm water resources (Khan et al., 1988).

In the sediment are heavy metals and other contaminants. Due to the fact that sediments represent actual pollution levels, metal analysis of sediments helps identify sources of aquatic trace metal contamination. Luoma (1990) proposes that heavy metal concentrations in sediments can operate as an early warning system for contaminated hydrological systems. pH affects heavy metal solubility, chelating agents, particle size, and sediment composition (Jain, 2004). Metals go through many physicochemical, hydrological, and biological processes before they are given in particulate or soluble form. Adsorption, inactivation, transport, and inclusion (da Silva et al. 2000).

Because cation exchange systems absorb soil solutions, surfaces, and fluids, aquatic and benthic animals and plants have easy access to metals (Kumar et al., 2011). Metals highly bonded to sediments or complexed with other chemical substances are unlikely to be biologically accessible. Metal buildup and near-bottom water layer degradation are produced by sediment mobilization/immobilization (Kumar et al., 2011). Metals have different fates and transportations depending on chemistry and biology. While all metals have the same environmental impact, their bioavailability and toxicity vary.

2. The Sources Of Pollution

Heavy metal pollution is caused by both natural and man-made sources. Examples of natural sources include volcanic activity, forest fires, and water seepage from rocks. The most significant anthropogenic sources of pollution are waste from homes and businesses. There is very little pollution from natural sources; however, sewage and industrial wastes contribute significantly.

Untreated sewage discharge into bodies of water is India's most significant source of water pollution. Water pollution in India is largely due to sewage, according to the country's Tenth Plan Document, prepared by the Indian Planning Commission. Of the 38000 million litres of waste generated each day, only about 12000 million litres can be treated. As a result, India's wastewater generation and treatment facilities are located at opposite ends of the country. Even with the existing treatment capacity, utilisation is hampered by operational and maintenance issues. Approximately 39% of plants fail to comply with the Environmental (Protection) Rules for discharge into streams because existing plants and sewage pumping stations are poorly operated and maintained. Class I cities in India are home to 2277 lakh people spread across 498 locations. Their total wastewater production is 35558 MLD, but they only treat 11553 MLD (32% of it) (CPCB 2009-10). India's ClassII towns are home to about 300,000 people. There is still a treatment gap between what they create (2696 MLD of wastewater) and what they can treat (234 MLD) (equal to 8.6 percent). (CPCB 2009–10). The rest of it is dumped in waterways.

About 57,000 polluting Indian industries generate 13,468 MLD wastewater from large and medium industries (of which approximately 60% is treated) generate approximately 57,000 polluting industries (Sengupta, 2006). Environmental damage is being inflicted by both large and small businesses these days. These polluting industries have been singled out by India's Central Pollution Control Board (CPCB): manufacturing industries such as cement mills and sugar refining facilities as well as thermal power plants, distilleries and fertiliser refineries, in addition to oil refineries, as well as the manufacture of caustic soda and petrochemical products. The distillery, textile, engineering, and pulp and paper industries also have an impact on aquatic water bodies. Nearly 40% of India's industrial wastewater is generated by 3.2 lakh small businesses, many of which are very polluting (Maria, 2003). When it comes to wastewater generation, engineering plays the largest role in these businesses.

Heavy metals have become a problem in some Indian cities like Ranipet in Tamil Nadu, Kanpur in Uttar Pradesh, and Vadodara in Gujarat as a result of excessive waste generation. Ratlam, Madhya Pradesh, and Vadodara, Gujarat, both have high levels of lead contamination. Similarly to Tamil Nadu's Kodaikanal, both Tuticorin and West Bengal's Tuticorin are contaminated with As (CPCB 2009-10).

80 percent of India's pollution is attributed to Gujarat, Maharashtra, and Andhra Pradesh (CPCB 2009-10). CPPB launched a national water quality monitoring programme in 1978 as part of a global environmental monitoring system to combat pollution in India's waterways (GEMS). Urbanization and industrialization without proper planning, on the other hand, have had disastrous consequences for our waterways (Singh et al. 2002).

3. Indian water bodies

toxic metal pollution is a major environmental issue in the United States. These toxic metals enter ecosystems via a variety of mechanisms, including geoaccumulation, bioaccumulation, and biomagnification. Heavy metals including Zn, Fe, Pb, Cd, Hg, Ni, and Cr are the most polluting. A record of prior pollution in urban runoff, atmospheric deposition, and upstream runoff is preserved in soil and sediments by contaminants like industrial effluents (Jain 2004). Singh et al. (2005) claim that sediment in water bodies contains heavy metals from both natural and human sources. Sediment from industrial water bodies can be used to improve management strategies and identify existing pollution control operations at the source. Aside from physical and chemical interactions, heavy metals can be harmful in sediments and have a wide range of mobility (Singh et al. 2005). Bioavailability and toxicity of metals have therefore been important research topics for a long time (Singh, 2001). About 30% of the world's oceanic sediment load comes from aquatic ecosystems on the Asian continent, which act as major transporters of continental weathering products into the ocean.

River Ecosystems: An Overview

River sediments are an important source of information for determining whether human pollution has contaminated the water (Forstner & Wittmann 1983). River quality has deteriorated dramatically in the last few decades as a result of increased population and waste discharge into rivers. 70 percent of metals are transported by the world's oceans, which are linked to river sediments (Gibbs 1977). The metal content of river sediments was influenced by numerous factors, including geology, land use change, agricultural activity, industrialization, and biological productivity (Aurada, 1983).

Ganges, Brahmaputra, and Meghna river

The Ganges, Brahmaputra, and Meghna river systems are interconnected Considering its location, size, population density and rapid sediment deposition, the Bengal Basin holds a unique place in the world's basins. This system transports 1060 million tonnes of dissolved solids, 1330 km3 of freshwater, and 744106 tonnes of sediment per year to the Bay of Bengal. A large sediment dispersal system is found in the Bengal Basin due to the high rate of chemical denudation (Datta & Subramanian, 1998). A total area of about 2,000 square kilometres is serviced by this system. Despite its lack of industrialization, this region has one of the world's highest densities of population, with a density of 400 to 1200 people per square kilometre. Mn, Zn, Cr, Ni, Cu, and Pb concentrations in the G-B-M surface sediment range from 460 to 2655 parts per million (ppm) (Datta & Subramanian 1998).

The Ganges

This river, the Ganges, had the worst pollution, and the sediment in its bed could act as a place for metals to settle out of solution. The Damodar and Hooghly stretches had become polluted with runoff from refineries, industries, and mines, as well as agricultural runoff (Subramanian et al. 1988). Comparing Meghna's main channel and its tributaries to standard shale values revealed higher levels of Fe and Mn, as well as Zn and Cr.

Gomti River

In addition to agricultural runoff, it also receives sewage, industrial waste, and municipal waste before discharging them into the river. Gomti. For Cd, the average concentration in river sediment was 2.43 mg/kg, and for Cr it was 8.15 mg/kg. For Ni, the average concentration in river sediment in the Gomti was 15.17 mg/kg, with Pb at 40.33 mg/kg and Zn at 41.66 mg/kg. Because heavy metals precipitated and settled in river sediment as carbonates, oxides, and hydroxides, the danger of heavy metal exposure to benthic biota is higher (pH range: 7.22- 8.27). This system's Cd and Pb levels were higher, but the heavy metal content was lower.

Cauvery River

The Cauvery River in India There is a lot riding on the Cauvery River in India. This 764-kilometer-long river carries 1.5106 tonnes of sediment per year across a 90000-square-kilometer basin (Alagarsamy & Zhang, 2005). Irrigation is vital throughout the Tanjore delta region, but it is especially important. Earlier heavy metal concentrations for Mn, Cr, Ni, Cu, Zn, and Pb were 1300, 150, 150, 60, 500, and 40 ppm. Incorporating agricultural, industrial, and household waste increased the Mn, Cr, Ni, and Zn concentrations above the global average.

Damodar River

East India's Damodar River flows through this region.. The catchment area covers an area of 23170 km2 and receives an average annual rainfall of 1200 mm. A number of smaller rivers and streams flowed into the main river at various points along the way. There were

7894-30188 parts per million (ppm) of Fe, Mn, Cu, Zn, Ni, and Cr heavy metals in the sediment, with concentrations ranging from 10-33 ppm. Heavy metal pollution in the Damodar River Basin was less severe due to human-induced increases in Cu and Zn concentration along the river's course.

The Ganges River in India is the world's third-largest sediment transporter, behind the Yellow and Amazon rivers. Sediment loads on the river average around 1600 billion kilogrammes per year, with a mean annual flow of 5.9 billion cubic metres. Because of the high concentrations of heavy metals in the Ganges river sediment, this was reflected in the sediment's textural composition and geochemical characteristics of its tributaries (Singh et al., 2005). As a result of the findings reported in Jha et al. (2002) The most abundant elements in the upper Ganges were Mn, Fe, Co, Cu, and Cd, while the least abundant were Cr, Zn, Ni, and Pb.

Yamuna

Cu, Pb, Cd, and Zn concentrations in the Yamuna River Sediment averaged 22.2 mg/kg (Jain 2004). Because of their alkaline nature and high organic content, the sediments tested positive for higher levels of lead and cadmium than the region's average. The Delhi area had excessive levels of heavy metals because of massive sewage and industrial waste discharges from municipal and industrial areas. Notably, Delhi is the river's most significant source of pollution, with various drains accounting for nearly 80% of the pollution load. In Delhi, Cr concentrations were 821 ppm, Mn 678 ppm, and Fe 31 ppm, according to Rawat et al. (2003). As a result of these industries, the average shale value was higher than the average municipal waste value (except for Mn). Cd, Pb, and Zn were rated as high, medium, and low risk, respectively, by Jain (2004).

Subernarekha River

Jharkhand's south Chhotanagpur plateau is bisected by the Subernarekha River. It's a 470-kilometer-long, rain-fed river. As a result, heavy metals contaminated the river near Jamshedpur, India's largest metallurgical hub. Upadhyay et al. (2006) found Zn concentrations of 32.84 parts per million, Pb concentrations of 9.77 parts per million, copper concentrations of 35.55 parts per million, and cadmium concentrations of 0.036 parts per million in this system. The lithogenic and human influences on the Kharkhai tributary lead to greater metal concentrations in specific locations.

The Jhanji River

The Jhanji River System is a tributary of the Brahmaputra. The river's catchment is 1350 km2. It's a vital water source for residents downstream, but it's also a dump for rubbish. This system transports around 100 tonnes of wastewater every day from various sources. The surrounding settlements of Tuli and Nagaland Industrial Township pollute the river heavily. Due to direct and indirect waste dumping, the river has become a vast chemical storage facility. Pb, Zn, Cu, Ni, Co, and Cr contents were 14.78, 103.53, 44.37, 48.62, 49.57, and 171.44 ppm, respectively, according to Baruah et al (1996). The river is polluted with metals from decades of rubbish disposal.

Uppanar River

The Uppanar River Sediment Study reported average Fe values of 1.146 ppm, along with Mn (1.827), Cr (1.372), Cu (2.116), Nickel (1.194), Copper (1.201), Lead (0.902), and Cadmium (0.902). (1.430). as per Ayyamperumal et al. (2006). The metals were marginally polluted and had lower concentrations than usual, but could be a future source of heavy metals due to their low concentration.

Aril River

Region tributary and primary artery, the Aril River. The Bilari region's biggest pollutants are urban trash and agricultural enterprises. As a result, the river's chromium and iron levels dropped. Ni, Cu, and Zn concentrations were also lower (Sharma et al., 2003). The Gangan River System was built to help drain Moradabad's western portion. This company handles sewer and industrial garbage. Heavy metals (102 ppm Cr, Fe, Ni, Cu, Zn) (Sharma et al., 2003). Heavy metals were present in this river due to industrial and urban trash.

The Haldi and Rupnarayan rivers

These two rivers meet in West Bengal's Hugli estuary. It powers, navigates, and irrigates. It also supplies the river towns. The nearby Kolaghat thermal power plant and Haldia industrial city and port. These sediments contained 22.4 mg/kg Ni, Pb, Zn and 11.8 mg/kg Cu (Kumar et al. 2011). Although these rivers' sediments do not contain heavy metals, the tides can sweep them away and dump them elsewhere.

Table 1. Other indian water bodies and their description

Other water bodies	Description
Dal Lake	Dal Lake, Srinagar, 11.50 km2. 9.83106 m3. The lake supplies water for drinking, agriculture, fisheries, recreation, and tourism. sewage and domestic waste have eutrophied it. This lake is polluted by the Telbal and Peshpaw drains. The Telbal drain contributes over 80% of the total lake input. Fe, Mn, Zn, Co, Cu, Pb, and Ni values were 0.84-1.26 ppm, according to Jeelani & Shah (2006). Metal mining, industrial, and municipal trash enriched lake sediment. The higher concentration was due to multiple causes of Pb deposition. So the river got Zn, Cu, and Pb.
Hussainsagar Lake	In Hyderabad and Secunderabad, Hussainsagar Lake is a 446-hectare hub. There is also industrial waste. Rao et al. (2004) found 72.19, 45.07, 337, 113, 1.99, 7.28, and 74.55 ppm Cr, Ni, Zn, Cu, Hg, Cd, and Pb. Festivities near the lake produced metals. Except for Cr and Ni, Hussainsagar Lake has higher heavy metal concentrations than shale.
Nainital Lake	The town's only supply of drinking water is the Nainital Lake, but increased human activity and modern farming methods are increasing heavy metal concentrations. Jha et al. found higher heavy metal concentrations in Nainital lake silt than in shale. Heavy metals have been dumped into the Nainital Lake, increasing the risk of them hurting aquatic creatures.
	This is Andhra Pradesh's largest natural freshwater lake, with a 4763 km2 catchment area. Locals rely on it for aquaculture and fishing. Heavy metals enter the system through agricultural runoff, household and industrial waste, and drains and channels. With the exception of Cu and Zn, the food chain accumulated less Cr (52.31 ppm) and less Ni (0.02 ppm).
Nal Sarovar	Large amounts of heavy metals were detected in the sediment of Nal Sarovar Lake from agricultural runoff and sewage effluents from periphery communities. Except for Zn and Cd, this lake was not toxicologically alarming, yet Zn and Cd limits in the research area were advised.
Lonar Lake	Lonar Lake is in the Indian peninsula. Like Mono, Owens, Karakul, and Magadi it is a soda lake (pH 10). (Kenya). It's the world's only basaltic meteoritic crater. It is an 1830 m diameter and 150 m deep depression. 7900 ppm Fe, 3.7 Co, and 8.25 Ni in lake sediment (Surakasi et al. 2007). Because there were no dumping sites in this lake, they were low.
Mansar Lake	Mansar Lake lies in Jammu's sub-Himalayan area. It is the region's largest and deepest lake, 1015 m long, 35 m deep, and 640 m wide. Subterranean springs and rainfall provide water. On average, this location receives 1500 mm of rain each year. ppm Fe, Mn, Pb, Co, Ni, Cr, Cu, and Zn in the lake silt. However, the others are unpolluted.

Kanewal Reservoir	The Kanewal Reservoir had 66.40, 26.29, 4773, 50.47, 8.01, and 1012 ppm Cd, respectively. Because of this, the sediments were contaminated with Zn. It was due to the local farming methods.
Lalbagh tank	The Lalbagh tank had Cr 17, Fe 4230, Ni 17, Cu 45, Zn 49, and Pb 29 mg/kg heavy metal concentrations (Lokeshwari & Chandrappa 2006). Seasonal factors influenced it. For Fe, Zn, Ni, and Co, the Lalbagh tank sediment is unpolluted.
Kolleru lake	Metal speciation, complex nature, metal-metal interaction influenced temperature, pH, and organic content. However, heavy metal concentrations were below average (excluding Cu and Zn) despite Cu and Zn stress.
Bheris pond	These were found in the pond: Cr 8.7; Mn 68.5; Fe 1353; Cu 74.92; Zn 3723; Pb 7.52. Except for Cu and Zn, heavy metal concentrations were below normal shale values.

4. Impact on aquatic life

Like metals, they are not easily biodegradable. Metals are re-distributed in water and sediments, or biota consume them. Metals are desorbed and remobilized by sediments. Contaminated habitats' metal deposits can infiltrate the human food chain, causing health issues (Hasan et al., 2017). Co-precipitation with Fe or Mn oxides or species bound as carbonates in sediments can cause metal accumulation in sediments (Equeenuddin et al., 2013).

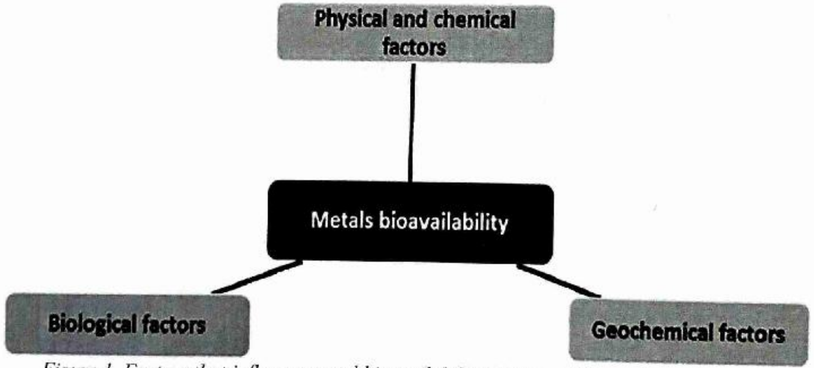

Figure 1. Factors that influence metal bioavailability (Source : Gheorghe et al., 2017).

The body can absorb a certain percentage of a metal's total concentration. Several factors affect metal bioavailability (Figure 1): Physical and chemical factors (temp, salinity, dissolved organic carbon, and total suspended particles); reproductive stage (Roosa et al., 2016).

Bioavailability determines metal intake. Drinking water contains metals, which are absorbed via the epidermis; food contains metals. It is important to note that metal toxicity is affected by pH, temperature, salinity, and oxidative conditions. Feeding rate and intestinal transit time affect swallowed uptake.

Most Cu, Cd, Zn, and Pb free hydrated metallic ions are found as (Wojtkowska et al., 2016). The use of low-molecular-weight organic ligands should be considered. They do this by diffusing hydrophobic compounds through lipid membranes in mussels and fish. The bioavailability of metal organic compounds has been questioned (Chapman et al., 1998). Chemical mercurials that dissolve in lipids make ingestion easier (Bryan et al., 1976).

Adsorption on suspended particles modifies the water's Metal absorption requires a metal-solid particle connection (Eggleton et al., 2004). The metal was soluble in interstitial water when certain circumstances were satisfied. Sediment-borne toxins may be a key source of bioaccumulation in planktonic and benthic species. More research is needed to understand dissolved and suspended metal accumulation/bioaccumulation mechanisms.

Metal bioavailability is size dependent in filter-feeding bivalve snails. Extracellular polymers or fulvic acids improved Cd, Zn, and Ag bioavailability. Metal binding decreased soil metal bioavailability (Rosado et al., 2016).

Endogen macromolecules (such protein or ADN) or certain cellular structures interacting with lipopolysaccharides induce toxic consequences. Metals are detoxified enzymes in operation.

Heavy metal exposure slows growth of phytoplankton, zooplankton, and fish. Heavy metals can damage molluscan development, byrsus, and reproduction Fish and crustaceans with gill necrosis and fatty liver degeneration. Metals impact aquatic creatures' enzymatic metabolism and physiology.

Metals found in crustaceans killed them by blocking respiratory enzymes. In fish and crustaceans, antioxidant enzyme suppression alters histology (El Basuini et al., 2016). Proteasome inhibitors slowed the organism's growth and development. The effects vary depending on the metal, altering bioaccumulation and enzyme sensitivity.

5. Conclusion and Recommendations

There are a number of human activities that have a negative impact on the quality of Indian river water, including overcrowding, inadequate sanitation treatment or non-existence, and massive discharges of untreated industrial waste waters into the riverine system that are not under government regulation. Increases in agricultural and industrial activity, as well as population growth, may be to blame. Industries are leaking wastewater into localised areas as a result of water pollution, endangering human health and aquatic life. Tanneries, mining, and other industries dump toxic metals like chromium and other heavy metals into rivers. These industries' effluent should be treated chemically and biologically before it is released into the river. Help ensure that water pollution control legislation and regulations are applied correctly and consistently. Agricultural and industrial effluents discharged into rivers must be regulated and monitored rigorously by the government. Further research is needed on the speciation of chromium (+3 and +6) and arsenic (+3 and +5) in Indian rivers. A metal fractionation study in river sediments is needed to figure out the inorganic load. Specialized studies on specific river segments may be carried out by the basin organisation as well. The number of variables and sampling frequency can be increased in order to better monitor, analyse, and simulate new significant factors such as biological characteristics.

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