

## Assessment of Heavy Metal Contamination in River Water

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**Abstract**

*The purpose of this study is to identify heavy metal contaminants in drinking water and better understand the effects of water pollution on human health. Heavy metals occur naturally in the earth's crust and can be formed through chemical leaching of bedrock, the discharge of urban, industrial, and rural wastewater, and water drainage, they cannot be destroyed. Heavy metals are harmful due to their bioaccumulation. Many heavy metals such as zinc, copper, chromium, iron, and manganese, can accumulate in the body to toxic levels. Heavy metals in groundwater are a serious health risk, causing cancer through drinking and skin contact, damaging the kidneys, liver, brain, and nervous system, lowering immunity, and causing digestive issues. Groundwater is a dynamic and essential source of water for both human and ecosystem survival and health.*

*To assess contamination levels and ecological risks, this study looked at the concentration and distribution of heavy metals (such as Pb, Cr, Cd, Cu, and Zn) in Bagad River water, a Ganga River tributary, and sediments.*

**Keywords**

*Heavy metals, Groundwater, River, Toxicity, Health risk, acceptable range of heavy metal*

## **Introduction**

Water (H<sub>2</sub>O) is a transparent liquid that is essential for life. It is made up of two hydrogen atoms and one oxygen atom. Water covers approximately 71% of the Earth's surface, but only 3% is freshwater[1].

Water, which makes up about 60% of the human body, is necessary for digestion, temperature regulation, and toxin removal. Water is necessary for the growth of food as well as for cellular processes like respiration and photosynthesis[2].

In industry area it is used in manufacturing, cooling, and generating electricity and Supports biodiversity in oceans, rivers, and wetlands and its also Regulates global temperatures due to its high heat capacity[3].

Water contamination occurs when harmful substances (such as heavy metals, pesticides, and industrial chemicals) enter water bodies, making them unsafe for humans and ecosystems. Heavy metals in water, such as lead, mercury, arsenic, and cadmium, are toxic pollutants emitted by industrial, agricultural, and natural sources that accumulate in ecosystems, posing serious health risks to humans and wildlife, including kidney and liver damage, cancer, and neurological issues[4]. Heavy metals have a density of more than 5 g/cm<sup>3</sup>. To save human lives and other organisms from disasters caused by heavy metals' toxic effects, preventive measures must be implemented[4]. In January 1985, the government of India established a separate Ministry of Environment and Forests to address environmental issues [5].

## **Acceptable range of heavy metal in drinking water**

Different international organizations have established maximum acceptable limits for heavy metal contamination, which are used as global standards all over the world. The two organizations considered are WHO and Nigeria's NAFDAC (National Agency for Food and Drug Administration and Control). The table below shows the WHO and NAFDAC's drinking water guidelines or acceptable ranges[6].

<b>Heavy Metal</b>	<b>Maximum Concentration (WHO)</b>	<b>Maximum Concentration (NAFDAC)</b>
Zinc	0.3mg/L	5.0 mg/l
Arsenic	0.01mg/L	0.00 mg/L
Magnesium	30 mg/L	30 mg/l
Calcium	75 mg/L	75 mg/l
Cadmium	3 µg/L	3 µg/L
Lead	10µg/L	10 µg/L
Iron	0.3mg/L	0.3mg/L

## **Main source and toxicities of heavy metal[7]**

**Arsenic (As):-**

**Main Sources:-** Burning of fossil fuel, mining, and pesticides

**Toxicities:-** Arsenic is a naturally occurring element in our environment. Arsenic poisoning can occur when you consume high levels of arsenic. Most cases are caused by drinking contaminated water. Immediate signs of arsenic poisoning include low blood pressure (hypotension), nausea, vomiting, Diarrhea, and an irregular heartbeat (arrhythmia)[7,8]

**Cadmium (Cd):-**

**Main Sources:-** Mining, welding, Refining pesticide, Fertilizer, smelting, and plastic.

**Toxicities:-** Cadmium (Cd) is a ductile metal that exists as a blueish or silvery-white powder. It naturally occurs in soil, minerals, and water. Cadmium (Cd) in water poses serious health risks, primarily causing kidney damage (renal tubular), bone problems (osteoporosis, stones), and an increase in cancer risk (prostate, lung)[7,9].

**Chromium (Cr):-**

**Main Sources :-** Textile industry, steel, electroplating, and Dyes

**Toxicities:-** The respiratory tract is the primary target organ for inhaled chromium. Chromium (VI) poisoning can cause serious respiratory, cardiovascular, gastrointestinal, hepatic, and renal damage, as well as possibly even death[7,10].

**Nickel (Ni):-**

**Main Sources:-** Storage batteries, electroplating, Porcelain enamelling, and paint

**Toxicities:-** Nickel (Ni) is a heavy metal that can cause cell damage, organ problems (kidney, heart, liver, lungs), allergic reactions (dermatitis), and even cancer in humans and aquatic life. Its toxicity varies in water [7,10].

**Copper (Cu):-**

**Main Sources:-** Electroplating, mining, pesticides, batteries, and copper cooking pots.

**Toxicities:-** Small amounts of copper in water are necessary, but high concentrations can be toxic and cause symptoms like nausea, vomiting, Diarrhea and abdominal pain, liver damage (cirrhosis, necrosis, jaundice), kidney damage, hemolytic anemia (breakdown of red blood cells), hypotension, seizures, coma, etc.[7,11]

**Lead (Pb):-**

**Main Sources:-** Batteries, mining, paint, pigments, explosives, and electroplating.

**Toxicities:-** Lead is a highly toxic heavy metal that contaminates water. It results in long-term cardiovascular and kidney problems in adults, irreversible neurological damage in children (learning/behavioral problems), decreased fertility, memory loss, headaches, stomach pain, etc.[7,12]

### **Mercury (Hg):-**

**Main Sources:-** Batteries, mining, paper and paint industries.

**Toxicities:-** When your body is exposed to too much mercury, you get mercury poisoning. Mercury is an elemental metal found in the Earth's crust that is harmful to humans. It causes bleeding or swollen gums, nausea or vomiting, coughing, difficulty breathing, and a metallic taste in the mouth[7,13].

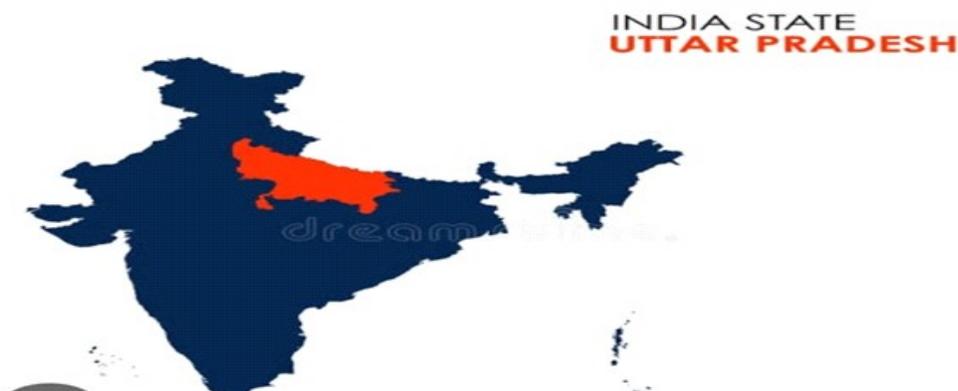
### **Zinc (Zn):-**

**Main Sources:-** Mining, refineries, Brass manufacturing, and plumping.

**Toxicities:-** Zinc in water is necessary in small amounts but toxic at higher concentrations. It affects the nervous and gastrointestinal systems and causes nausea, fever, and respiratory problems[7,14].

### **Material and Methods**

The samples were taken from the Bagad River to test for heavy metals. Which is located in Gajraula, Uttar Pradesh, and is a sub basin of the Upper Ganga basin. The river Samples y were collected from two points: (a) from the Bank, and (b) from the middle of the river. It is a micro level study of Bagad River and Ganga water (Brijghat) which are situated in between Garhmukteshwar town and Gajraula city. This river, located near Gajraula's industrial area, has heavy metal contamination from industrial effluents, affecting water quality and human health in the region. Gajraula is an important industrial town in Uttar Pradesh's Amroha district. Bagad River is only 7 kilometres away from the Ganga. Bagad River flows parallel to the Ganga River, meeting at Agroula Kalan (RL9: N28.780298, E78.232338) and ending at Paurara Ahtmalı (RL15: N28.51517, E78.29123) in Uttar Pradesh. The discharge of untreated industrial effluents from the Gajraula industrial area has a significant negative impact on nearby rivers, particularly the Bagad River. The Ganga River, where the Bagad eventually converges, is contaminated overall by these pollutants[15,16].





#### (Sampling locations of Bagad River along with Ganga River)

The samples were collected from three stations, Tigaria khadar, Shahbazpur dor and Ganga river (Brijghat ). Total of 6 samples ( 4 from Bank and middle of Bagad river and 2 from Bank and middle of Ganga river. All samples were collected in new, pre-cleaned bottles. The bottles have a capacity of 125 ml, and are made from high-density polypropylene (HDPE). Sample bottles were thoroughly cleaned with double-distilled water and milli-Q water after being soaked in 10% nitric acid for a full day prior to sampling[16]. (MilliporeSigma produces ultra-pure Milli-Q water, which is necessary for sensitive laboratory work)[17].All of the bottles were then dried in an oven set to 500C for six hours. The Atomic Absorption Spectrophotometer (AAS) was used to measure the concentrations of the trace elements (Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb).

An Atomic Absorption Spectrometer (AAS) determines an element's concentration by converting a sample into free atoms and then shining light through it; the specific wavelength of light absorbed by those atoms indicates how much of the element is present, with greater absorption indicating higher concentration. The instrument was calibrated by drawing a standard curve with a known metal sample concentration[18].

#### Result:-

The table shows heavy metal concentrations in  $\mu\text{g/L}$  or  $\text{mg/L}$  at various sample locations of the Bagad and Ganga rivers.

Heavy metals	Sample locations						Unit
	Tigaria khadar		Shahbazpur dor		Ganga river (Brijghat )		
	From Bank	From middle	From Bank	From middle	From Bank	From middle	
Zinc(Zn)	3.65	3.12	2.0	2.26	4.12	3.0	mg/L
Arsenic	2.76	2.64	4.4	3.93	4.34	4.12	mg/L
Magnesium	35.7	35	28.6	28.2	34.9	34.9	mg/L
Calcium	72.7	72.12	74.16	74.11	77	75.98	mg/L
Cadmium	6.274	6.865	5.273	5.101	9.127	5.124	µg/L
Lead	1.01	0.97	1.10	1.01	1.18	0.99	mg/L
Iron(Fe)	0.327	0.389	0.427	0.427	0.365	0.345	mg/L
Mercury	1.32	1.32	1.39	1.27	1.40	1.32	µg/L

The table shows the concentrations of heavy metals in the sediment samples taken from the chosen locations.

Zinc levels in the current study ranged from 2.0 mg/L to 4.12 mg/L. The highest concentration of Zn (4.12 mg/L) was found on the Ganga river bank. The minimum concentration of 2.0mg/l was observed on the river bank of Shahbazpur Dor.

Arsenic concentrations in this study ranged from 2.64 mg/L to 4.34 mg/L. The highest concentration of Arsenic, 4.34 mg/L, was found on the Ganga River bank. The minimum Arsenic concentration of 2.64mg/L was found in the middle river of Tigaria Khadar.

Magnesium concentrations in the current study ranged between 28.2mg/L and 35.7mg/L. The highest Magnesium concentration (35.7mg/L) was found on the banks of the Tigaria Khadar River. The minimum Magnesium concentration is 28.2 mg/L. Recorded from the middle river of Shahbazpur Dor.

In this study, mercury concentrations ranged from 1.40µg/L to 1.27µg/L. At the Ganga River's bank, the highest concentration of mercury (1.40 µg/L) was found. The middle river of Shahbazpur Dor had the lowest mercury concentration, 1.27 mg/L. Similar heavy metal contamination is shown in the table above.

### Summary

The Ganga River is contaminated with heavy metals as a result of the rapid urbanization, industrialization, and agricultural activities along its basin.

Metals like lead (Pb), cadmium (Cd), chromium (Cr), mercury (Hg), arsenic (As), nickel (Ni), iron (Fe), manganese (Mn), copper (Cu), and zinc (Zn) are frequently found in river water, sediments, and aquatic animals.

The primary sources of these heavy metals are industrial effluents (tanneries, electroplating, and chemical industries), untreated municipal sewage, agricultural runoff, and atmospheric deposition.

Metal concentrations in several stretches have been found to exceed WHO and BIS permissible drinking water limits, particularly near industrial towns and densely populated areas. Because they are persistent and non-biodegradable, heavy metals accumulate in sediments and bioaccumulate in fish and other aquatic life. This poses significant ecological and health risks to humans, including neurological, renal, and developmental issues if contaminated fish or water is consumed.

Overall, the Ganga's water quality has declined due to heavy metal pollution, endangering both its ecological balance and safe use. Continuous monitoring, effective wastewater treatment, and stringent pollution control are all required to reduce contamination and protect the river.

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