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Seasonalvariation of heavy metals in three different sites in Shivnath River, Durg, Chhattisgarh, (India)

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Abstract
Shivnath River in Chhattisgarh State is considered as Life line of Chhattisgarh, which covers about 290 km. Three different location were selected for study, first area Piperchhery, second Mahamarra Ghat, and third Changory. This study investigates the spatial distribution, seasonal variations, and potential human health risks of heavy metal contamination in the water of the Shivnath River, Chhattisgarh. Water samples were collected across three seasons from three strategically selected sites reflecting different anthropogenic pressures: Piperchhedy, Mahamara Ghat, and Changory. The concentrations of key toxic metals, including Lead (Pb), Iron (Fe), cadmium (Cd) and Hg (mercury), were analyzed using Atomic Absorption Spectroscopy (AAS). Environmental indices, such as the Heavy Metal Pollution Index (HPI), were computed to quantify overall water quality. Human health risk was evaluated via the Hazard Quotient (HQ) and Carcinogenic Risk (CR) for both adults and children through oral ingestion and dermal pathways. The results revealed significant spatial variation; Mahamara Ghat exhibited elevated levels of specific metals during post-monsoon and festival seasons due to high anthropogenic and religious activities, while Piperchhedy and Changory showed distinct profiles influenced by agricultural runoff and downstream accumulation. The study underscores the critical need for localized monitoring at these specific ghats and zones to safeguard public health and riverine ecology. To maintain the healthy ecosystem of the river, proper management and monitoring of water quality of the river is needed.

Keywords: Water quality, heavy metals (Hg, Pb, Cd, Fe), pollution, seasonal variation, Shivnath River

Introduction

The state of Chhattisgarh is the co-origin of numerous small and large rivers. The Mahanadi River, also referred to as Chhattisgarh's life line, is the state's most significant river. The state's Shivnath River is 290 kilometers long. It comes from the 625-meter-high Panbaras range in the Rajnandgaon district's Ambagarh tehsil. It flows about 40 km north after emerging from Panabaras, and at Ambagarh Chouky, it changes direction to the east. Some of the major places on the bank of the Shivnath River are Rajnandgaon, Durg, and Janjgir, Champa district. The Shivnath River's principal tributaries include Arpa, Lilagar, Maniyari, Kharoon, Aabar, Surahi,Tandula,andsoon.The Shivnath River is severely poll uted as a result of the disposal of numerous wastes, both do mestic and industrial.The evaluation of the discharges' effect s on the Shivnath River water's physicochemical and microb iological quality in the Durg district. In this work, we assessed the heavy metals of water in river shivnath of three different water site first is Changory, second is Mahamarra Ghat and third is Piperchheri in Durg district in India.

The term “heavy metals” generally refers to a group of naturally occurring metallic elements characterized by relatively high density, atomic weight, and atomic number. Although these elements occur naturally in the Earth's crust and are present in trace concentrations in the environment, anthropogenic activities have significantly increased their concentrations in many ecosystems (Koller and Saleh, 2018) [4]. Heavy metals are commonly classified according to their physicochemical properties, including density, atomic mass, atomic number, and position within the periodic table. Generally, metals possessing densities between 3.5 and 7.0 g/cm³, atomic weights ranging from 23 to 40, and atomic numbers between 20 and 92 are categorized as heavy metals. Environmental remediation technologies for metal-contaminated soils (Hasegawa *et al*., 2015). Kumar *et al*. (2025) [2, 3] studied seasonal variations in the physicochemical properties of Shivnath River water at three sites—Piperchhery, Mahamarra Ghat and Changory, Durg (Chhattisgarh). The study reported significant seasonal and site-wise variations in water quality parameters and highlighted the need for regular monitoring of the river. Sahu and Minj (2025) [5, 6] evaluated fluoride levels in groundwater of Dongargarh Block, Rajnandgaon, Chhattisgarh.

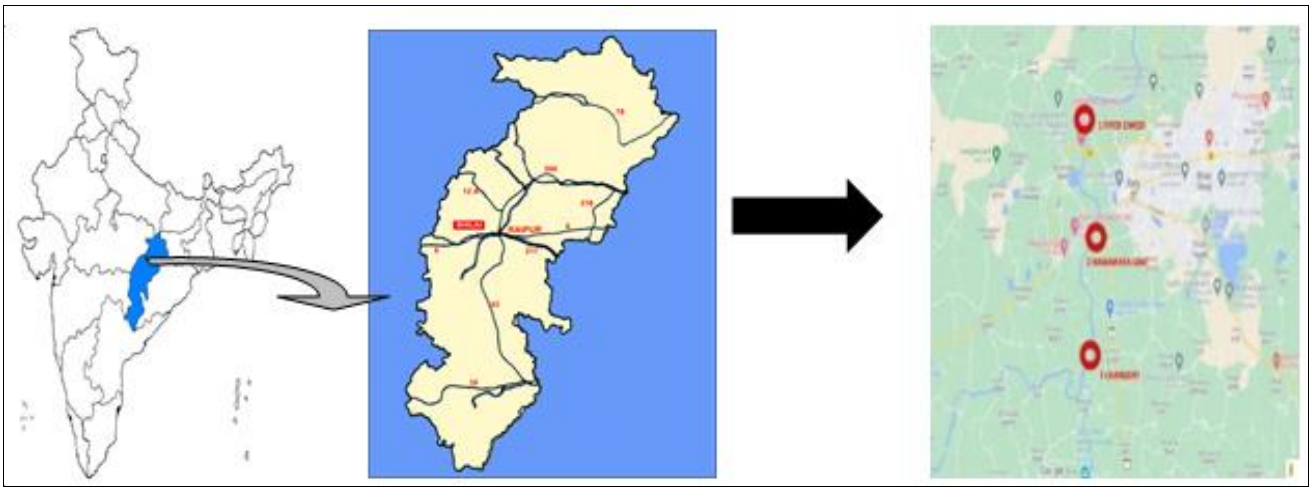
The study assessed the occurrence and distribution of fluoride in groundwater and highlighted the need for regular monitoring of groundwater quality. Sahu and Minj (2025) [5, 6] also investigated arsenic concentrations in groundwater of Churia Block, Rajnandgaon, Chhattisgarh. The study focused on the distribution of arsenic in groundwater and emphasized the importance of groundwater quality assessment for environmental and human health protection.

Material and Methods

Study area

Durg is important district of Chhattisgarh with latitude 21.1623^0 N and longitude 81.6296^0 E. Shivnathriver is one of the important rivers in Chhattisgarh. The Shivnath river originated from Panabaras hill, 624meters (2047ft) above sea level in the Ambagarh Chouki division of Rajnandgaon district of Chhattisgarh. Shivnath river is longest tributary of Mahanandi river. 3 different location will be selected for present study in shivnath river from drug district, 1st location will be Changori (latitude21.0839 ^{0}N and longitude 81.2388 ^{0}E),

the 2nd location is Mahmara – Ghat (latatitude21 ^{0}09’ 55.3” N and longitude 81 ^{0}14’21.6” E.) and the 3rd location will be Piperchhery with latitude 21.2038 ^{0} N and longitude 81.2346 ^{0} E.



Collection of water sample

Water sample from different sites of Shivnath River were collected in Cans in the Summer winter and Rainy season. Water Samples were collected from a depth of 25-30cm. Water samples were collected, preserved and transported to the laboratory as per standard methods of analysis. Before instrumental measurement, samples were digested using concentrated nitric acid on a controlled hot plate. After digestion, samples were cooled and diluted with double distilled water. This step ensures that only dissolved fractions of metals enter the analytical instrument, which is necessary for consistency. Atomic Absorption Spectrophotometry (AAS) was used for quantifying concentrations of Hg, Pb, and Fe. AAS is preferred for environmental metal analysis because it offers high sensitivity, good accuracy, and reliability even at low concentrations. For mercury, hydride generation or cold vapor techniques were employed to enhance detection, considering Hg’s reactivity and volatility.

Result and Discussion

Monitoring the river water quality is vital for managing the river ecosystem. The given following finding results in present study of Shivansh river water quality examining some heavy like Hg, Pb, Cd, Fe.

Table1: seasonal variation of heavy metals concentration (Hg, Pb, Cd, Fe) in Shivnath River water at three different sites of sampling location.

	Piperchhedy	**Mahamarra Ghat**	**changory**	**BIS limits (PPB)**
	2023	2023	2023	
Summer season				
Hg (PPB)	0.06	0.17	0.09	1
Pb (PPB)	0.45	0.42	0.33	10
Fe (PPB)	345	130	117	1000
Cd (PPB)	0.06	0.06	0.04	3
Rainy season				
Hg (PPB)	0.05	0.14	0.06	1
Pb (PPB)	0.42	0.39	0.30	10
Fe (PPB)	340	124	111	1000
Cd (PPB)	0.03	0.03	0.01	3
Winter season				
Hg (PPB)	0.06	0.15	0.07	1
Pb (PPB)	0.43	0.40	0.31	10
Fe (PPB)	343	127	115	1000
Cd (PPB)	0.04	0.04	0.02	3

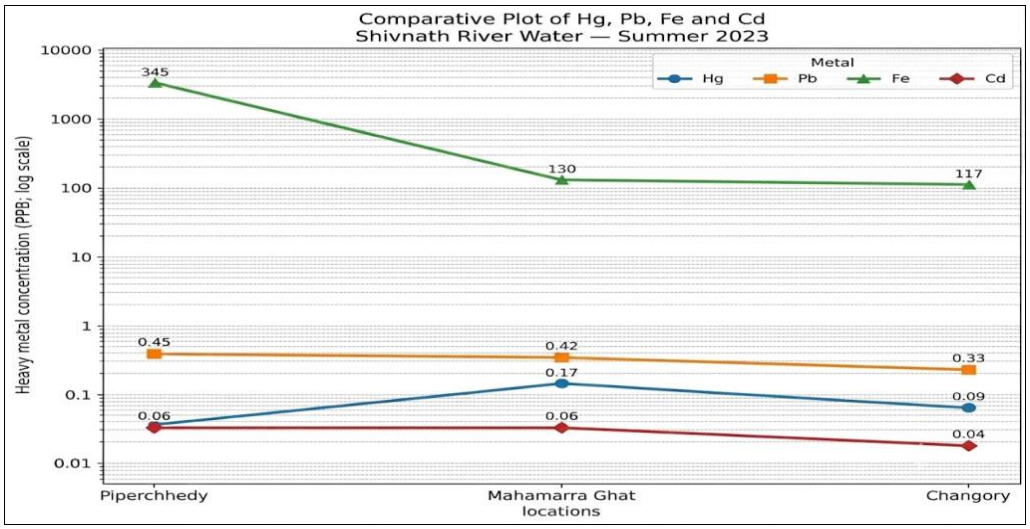


Fig 1: compare to all three-site water heavy metal (Hg, Fe, Cd, Pb) in Shivnath River at Summer season 2023.

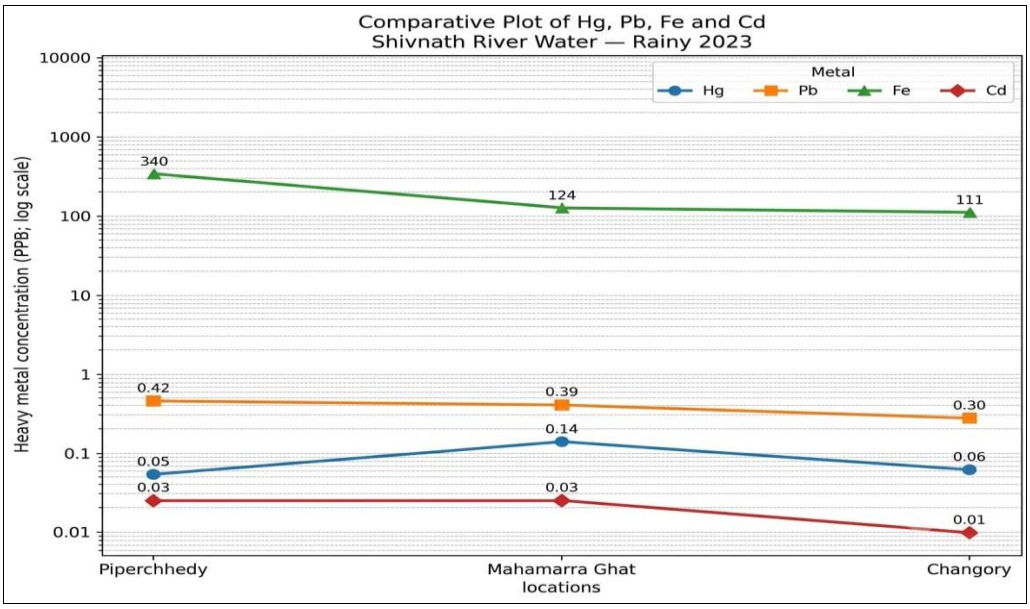


Fig 2: compare to all three-site water heavy metal (Hg, Fe, Cd, Pb) in Shivnath River at Rainy season 2023.

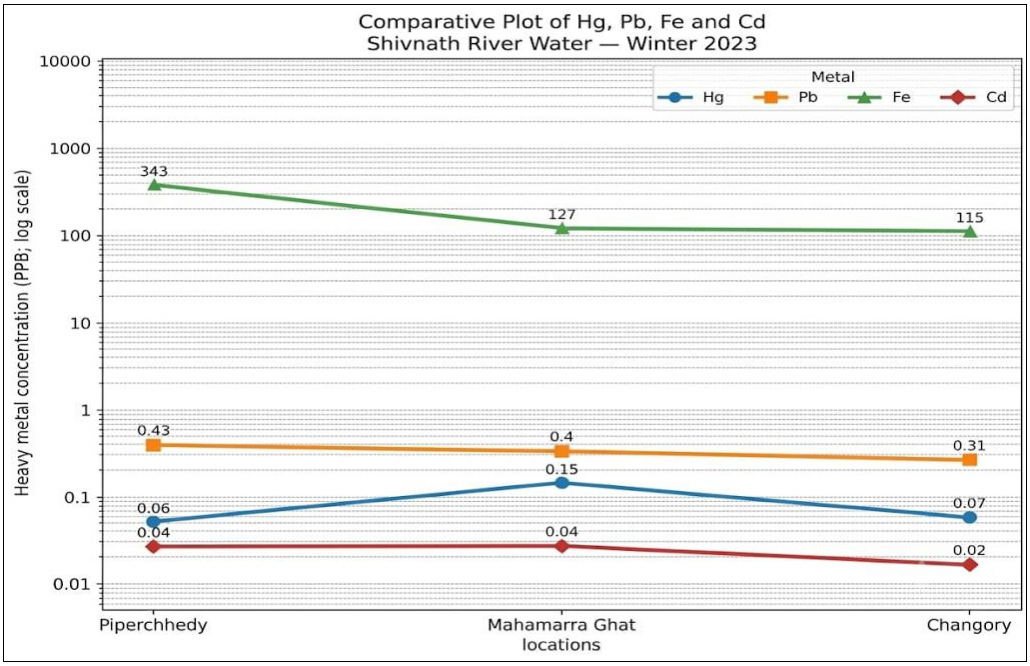


Fig 3: compare to all three-site water heavy metal (Hg, Fe, Cd, Pb) in Shivnath River at winter season 2023.

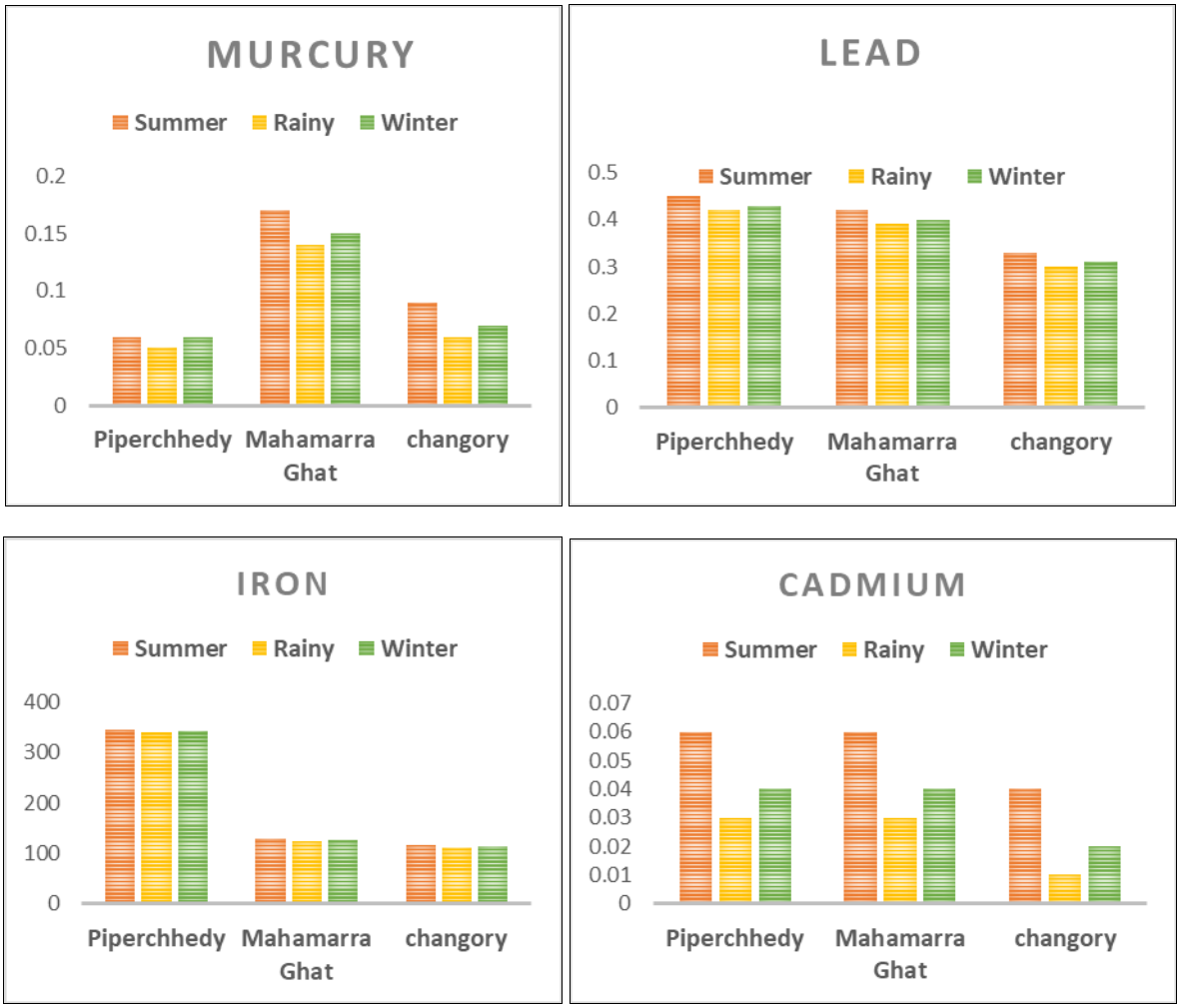


Fig 4: seasonal compare to all three-site water heavy metal (Hg, Fe, Cd, Pb) at Shivnath River in year 2023.

Looking at the graph of Mercury, it is seen that its level in Mahamarra Ghat is much higher than both the other places, where it reaches its high level of about 0.17 in the summer season, whereas in Piperchhedy the level of Mercury is recorded lowest (between 0.05 to 0.06) in all the seasons.

The situation is different for lead; Piperchhedy has the highest lead content, reaching around 0.45 in the summer season, while Changory has a lower level (between 0.30 and 0.33) than the other two locations. A significant difference is seen in the graph for iron; while Piperchhedy has a very high iron level, crossing 350, the level in Mahamarra Ghat and Changory is much lower (between 100 and 130) and is almost normal.

Cadmium levels the level of cadmium can be seen to be exactly the same at both Piperchhedy and Mahamarra Ghat, where it reaches its highest level i.e. 0.06 in the summer season, decreases to 0.04 in the winter and reaches the lowest level i.e. 0.03 in the rainy season. On the other hand, the amount of cadmium in Changory has been recorded to be much lower than the other two places, where it is 0.04 in the summer, 0.02 in the winter and falls to its lowest level i.e. about 0.01 during the rainy days. After analyzing the entire graph, it is clearly visible that at all the three places the level of cadmium remains the highest in the summer season and becomes the lowest in the rainy season.

Conclusion

The present study assessed the concentration of four heavy metals, namely mercury (Hg), lead (Pb), iron (Fe), and cadmium (Cd), in Shivnath River water at three sampling sites - Piperchhery, Mahamarra Ghat, and Changory - during summer, rainy, and winter seasons of 2023.The results showed that all recorded concentrations of Hg, Pb, Fe, and Cd were below the respective BIS permissible limits given in the table. Therefore, none of the investigated metals exceeded the specified limits during the study period.

Among the three sampling sites, Piperchhery generally showed the highest concentrations of Fe and Pb, whereas Mahamarra Ghat showed the highest concentration of Hg. Changory generally recorded comparatively lower concentrations of all the studied heavy metals. The highest Fe concentration was recorded at Piperchhery during summer (345 PPB), while the lowest Fe concentration was observed at Changory during the rainy season (111 PPB). Seasonal variation was also observed. In general, the concentrations of Hg, Pb and Fe were highest during summer, decreased during the rainy season, and showed intermediate values during winter. Cadmium also showed seasonal variation, with its highest values during summer and lowest values during the rainy season.

Overall, the observed concentrations followed the general pattern:

Piperchhery > Mahamarra Ghat > Changory for Fe and Pb, while Hg was comparatively higher at Mahamarra Ghat.

Although the concentrations remained below the BIS limits, the presence of these heavy metals indicates that continuous monitoring of Shivnath River water is important, particularly at sites showing relatively higher

concentrations. Further investigation involving sediment and aquatic organisms such as freshwater crabs would help to determine whether these metals are accumulating in the aquatic ecosystem

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