ASSESSMENT OF HEAVY METAL TOXICITY IN FISH FROM COAL MINING AREAS: A CASE STUDY OF JHARKHAND, INDIA

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ABSTRACT

Heavy metal toxicity in fish from coal mining areas refers to the elevated levels of harmful heavy metals found in fish due to contamination from mining activities. This study focuses on assessing the toxicity of heavy metals in fish from coal mining areas in Jharkhand, India. The investigation includes the analysis of heavy metals in water samples, sediment samples, and fish species. The highest concentration of heavy metal in water was found to be of Sr (170.5μg/L) and in sediments 182.5 μg/g Zn was found. In fish, highest concentration was of Fe (226.3mg/kg). The Target Hazard Quotient (THQ) is used as a measure to assess the risk of heavy metal ingestion. The highest THQ amount was observed in *P. conchonius*, (116.99mg/kg). The results of this study provide valuable insights into the extent of heavy metal contamination in the aquatic ecosystem of coal mining areas, highlighting potential risks to human health through the consumption of contaminated fish. This research underscores the importance of ongoing monitoring and mitigation efforts to ensure the safety of fish and protect the wellbeing of communities residing in these regions.

Keywords: Heavy metal toxicity, Fish, Coal mining areas, Toxicity, Target Hazard Quotient (THQ).

1. INTRODUCTION

Heavy metal (HM) toxicity refers to the harmful effects caused by the accumulation of excessive amounts of metallic elements with high atomic weights in living organisms. These metals, such as “lead, mercury, cadmium, arsenic, and chromium”, are naturally occurring elements but become toxic when they are present in high concentrations [1]. HM’s can enter the environment through “natural processes, industrial activities, and human actions, posing significant risks to ecosystems and human health”. HMs are persistent pollutants that do not degrade easily in the environment. They can bio accumulate in organisms, meaning that they gradually build up in the tissues of living organisms over time [2]. This accumulation can occur through direct exposure to contaminated air, water, and soil, or the consumption of contaminated food sources, such as fish and crops grown in polluted areas. The detrimental effects of HM toxicity on human health are well-documented. Depending on the specific metal and level of exposure, HM toxicity can lead to various adverse health outcomes, including neurological disorders, kidney damage, respiratory issues, cardiovascular problems, reproductive abnormalities, and even cancer. Vulnerable populations such as “children, pregnant women, and individuals” with compromised immune systems are particularly at risk. HM contamination is often associated with industrial activities such as mining, smelting, manufacturing, and improper waste disposal [3]. Coal mining, in particular, can release significant amounts of HM’s into the surrounding environment, leading to contamination of water bodies and ecosystems [4]. The coal fines generated during mining operations can contribute to HM pollution, as they may contain high concentrations of these toxic elements.

In regions like Jharkhand, India, where coal mining is prevalent, the release of HM’s into the environment can have severe consequences. Not only does this pose risks to aquatic organisms such as fish, but it also raises concerns about the safety of consuming fish from these polluted areas [5]. Assessing the extent of HM contamination in fish and evaluating the associated risks to human health are crucial for understanding the potential impacts of coal mining activities and developing effective mitigation strategies [6] [7]. HM toxicity in fish from coal mining areas is a significant environmental concern that has implications for both aquatic ecosystems and human health [8]. Coal mining operations can introduce HM’s into nearby water bodies through various mechanisms, including leaching from mining waste, runoff from mine sites, and the discharge of untreated or inadequately treated mine water [9]. Fish, being an integral part of aquatic food chains, can accumulate HM’s in their tissues through a process known as bioaccumulation. When fish are exposed to contaminated water, they absorb HM’s through their gills and skin, and also by ingesting contaminated sediments and prey [10]. Over time, these metals can accumulate in fish tissues, particularly in organs such as the liver and kidneys.

Each of these metals has its own set of toxicological properties and can cause various adverse effects in fish [11]. Mercury is a potent neurotoxin that can impair the nervous system of fish, leading to behavioral changes, reduced reproductive success, and even death. Cadmium, on the other hand, can accumulate in fish kidneys and interfere with their normal functioning, potentially causing kidney damage [12] [13]. The presence of HM’s in fish from coal mining areas raises concerns about human health risks associated with consuming contaminated fish [14]. When humans consume fish that have accumulated high levels of HM’s, there is a potential for these toxic elements to be transferred to the human body. Chronic exposure to HM’s through contaminated fish consumption can lead to a range of health issues, including “neurological disorders, kidney damage, developmental abnormalities, and increased cancer risk” [15]. This study aims to investigate the effects of coal fines on fish in the coal mining area of Jharkhand and assess the potential risk to human health posed by consuming contaminated fish. By examining the levels of HM accumulation in fish tissues and considering the existing toxicological data, this research seeks to provide insights into the environmental and health implications of HM toxicity in coal mining regions, thereby informing policy decisions and promoting sustainable resource management practices.

The rest of the paper is arranged as follows, section 2 elaborates the methods and materials, section 3 shows the results, section 4 shows the discussions and finally section 5 covers the conclusion, implication and future scope.

2. MATERIAL AND METHODS

To evaluate the levels of HM contamination in fish samples taken from coal mining regions in Jharkhand (India), the research study combined field sampling and laboratory analysis. The study used the materials and techniques listed below. Figure 1 shows the workflow diagram.

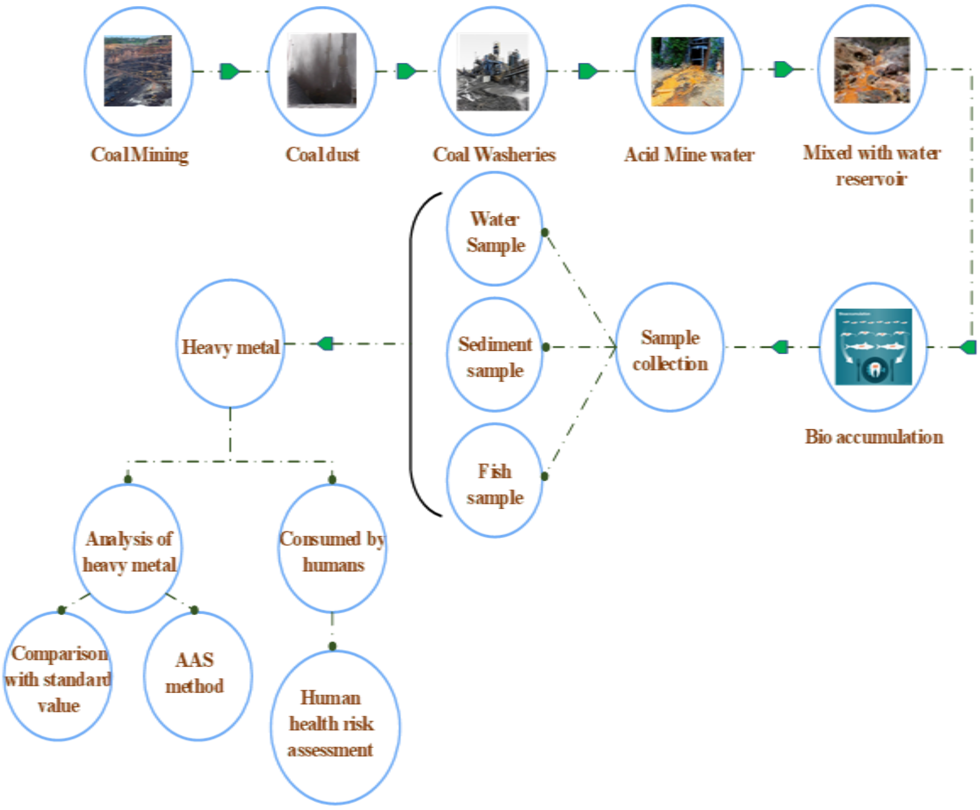

Figure 1: Work flow chart

2.1 Sampling sites

For its vast coal pockets, the Damodar River basin is well-known. Five dams, namely Konar Dam (S1), Maithon Dam (S2), Panchet Dam (S3), Tenughut Dam (S4), and Tilaya Dam (S5), were chosen for the current study based on mining operations and industries, particularly coal mines. While the first two sampling locations (S1 and S2) are located far from the industrial zone, site S3 is located right in the middle of a significant colliery. The remaining two locations, S4 and S5, are in an industrial neighborhood with typical exposure. The five sampling locations were discovered to be either in Damodar's main channel or one of its tributaries. Figure 2 depicts a map of the Damodar River watershed with sample collection dams. Table 1 provides descriptions of a few dams.

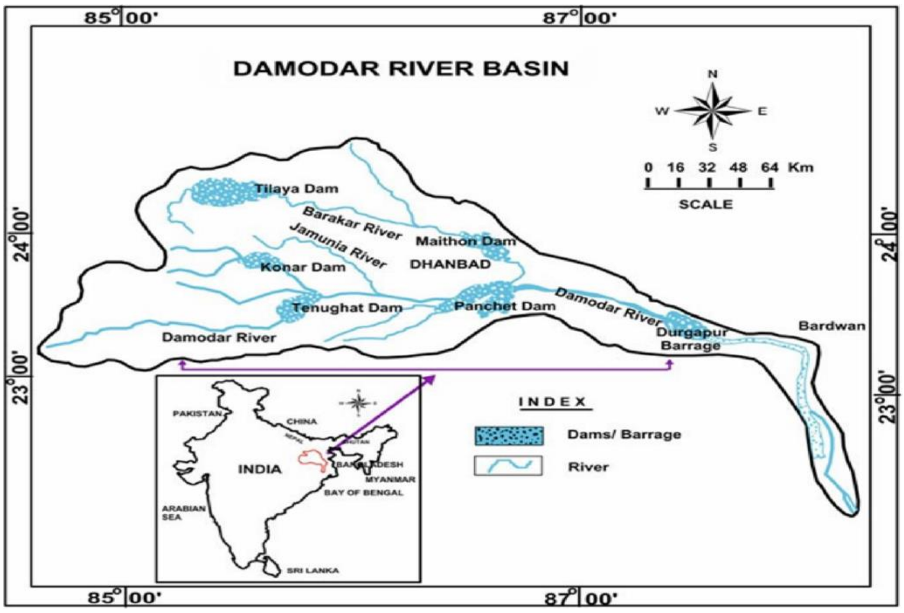

Figure 2: Map of Damodar River Basin with the dams of sample collection

Table 1: Description of Selected Dams

Sampling sites	**Latitude and Longitude**	**Altitude (m)**	**Length of the Dam (m)**	**Remark**
Konar Dam	23 º55’47.34” N 85 º45’39.66” E	425	4535	Igneous rock mines
Maithon Dam	23 º50’59.14” N 86 º46’37.04” E	153	4789	ECL Coals and Maithon power plant
Panchet Dam	23 º40’37.68” N 86 º44’41.86” E	132	6777	BCCL coal mines, IISCO steel plant, and oil industries
Tenughut Dam	23 º43’30.68” N 85 º56’08.05” E	260	5000	Kathara Colliery, coal washeries, and chemical plant
Tilaya Dam	24 º19’22.83” N 85 º31’13.71” E	369	366	Bhowra, Ramgargh coal industries, iron and steel industries

2.2 Water sampling

The water samples collected from sampling sites used for the HM analysis were approximately 2 litres and were collected in a sampling bottle, preferably made of polyethylene (or glass bottles). Following collection, the water was filtered using millipore filter paper with a 0.45 m pore size. The pH was brought down to less than 2 by adding ultrapure 6 regular nitric acids, which preserves the filtered water. To avoid contamination, the sample bottles are securely secured.

2.2.1 Heavy metal analysis of water sample

The collected water sample was analysed using the words and technique approved by the "U.S. Environmental Protection Agency (USEPA)", which are as follows. The cause of the etching of glass is hydro fluoride in water. The HF is eliminated from the water using the APHA (4500-F) standard method for wastewater and water analysis in order to prevent glass deterioration. This process turns hydrofluoric acid into fluorosilicic acid, which is then further removed using distillation. Glass beads and a strong, high-boiling acid are present during the conversion. In order to make the water sample more acidic, 1 litre of it received 5 ml of ultra-pure nitric acid. In order to use it for the HM analysis, 500 ml of collected acidified water are boiled and decreased in volume to 50 ml. The acid water mixture must be heated with prudence. To combine acid and water uniformly, use a magnetic stirrer. AAS (Atomic Absorption Spectrophotometer) Perkin-Elmer 3110 is used to identify the presence of HM's in the sample.

2.3 Sediment sampling

The aforementioned sampling sites also yielded sample sediments. We obtained the most recent deposition of the river by taking a sample of 2 to 4 cm from the surface silt of the river bed using a plastic shovel. After being sealed and transported, the sample sediments were then put in a polyethylene bag and allowed to dry at room temperature, typically between 25 and 30 ºC. Using the Corning and Quartering procedure, the samples are well combined. Then, it was dried for over 24 hours in an oven at below 110o C while resting on a porcelain plate. Using a dry mortar and pestle and a standard sieve with a mesh size of 200, the dried sample was first ground into powders. Sediment samples were digested in a microwave using the USEPA's 3052 procedure. For this, "0.25 g of sediment was taken, and it was then given 4.5 mL HNO3, 2 mL HF, 1 mL HCl, and 0.5 mL H2O2". The samples were digested using an Anton Paar microwave system, filtered, and then 2% (v/v) nitric acid was added to increase the volume to 50 mL.

2.3.1 Heavy metal analysis of Sediments

The soil was examined for the presence of HM's in accordance with the AOAC's (Association of Official Agricultural Chemists) recommended approach. Following drying, a concentrated HNO3 (1N) solution and 70% perchloric acid were added in a 3:1 ratio to acidify the soil sample. The solution was then cooked on a hot plate until it had reduced to around 2 ml in volume. Then, it was diluted to 25 ml using pure water. The sample's HM concentration was measured using an "Atomic Absorption Spectrophotometer (AAS)" by Perkin-Elmer 3110.

2.4 Sampling of Fish

The sample fishes were collected using standard nets ie, cast nets, and gill nets and some are collected from the cages to make sure the collection was not biased. The availability of different species of fish and their occurrence and capturing percentage were also noted. The fish varieties chosen for our study includes *Penaeus indicus, Mystus gulio, Pethia conchonius, Labeo calabash, Labeo rohita, and Labeo bata. Penaeus indicus* also called Indian prawn and is the most commercially grown prawn variety of India.

(a) (b) (c)

(d) (e) (f)

Figure 3: Fish varieties collected: (a) *P. indices*, (b) *M. gulio*, (c) *P. conchonius*, (d) *L. calabash*, (e) *L. rohita*, (f) *L. bata*.

The fish stored in 10% formaldehyde were cleaned with tap water and then with deionized water to remove the preservatives and to remove any impurities present if any. The dorsal tissue of the fish is taken for our study. The separated soft tissues were cleaned thoroughly using Millipore water and dried at 100ºC to a constant weight in a petri dish cleaned with acid. The dried samples were grounded to a very fine powder. About 2 g of the sample were weighed accurately with an accuracy of ±0.001g for analytical purposes. The digestion was carried out on a hotplate at 80-90° until the solution became clear using a combination (7:3 v/v) of 65% nitric acid and 70% perchloric acid (AR grade). The leftovers were dissolved in 5 mL of 15% HNO3 following digestion. All of the digested solutions were filtered using Whatman filter paper (No. 1) before being diluted with ultrapure water to a level of 25 mL in the volumetric flask. Each analytical series was conducted in triplicate while running the blank and reference materials (DOLT-4) concurrently.

2.4.1 Heavy metal analysis in Fish

The levels of "As, Cd, Cu, Fe, Pb, Ni, Zn, Cr, Co, and Sr in water, soil, & fish" have been calculated using plasma-mass inductively coupled spectrometry. To verify the ICP calibration MS's status, 15 samples were evaluated together with a verification standard for independent calibration as well as a calibration blank. Metal concentrations were given as µg/g of fresh fish tissue weight. For all elements, matrix interference (Blank) was less than 1%. Metals spiking in fish muscles, water, and sediments recovered at rates ranging from 88% - 110%. Relative percent differences of 5% were found after the analysis of three samples.

2.5 Risk of ingesting heavy metals: THQ

It has been acknowledged that the US Environmental Protection Agency's (US EPA 1989) THQ is one of the suitable indices for the evaluation of the intake of HMs through eating contaminated foods and is one of the methods that have been proposed to estimate the potential risks of toxic metals on human health [30]. Where ADD is the average daily dose, Target Hazard Quotient is known as THQ, and R_fD is the reference dose. If THQ has a value greater than one (i.e., THQ > 1), then the population revealed through consuming contaminated food foods is most likely to experience overtly negative impacts. The likelihood that a hazard will affect a person's body increases with increasing THQ values.

3. RESULT

3.1 Heavy metal concentration in water

Table 2 provides the concentrations of HM's in the surface water of the Damodar River basin.

Table 2: Surface water heavy metal concentration of Damodar River basin

Location	**As**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Ni**	**Pb**	**Sr**	**Zn**
				Surface water(µg/L)						
Konar										
Dam	1.09	N. D	0.05	0.1	0.51	81.73	1.41	N. D	170.5	5.25
Maithon										
Dam	0.65	N. D	0.20	0.1	4.63	61.61	2.23	N. D	86.36	6.44
Panchet										
Dam	0.62	N. D	1.18	0.25	16.52	64.93	3.66	N. D	96.23	12.6

Tenughut										
Dam	0.63	N. D	1.27	0.06	0.59	59.06	1.02	N. D	86.52	13.5
Tilaya										
Dam	0.65	N. D	0.89	0.07	1.77	39.95	0.96	N. D	67.98	13

N.D*- Not Detected

The provided data shows the concentrations of various HM's in the surface water of five dams: Konar Dam, Maithon Dam, Panchet Dam, Tenughut Dam, and Tilaya Dam. The concentrations are measured in micrograms per liter (µg/L). Arsenic (As) concentrations range from 0.62 µg/L in Panchet Dam to 1.09 µg/L in Konar Dam. Cadmium (Cd) concentrations are below the detection limit (N.D) in all the dams. Chromium (Cr) concentrations range from 0.05 µg/L in Konar Dam to 1.27 µg/L in Tenughut Dam. Cobalt (Co) concentrations range from 0.06 µg/L in Tenughut Dam to 0.25 µg/L in Panchet Dam. Copper (Cu) concentrations vary from 0.51 µg/L in Konar Dam to 16.52 µg/L in Panchet Dam. Iron (Fe) concentrations range from 39.95 µg/L in Tilaya Dam to 81.73 µg/L in Konar Dam. Nickel (Ni) concentrations range from 0.96 µg/L in Tilaya Dam to 3.66 µg/L in Panchet Dam. Lead (Pb) concentrations are the highest in Konar Dam at 170.5 µg/L, followed by 96.23 µg/L in Panchet Dam. Strontium (Sr) concentrations range from 67.98 µg/L in Tilaya Dam to 96.23 µg/L in Panchet Dam. Zinc (Zn) concentrations vary from 5.25 µg/L in Konar Dam to 13.5 µg/L in Tenughut Dam.

3.2 Heavy metal concentration in sediments

The average concentration of heavy metals in sediments of the Damodar River basin presented in Table 3.

Table 3: Average concentration of heavy metals in sediments of Damodar River basin

Location	As	Cd	Cr	Co	Cu	Fe	Ni	Pb	Sr	Zn
				Sediments(µg/g)						
Konar Dam	1.356	0.881	94.06	11.99	43.5	21,768	40.3	37.3	29.7	59.62
Maithon Dam	1.275	0.772	50.43	10.49	57.9	16,143	30.5	49	36.2	49.90

Panchet Dam	0.316	0.877	53.65	11.59	168.9	17 , 592	37	48.3	25.9	53.71
Tenughut Dam	0.766	0.842	80	13.59	44.59	24,677	27.9	65.3	15.31	182.5
Tilaya Dam	1.351	2.653	123.2	15.65	63.95	44,083	45.9	83.21	26.53	125.93

In Konar Dam, the sediment samples show concentrations of "1.356 µg/g for arsenic (As), 0.881 µg/g for cadmium (Cd), 94.06 µg/g for chromium (Cr), 11.99 µg/g for cobalt (Co), 43.5 µg/g for copper (Cu), 21,768 µg/g for iron (Fe), 40.3 µg/g for nickel (Ni), 37.3 µg/g for lead (Pb), 29.7 µg/g for strontium (Sr), and 59.62 µg/g for zinc (Zn). Maithon Dam sediments contain concentrations of 1.275 µg/g for As, 0.772 µg/g for Cd, 50.43 µg/g for Cr, 10.49 µg/g for Co, 57.9 µg/g for Cu, 16,143 µg/g for Fe, 30.5 µg/g for Ni, 49 µg/g for Pb, 36.2 µg/g for Sr, and 49.90 µg/g for Zn. Panchet Dam sediments exhibit concentrations of 0.316 µg/g for As, 0.877 µg/g for Cd, 53.65 µg/g for Cr, 11.59 µg/g for Co, 168.9 µg/g for Cu, 17,592 µg/g for Fe, 37 µg/g for Ni, 48.3 µg/g for Pb, 25.9 µg/g for Sr, and 53.71 µg/g for Zn. In Tenughut Dam, the sediment samples show concentrations of 0.766 µg/g for As, 0.842 µg/g for Cd, 80 µg/g for Cr, 13.59 µg/g for Co, 44.59 µg/g for Cu, 24,677 µg/g for Fe, 27.9 µg/g for Ni, 65.3 µg/g for Pb, 15.31 µg/g for Sr, and 182.5 µg/g for Zn. Tilaya Dam sediments contain concentrations of 1.351 µg/g for As, 2.653 µg/g for Cd, 123.2 µg/g for Cr, 15.65 µg/g for Co, 63.95 µg/g for Cu, 44,083 µg/g for Fe, 45.9 µg/g for Ni, 83.21 µg/g for Pb, 26.53 µg/g for Sr, and 125.93 µg/g for Zn".

3.3 Heavy Metal Concentration in Fish species

The concentration of heavy metals in fish species collected from water bodies near coal mining areas is calculated and presented in Table 4.

Table 4: Heavy metal analysis

Locations	Species	As	Cd	Cr	Co	Cu	Fe	Ni	Pb	Sr	Zn
Konar Dam	*P. indices*	0.261	0.054	0.692	0.282	10.252	161.75	5.87	0.056	78.62	14.26
	M. gulio	0.036	0.029	0.213	0.156	1.103	106.23	2.15	0.087	32.13	42.61
	P. conchonius	0.247	0.019	1.121	1.151	3.337	130.68	7.972	0.033	61.26	42.05
	L. calbasu	0.227	0.009	0.545	0.036	0.961	60.5	11.45	0.059	30.15	48.63
	L. rohita	0.316	0.065	0.316	0.061	4.23	68.19	1.232	0.093	19.61	42.64
	L. bata	0.229	0.213	0.893	0.325	16.35	132.64	2.315	0.033	32.16	45.23
Maithon Dam	*P. indices*	0.511	0.045	1.03	0.326	14.256	116.32	5.364	0.065	125.62	12.34
	M. gulio	0.051	0.037	0.575	0.183	1.253	79.74	3.012	0.093	39.64	52.13
	P.	0.1	0.0	0.9	0.8	1.25	163.	5.2	0.0	51.2	63.2

	conchonius	74	23	83	55	4	13	45	44		57
	L. calbasu	0.175	0.008	0.41	0.046	1.253	57.232	10.21	0.055	28.21	52.34
	L. rohita	0.294	0.056	0.253	0.056	5.322	107.26	1.322	0.115	25.62	35.64
	L. bata	0.286	0.144	1.046	0.875	19.63	122.15	2.585	0.027	49.87	52.03
Panchet Dam	*P. indicus*	0.673	0.85	4.231	1.251	145.21	147.54	21.52	0.41	96.2	96.34
	M. gulio	0.092	0.1	0.501	0.583	14.011	103.84	7.512	0.343	51.71	47.412
	P. conchonius	0.165	0.061	1.398	1.371	10.631	175.43	13.82	0.238	40.47	81.32
	L. calbasu	0.125	0.006	0.513	0.067	13.51	98.27	15.14	0.094	23.61	75.322
	L. rohita	0.459	0.097	0.825	0.344	20.84	125.96	4.567	0.135	28.326	49.289

	L. bata	0.481	0.512	0.741	0.415	46.33	128.23	4.37	0.212	24.317	54.34
Tenughat Dam	*P. indices*	0.601	0.623	11.36	0.534	29.53	226.3	21.34	0.323	62.32	109.53
	M. gulio	0.025	0.024	0.963	0.381	1.176	75.55	5.534	0.254	27.613	77.511
	P. conchonius	0.081	0.027	1.281	0.33	5.155	121.32	3.4	0.144	30.87	89.53
	L. calbasu	0.246	0.003	0.682	0.043	1.477	56.51	1.725	0.083	21.76	99.13
	L. rohita	0.419	0.007	1.049	0.663	7.68	177.65	3.421	0.327	39.53	79.32
	L. bata	0.423	0.232	1.525	0.454	2.962	81.58	3.456	0.36	26.56	65.21
Tilaya Dam	*P. indicus*	0.352	0.049	1.434	0.439	21.2	64.83	14.55	0.157	51.15	30.81
	M. gulio	0.182	0.003	0.693	0.047	0.745	94.73	3.354	0.325	33.67	67.1

	P. conchonius	0.11	0.002	0.59	0.019	1.411	58.544	1.715	0.232	25.95	63.75
	L. calbasu	0.173	0.004	0.494	0.03	2.49	61.651	2.412	0.266	24.32	81.95
	L. rohita	0.369	0.002	0.323	0.049	5.6	56.13	1.521	0.143	21.34	52.13
	L. bata	0.365	0.002	0.724	0.022	1.602	57.03	1.71	0.28	30.1	40.32

The table includes the species of fish analyzed and the concentrations of various HM's, namely As (arsenic), Cd (cadmium), Cr (chromium), Co (cobalt), Cu (copper), Fe (iron), Ni (nickel), Pb (lead), Sr (strontium), and Zn (zinc). The concentrations of HM's vary among the different fish species and locations, like in Konar Dam, the fish species *P. indicus* had concentrations of HM's such as 0.261 mg/kg of As, 0.054 mg/kg of Cd, 0.692 mg/kg of Cr, 0.282 mg/kg of Co, 10.252 mg/kg of Cu, 161.75 mg/kg of Fe, 5.87 mg/kg of Ni, 0.056 mg/kg of Pb, 78.62 mg/kg of Sr and 14.26 mg/kg of Zn.

3.4 Comparison between standard and observed value of HM concentration in fish

Table 5 shows the comparison between standard versus observed HM concentration in a fish sample.

Table 5: Comparison between Standard Vs Observed HM concentrations in a fish Sample

Elements	**As**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Ni**	**Pb**	**Sr**	**Zn**
Standard heavy metal concentration in fish (µg/g)	0.026	0.003	0.06	0.005	3	0.3	0.05	2	1.5	15

Average heavy metal concentration in fish samples (µg/g)	***P. indices***	0.48	0.32	3.75	0.57	44.09	143.35	13.73	0.20	82.78	52.66
	M. gulio	0.08	0.04	0.59	0.27	3.66	92.02	4.31	0.22	36.95	57.35
	P. conchonius	0.16	0.03	1.08	0.75	4.36	129.82	6.43	0.14	41.95	67.98
	L. calbasu	0.19	0.006	0.53	0.04	3.94	66.83	8.19	0.11	25.61	71.47
	L. rohita	0.37	0.05	0.55	0.24	8.73	107.04	2.41	0.16	26.89	51.80
	L. bata	0.36	0.22	0.99	0.42	17.38	104.33	2.89	0.18	32.60	51.42

Comparing the average HM concentrations in fish samples to the standard concentrations, it can be observed that most of the HM's exceed the recommended levels in fish. Arsenic (As) concentrations in all fish species are higher than the standard concentration of 0.026 µg/g. Copper (Cu) concentrations in all fish species, except for *P. indicus*, exceed the standard concentration of 3 µg/g. Iron (Fe) concentrations in all fish species exceed the standard concentration of 0.3 µg/g.

3.5 Risk of ingesting heavy metals: THQ

THQ of HM's by consuming fish and shrimp collected from the Damodar River basin is shown in Table 6. 0

Table 6: THQ of heavy metals by consuming fish and shrimp collected from the Damodar River basin

species					THQ					
	As	Cd	Cr	Co	Cu	Fe	Ni	Pb	Sr	Zn
P. indices	0.51	0.45	6.2	0.79	79.73	145.57	13.44	0.24	88.39	60.94
M. gulio	0.1	0.05	0.73	0.32	7.38	90.89	5.26	0.22	39.66	62.46
P.										
conchonius	0.16	0.03	0.99	0.7	5.94	116.99	7.77	0.14	43.61	76.39
L. calbasu	0.19	0.01	0.55	0.05	7.38	77.39	8.43	0.16	25.96	75.74
L. rohita	0.38	0.05	0.65	0.36	13.08	116.89	2.94	0.22	30.44	57.48
L. bata	0.38	0.26	1.12	0.45	23.97	94.84	3.04	0.19	37.09	52.77

The data provided includes the Target Hazard Quotient (THQ) values for different HM's in various fish species. Analyzing the THQ values for the HM's in the different fish species, it can be observed that the THQ values vary across the metals and species. For *P. indicus*, the THQ values exceed 1 (indicating potential health risks) for arsenic (As), copper (Cu), and iron (Fe), suggesting that the consumption of this fish species may pose health concerns related to these specific HM's. In the case of *M. gulio*, the THQ value exceeds 1 for iron (Fe), indicating a potential health risk associated with Fe intake from this fish species. *P. conchonius* exhibits a THQ value exceeding 1 for copper (Cu), while *L. calbasu* shows a THQ value above 1 for iron (Fe). These results suggest that the consumption of these fish species may present health risks related to these specific HM's. *L. rohita* and *L. bata* both have THQ values exceeding 1 for copper (Cu) and iron (Fe), indicating potential health risks associated with the consumption of these fish species.

4. DISCUSSION

In a similar study done by **Liu *et al.*, 2019** [16] on the HM contamination of soils brought on by China's coal mining operations, evaluated the degree and severity of HM contamination in soils around coal mines. The concentrations of all the studied HMs, except Ni, were highest in Anthrosols soil and lowest in hydromorphic soils, thus indicating that anthropogenic activities greatly impacted soil HMs. According to the study's conclusions, there is significant contamination since the soils close to coal mining regions contain elevated levels of HM's. **Masto *et al.*, 2019** [17] studied the Potentially Toxic Elements (Cu, Cr, Zn, Sr, Ba, Pb, As) which were discovered in the road dust of a coal mining area (Dhanbad, India). Ba had the greatest mean PTE concentration (293 mg/kg), followed by Zn (224), Pb (128), Cr (45.2), Ni (22.0), As (17.5), Cu (52.6) and Co. (8.11). The total pollution load index had a range of 0.43 to 1.0. PTEs (Zn, Fe, Mn, Co, and Pb) were discovered in the road dust at the study location. **Lakra *et al.*, 2019** [18] were analyzed the concentration of heavy metals Fe, Zn, Cu, Mn, Ni, Cd, Pb and Cr in the water and various tissues of edible catfish *Clarias batrachus* reared in a pond receiving effluents from Rajrappa coal mine, Jharkhand, India. The metal concentrations in the pond water were dramatically higher (Fe 350%, Zn 423%, Cu 12%, Mn 7029%, Ni 713%, Cd 1700%, Pb 4333% and Cr 588%) than the safe limit of Environmental Pollution Agency as well as the control tap water. **Cheng *et al.*, 2019** [19] investigated tissue-specific metal accumulation in six economically important fish species common to Gaotang Lake, China, located in a coal mining area. Mean concentrations of arsenic, cadmium, cobalt, copper, mercury, lead, and antimony in the muscle of six fish species were below the corresponding Chinese maximum allowable concentrations except chromium.

5. CONCLUSION

The research paper concludes that fish from coal mining areas in Jharkhand, India, exhibit elevated levels of harmful heavy metals due to contamination from mining activities. The analysis of water samples, sediment samples, and fish species revealed significant environmental contamination in these areas. The assessment of heavy metal toxicity in fish through the Target Hazard Quotient (THQ) indicated potential risks associated with ingesting these metals. The findings emphasize the urgent need for ongoing monitoring and mitigation efforts to ensure the safety of fish and protect human health in coal mining regions. The implications of this research paper are significant so as to ensure the implementation of sustainable practices and the well-being of affected populations.

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