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Impact of Cadmium Toxicity decreases the Fish Population in Gomati River of Jaunpur

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Introduction

In the current scenario, it is estimated that the freshwater fisheries and fishes are most affected, and their population in natural freshwater environment is highly vulnerable resources that possesses impact not only on human population but it also affects the biodiversity of the freshwater ecosystem (Dudgeon D et al., 2006, Reid, A.J 2018). Uttar Pradesh, which includes a huge enormous amount of freshwater in the form of both lentic and lotic ecosystems, is one of the largest states in India, has great potential for aquatic resources, and provides a huge opportunity for fresh water fisheries development and aquaculture. In Current condition a major problem with freshwater ecosystems is that the riverine ecosystems of India have suffering from majorly from anthropogenic intervention, through household effluents directly flowing in riverine water, agricultural waste in the form of pesticides, insecticides, different fertilizers and through industrial effluents, resulting in water pollution, that affect habitat loss and fragmentation of habitat, and degradation, and that causes many freshwater fish species, amphibians, and freshwater insect populations to become heavily endangered, particularly in Gomti river (Kumar R. et al., 2024, Bora M et al., 2017) . Gomti river is a tributary of river Ganga and it flow entirely in Uttar Pradesh only. The Gomti River originates from the Gomat Taal, otherwise called Fulhaar Jheel, which is found near the Madho Tanda in the Pilibhit district of Uttar Pradesh. Different rivers as like Sai River, Chowka River, Kathina River and Saryu River are important tributaries of Gomati River. The Gomati River is perennial ie., water flow occurs throughout the year. Although Gomati River has a slow flow of water all year long, but during monsoon season, when a due to huge rain area covered by Gomati River, lot of rain water inflow increases the discharge significantly. From its origin Gomati River faces multiple irreversible pollution causing conditions as like industries, house hold pollutant and agricultural waste and changes in natural population by introductions of exotic species and diseases (Dudgeon et al.2005; Arthington and Welcome 1995; Arthington AH et al., 2009; De Silva and Abery 2007, Botle A et al., 2022). India's fisheries industry ranks third globally in terms of overall fish output and accounts for approximately 1.07% of the nation's GDP, with agriculture accounting for 5.34%. Fishing industry ranks third, in the form of direct employment creation, rural development, and nutritional security (CFMRI Kochi, 2022; Kumar A and Pathak H, 2024). In India, Uttar Pradesh, one of the largest states offers a significant range of cultural and capture fisheries development opportunities in addition to its enormous potential for aquatic freshwater resources. As shown in different recent studies, there are roughly 125 species, 74 genera, and 28 families of fish population occurs in fresh water bodies that play a major role in biodiversity. Near about 14.68% of India's freshwater fish variety can be attributed to this diversity. Compared to the 56 species previously recorded by Sarkar et al. (2010), the River Gomti displayed a total species variety of 68 species. Uttar Pradesh (UP), is generate huge GDP with an abundance of aquatic bioresources, including a various range of freshwater fishes with huge genetic diversity. UP offers significant potential for the development of inland fisheries and aquaculture, and it accounts for about 14.68% of India's fish biodiversity (Lakra 2010). Biodiversity is the major concern of the 21st century and loss of biodiversity is one of the world's most alarming crisis (Wilson 2000, Khanna V. 2011, Chavan V, 2011). The estimated current extinction rate of flora and fauna is between 1,000 and 10,000 times higher than it would naturally occurs (Bowker 2005). India is one of 12 countries with biodiversity and 25 hotspots of the world's richest and most endangered ecoregions. It also contributes 60–70% of the world's biological resources (Jaishankar I. et. al., 2018, Chaudhuri et al., 2003). Without proper treatment of sewage water from 26 drains in the Lucknow region is dumped into the river. Gomti also receives garbage from Sitapur's industry before Lucknow does. The Gomti River is now widely known to be extremely polluted. According to the Uttar Pradesh Pollution Control Board's (UPPCB) study, the Gomti's flow has significantly diminished, which has led to a rise in the biomass on the canal. In different groups of vertebrates, freshwater fishes are the most diversified and endangered because of the pollution. *Labeo rohita*, *Catla catla*, *Wallago attu, Channa punctatus, Heteropneustes fossilis,* and other fish are more common in the Gomati River. The various species are brought here to be studied for their biological activities, which help us understand their life cycle, feeding habits, and the habitat they needed to survive.

As the world population increasing continuously, demand for high-quality water globally increased day by day, either for drinking, sanitation, agriculture, or industrial use, there has been a growing concern in recent years about water treatment and reuse, which calls for the strictest standards. Almost all fresh water bodies have become contaminated with different contaminates above the permissible limits for effluent due to increased industrial operations. Potentially harmful substances have raised the most concerns for human and environmental health among the many pollutants because of their high capacity for accumulation and lack of biodegradability. Heavy metals, also referred to as potentially poisonous elements (PTEs), are metallic compounds that have a density greater than that of water. When levels of these metals exceed what is deemed normal, they can be harmful to humans and are highly poisonous.

While some of the priority metals in the form of micronutrients found in groundwater are essential for life, larger amounts of these metals can actually be harmful. Industrialization, improper land and water resource use, farming methods with the use of huge number of insecticides, pesticides and population increase are all increases strain on these essential living resources, such land and water. Fresh waterbody contamination is now a worldwide problem that has been getting worse in both developed and developing nations, hindering economic development and endangering both wildlife population and public health. The uncontrolled release of harmful heavy metal ions into the environment is having a detrimental effect on the state and characteristics of our limited freshwater supplies. The sustainability and availability of drinking water are being threatened by the unchecked release of contaminants, which is causing public concern on a global scale (Jan Saima et al., 2023, WHO, 2022). Even in trace amounts, possible dangerous metals have sparked health concerns due to their bio accumulative nature (Ali H. et al., 2019, Stankovic S. et al., 2014). The Environmental Protection Agency has identified certain of these elements as priority contaminants to be managed because they are non-biodegradable, such as arsenic (As), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Lead (Pb), and Zinc (Zn) (Edo G I et al., 2024, Hazrat A. et al., 2019, Kady El et al., 2018). The rapid expansion of Indian industry over the last few decades has led to significant economic growth, but it has also resulted in the extreme contamination of the environment. As a result, the water quality, which is much below international norms, is negatively impacted. Water contamination is a result of waste water from the manufacturing and chemical processing sectors. Typically, industrial wastewater comprises distinct and easily recognized chemical components. It has been discovered that solid waste, effluent discharge, and other hazardous wastes account for one-third of all water pollution. A significant amount of this can be linked to the food products business and the processing of industrial chemicals. The primary source of waste disposal for industry is surface water. Effluents that are untreated or purportedly treated have caused 22 of the nation's most polluted districts to see increases in surface water contamination of up to 20 times the safe threshold. Nearly all rivers are reported to be contaminated by industry in most of their lengths (Khan A et al., 2021, Goldar B et al., 2004). Even though the Central Pollution Control Board (CPCB) enforces stringent regulations for all Indian enterprises, the state of the environment is still far from ideal (Dey S. et al., 2024). Various guidelines and standards are provided for each industry based on the possibility for pollution. The majority of significant industries have industrial wastewater treatment plants.

This isn't the case for small businesses, either, as their profit margins are so thin that they cannot afford to make significant investments in pollution control machinery. Because of this, there is ample evidence of improper handling of industrial waste in India (Misra V et al., 2005, Nixon JD et al., 2017). Petrochemical companies, sugar mills, distilleries, leather processing companies, paper mills, agrochemical and pesticide manufacturing companies, and pharmaceutical companies make up the majority of these defaulting industries. As a result, the pollution issue becomes a grave concern toward the conclusion of each time period.

Toxic heavy metals have made the issue of water pollution even worse (Singh A et al., 2022, Mance, Geoffrey. 2012.).

The increasing trend in concentration of heavy metals in the environment has attracted considerable attention amongst ecologists globally during the last decades and has also begun to cause concern in most of the major metropolitan cities. Sewage water and untreated or purportedly treated industrial effluents include varying concentrations of heavy metals as lead, arsenic, copper, nickel, cadmium, mercury, zinc, and chromium (Roy et al., 2024.), which could contaminate crops grown with this type of irrigation (Zhang, P et al., 2023). Water quality degradation due to heavy metal contamination: Health impacts and eco-friendly approaches for heavy metal remediation. (Briffa, J. et al., 2020). Aquatic plants and animals are significantly impacted by these heavy metals, which bio magnify their way into the food chain and eventually impact humans. The issue of heavy metal pollution in our rivers, lakes, and oceans is getting worse every day. There have been reports of heavy metal buildup in fish, oysters, sediments, and other aquatic ecosystem components worldwide (Meena R. et al., 2018). Despite their ability to create soluble complexes and free metal ions that are available for biological organisms to absorb, these hazardous heavy metals that enter the aquatic environment are adsorbed onto particulate matter (Ansari TM. Et al., 2004). The metals linked to particulate matter are deposited in estuarine sediments and are also available for biological absorption (Piwowarska, D., et al., 2024). Once deposited, trace metals are rendered immobile by binding by sulfides and/or iron hydroxides until a pH or redox shift takes place. Consequently, trace metals are accumulated by surficial sediments, especially the fine fraction, which also offers a way to assess the long-term buildup of pollutants (Gavhane, S. K et al., 2021).

2. Materials and Methods

2.1. Area of Study

The study was carried at the urban area which is one of the most rapidly developing and heavily polluted industrial belts of Jaunpur. The urban area is spread over about the stretch of 5 km of river bank although

Gomti River flow around 45 km stretch in Jaunpur, consisting of scale industries like jewellery processing units, steel processing industries, chemical units, paints, pharmaceutical units, textile industries etc. Jaunpur district is situated roughly between 25°22'30" and 26°10'00" north latitude and 82°06'00" and 83°00'00" east longitude. The Gomti enters Jaunpur from the northwest and exits towards the southeast. The effluent discharge, treated and untreated amounts to 28,750 m3 /day i.e., 64% of the total industrial effluents. This has created health hazards not only for local population but also resulted in disturbances of aquatic life of the Gomati River flowing

2.2. Climatic Conditions

With temperatures ranging from 4°C to 45°C, Jaunpur's climate has a big impact on its ecology. Rainfall averages 1,098 millimetres in the area, mostly during the monsoon season (June to September). The place experiences the onset of the monsoon in the month of June and experiences monsoon till the end of September. The average temperature recorded varies from 04 to 45°C.

2.3. Requirements for Water Sampling

Before using de-ionized distilled water, all of the glassware, casserole, and other pipettes were carefully cleaned with distilled water. Prior to use, the burette and pipettes were rinsed with the solution. Analytical reagent grade chemicals and reagents were utilized in the analysis. The process of determining the various parameters was carried out in the lab.

2.4. Heavy Metal Analysis by AAS Technique

Analysis of heavy metals was done by atomic absorption spectrophotometer (AAS) following the protocol described by Tuzen and Soylak (2006). Each water sample (200ml) was digested with 10ml of HNO_3 in a conical flask by keeping the same at 80°C in the water bath. After complete digestion (until sample was evaporated to half of its volume), samples were allowed to cool and then filtered. Each sample was diluted to 50ml and analysed. The heavy metals analysed were Lead (Pb) and cadmium (Cd). A reagent blank sample was analysed and subtracted from the samples to correct for reagent impurities and other sources of errors from the environment. Average values of three replicates were taken for each determination.

2.5. Collection of Fish Population in Gomati River

Three significant locations along the river Gomti were chosen for sampling: Site-1 (Badlapur), Site-2 (Near Shahi Bridge), and Site-3 (Near Kerakat) of Jaunpur. Fishes were gathered utilizing gill, drag, and scoop nets over the course of one year, from January 2022 to December 2023. Specimens of fish were transported to the laboratory following preservation in 5% formalin for subsequent analysis. The relative abundance and species richness of fish were assessed across the various sites.

3. Result and Discussion:

3.1: We collected the water sample form three different site of Gomati River. Site 1 (Near Badlapur) of the collection water is selected on the basis of entry of Gomati River in jaunpur city. Site 2 selected for sample water collection is Near Shahi Bridge of Jaunpur. Site 3 selected for water sample collection is kerekat, near exit point of Gomati River form the Jaunpur district. After using atomic absorption spectroscopy (AAS) for detection of Cadmium in water samples in all three sites Cadmium level is up to 0.05ppm or 0.05 mg/Liter that is up to 16 times higher than permissible limit of World Health Organisation (WHO) (Figure 1).

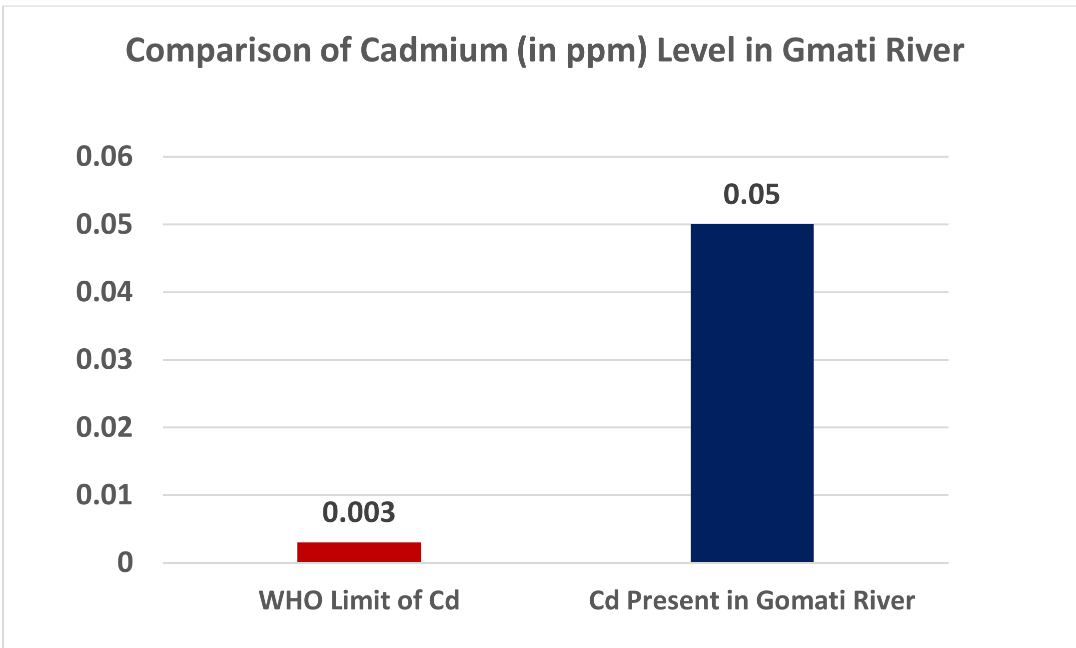

Fig 1. Cadmium measured in Gomati River Water using Atomic Absorption Spectroscopy

Collection and Identification of Fishes:

We collected the fishes from all three sites selected sites of study. Different methods used for collection of fishes form the River Gomati. For the collection of fishes we used cast nets, dip nets used for shallow areas of river. Fish baits using hooks are also used for collection fishes. Trap method used for the collection of fishes at all three sites. Fishes were collected in different seasons at all three sites as in summer during April to May, winter during November to December and monsoon season during august to August to September. Collection of fishes were carried through out the year of 2022-23. After extensive fishing through different methods of fish capturing, at all three different sites of Gomati River in Jaunpur. Total 46 different species of fishes were capture through different capturing methods of fishing in Gomati River. All the fishes were collected and stored in preservative (10% of formalin) for further studies. Fin formulas and fishes local name and scientific names were searched through literature (Bano F. and Sirajuddin M., 2016, Das MK et al., 2012, Kurup Bm et al., 2004, Patra BC and Saha MK 2013, Sarkar U.K et al., 2010, Srivastava S.C et al., 2014). The fishes collected from the river Gomati were identified as per the manuals and keys described in his study by Talwar & Jhingran (1991) and Jayaram (1999). Fishes shows different skin colour, banding patterns of scale, morphometric and meristic characters were noted down and fin formulas of each fish species of the collected indigenous and exotic fishes were derived as per Srivastava (1980 & 1988). The fish population and their density in Gomati River Jaunpur is decreasing constantly as described Bano F. and Sirajuddin M., 2016, as their study target area was Lucknow during 2015-16 and they have collected and denoted 56 different fish species in Gomati River. Ashish Sahu et al., 2024 from the NBFGR Lucknow has shown in his study that 76 different fish species were present.

S. No.	Local Name	Scientific name	Fin formulae	Current Population Status
1	Suhia	*Gudusia chapra* (Hamilton, 1822)	D 14-15(3/11-12); P 13; V 8; A 22-24; C 17	Decreasing
2	Patara	*Notopterus notopterus* (Pallas, 1769)	D 8(1/7); P17; V 6; A100; C 19	Unknown
3	Bhakur	*Catla catla* (Hamilton, 1822)	D 18-19(3/15-16); P 19; V 9; A8(3/5); C 19	Unknown
4	Nain	*Cirrhinus mrigala* (Hamilton, 1822)	Diii-iv12-13; P I 17; Aiii 5; V I 8	Stable
5	Rewa bata	Cirrhinus reba (Hamilton, 1822)	D2/9; P16; V9; A2/6; C19	Stable
6	Grass carp	Ctenopharyngodon idella (Valenciennes, 1884)	D 10; P18; V 9; A 10-11; C 26-32-	Unknown
7	Silver carp	Hypophthalmichthys molitrix (Valenciennes, 1844)	D10-11; P20-21; A 14-15; V 8-	Unknown
8	Dendua	Esomus danricus	D 8-9(2/6-7); P 11-12; V	Stable

		(Hamilton, 1822)	8; A9(3/6)	
9	Bata	Labeo bata (Hamilton, 1822)	D11-12(2-3/9-10); P 18; V 9; A 7(2/5); C 19	Unknown
10	Karaunchi	Labeo calbasu (Hamilton, 1822)	D17(3/14); P19; V 9; A7(2/5); C 19	Unknown
11	Kursi	Labeo gonius (Hamilton, 1822)	D16(3/13); P 17; V 9; A 7 (2/5) ; C19	Unknown
12	Rohu	Labeo rohita (Hamilton, 1822)	D16(3/13); P 17; V 9; A7 (2/5) ; C 19	Unknown
13	Gurda	Osteobrama cotio (Hamilton, 1822)	D11(2/9); P 14-15; V 10; A 33-35(2/31-34); C 19	Unknown
14	Chalhawa	Salmostoma bacaila (Hamilton, 1822)	D2/7-9; P12-13; V 9; A 2/13-15; C 19	Stable
15	Sidhari	16 Puntius sarana (Hamilton, 1822)	D3/8-9; P 15-16; V 8-9; A 3/5 ; C19	Unknown
16	Dendua	*Rasbora daniconius* (Hamilton, 1822)	D 2/ 7; P 15;V.9; A 2/ 5; C 19	Unknown
17	Bagha	*Botia lohachata* (Chaudhuri, 1912)	D2/ 9; P 13-15; V 8; A 2/ 5; C 19	Unknown
18	Nakati	*Lepidocephalichthys guntea* (Hamilton, 1822)	D 2/ 6; P 8; V 7; A 2/ 5; C 16	Unknown
19	Jalkapoor	*bimaculatus* (Bloch, 1794)	D4; P 1/ 13-14; V 8; A 2/63-67; C18	Unknown
20	Pabda	*Ompok* *Ompok pabda* (Hamilton, 1822	D4-5; P 1/ 11-13; V 1/ 6-7 A 2/ 48-54	Decreasing
21	Padhani	*Wallago attu* (Bloch et Schneider, 1801)	D 5; P1/14; V 10; A 4/82; C17	Decreasing

22	Tengan	*Mystus seenghala* (Sykes, 1839)	D1/7/0; P 1/ 9; V 6; A 3/ 8-9; C 19-21	Unknown
23	Tengra	*Mystus tengara* (Hamilton, 1822)	D1/ 7/0; P 1/ 8; V 6; A2-3/9-10; C19	Unknown
24	Tengara	*Mystus vittatus* (Bloch, 1794)	D 1/ 7/0; P 1/8; V 6; A 2/9; C17	Decreasing
25	Dariai Tengar	*Mystus cavasius* (Hamilton, 1822)	D1/ 7/0; P 1/9 8; V 6; A 3-4/7-8; C 16	Decreasing
26	Tengan	*Mystus aor* (Hamilton, 1822)	D 1/ 7/0; P 1/10; V 6; A 3/10; C 17	Decreasing
27	Hunna	*Rita rita* (Hamilton, 1822)	D 1/ 6; P 1/ 10; V 8; A 4/9 ; C 19	Decreasing
28	Gonch	*Bagarius bagarius* (Hamilton, 1822)	D1/6/0; P 1/12; V 6 ; A 3/10; C 17	Decreasing
29	*Kosi nangra*	*Nangra nangra* (Hamilton, 1822)	D 1/ 6; P 1/ 8; V 6; A 11-12; C 18	Stable
30	Baghi	*Gagata cenia* (Hamilton, 1822)	D8 (2/ 6) 1/0; P 1/ 8-9; V 1/ 5; A 3/ 10-11; C 19	Unknown
31	Patasi	*Ailia coila* (Hamilton, 1822)	D0; P I 13-14; V 6; A 72-75; C 19	Decreasing
32	Karahi	*Clupisoma garua* (Hamilton, 1822)	D1/ 7; P 1/11; V 6; A 3/29 ; C 17	Decreasing
33	Banjhoo	*Eutropiichthys vacha* (Hamilton, 1822)	D I /7; P 1/ 15-17; V 6; A 3/45; C 17	Decreasing
34	Singhi	*Heteropneustes fossilis*	D 6; P 1/7; V 6; A62-66;	Stable

		(Bloch, 1794)	C19	
35	Mangur	*Clarias batrachus* (Linnaeus, 1758)	D 65-70; P1/8; V6; A47; C17	Unknown
36	Hunra	*Rhinomugil corsula* (Hamilton, 1822)	D 4/1/8; P 5; V1/5; A3/8-9; C15	Unknown
37	Kauwa	*Xenentodon cancila* (Hamilton, 1822)	D 16-17; P 11; V 6; A 17; C 15	Unknown
38	Souri	*Channa marulius* (Hamilton, 1822)	D 46; P 18; V 6; A 32; C 12	Unknown
39	Girohi	*Channa punctata* (Bloch, 1793)	D 29-30; P 16-17; V 6; A 20-22; C 12	Unknown
40	Souri	*Channa striata* (Bloch, 1793)	D 41-43; P 16-18; V 6; A 24-25; C 14	Unknown
41	Chanari	*Chanda nama* (Hamilton, 1822)	D 1+7/1/16-17; P 12-13; V 1/ 5; A 3/16-18; C17	Decreasing
42	Patharchatt i	*Sciaena coitor* (Hamilton, 1822)	D11/2/27; P 17; V1/5; A 2/7; C17	Stable
43	Sumha	*Badis badis* (Hamilton, 1822)	D 16/ 7-10; P 12; V 15; A 3/7; C 16	Unknown
44	Kawai, Koi	*Anabas testudineus* (Bloch, 1792)	D 17/9-10; P 15; V1/5; A 10-11; C16	Unknown
45	Khosti	*Trichogaster lalius*	D 15-17 / 7-10; P 10;	Unknown

		(Hamilton, 1822)	V 1; A 17-18/ 13-14 C15	
46	Bam	*Mastacembelus armatus* (Lacepède, 1800)	D 37-39/78-82; P 21-27; A 3/ 75-78	Unknown

Table 1. Fish species collected and identified in Gomati River Jaunpur.

Conclusion:

As the result shown in our study that fish population specifically drastically decreasing in Gomati River specifically in Jaunpur region. Most probable reason as shown in our study that heavy metal toxicity specifically cadmium level in increasing at alarming level in Gomati River. Although population density near river basin area, intake of polluted water, agricultural waste products, insecticides, pesticides, herbicides use also affect the fish population as shown in different studies. Most probably higher level of Cd affects the fish species diversity in Gomati River. For future prospective we have to study different other parameters to go through concrete evidence for decrease in fish species population in Gomati River.

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