Evaluation of some heavy metals toxicity in *Channa punctatus* and riverine water of Kosi in Rampur, Uttar Pradesh, India

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**Abstract**

This study was aimed to assess the bioaccumulation and concentration level of three heavy metals such as Chromium (Cr), Cadmium (Cd) and Lead (Pb) in the riverine water and edible fish, *Channa punctatus* obtained from River Kosi, Rampur, Uttar Pradesh, India. These toxic heavy metals are released into the environment because of E-waste, industrial activities, municipal urban runoff, coal burning, fertilizers etc., then paved the way into the aquatic system due to direct input, atmospheric deposition, and erosions caused by rain. There is every apprehension of aquatic animals getting exposed to elevated levels of heavy metals, thus possessing harmful effects both to flora and fauna. The concentrations of Cd, Cr and Pb in water were found to be 0.051 ± 0.026, 1.091 ± 0.408, and 0.019 ± 0.002 whereas in the kidneys of *Channa punctatus*, as 0.076 ± 0.208, 0.482 ± 0.059, and 0.127 ± 0.705 respectively.

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1. Introduction

Heavy metal elements have been used for many years in the manufacturing of household materials, plastics and electric and electronic products (Dixit et al., 2015). Lead (Pb), cadmium (Cd), chromium (Cr), mercury (Hg), bromine (Br), tin (Sn) and antimony (Sb) are usually added to polymers as pigments, filters, UV stabilizers, and flame retardants (Stenmarck et al., 2017). Also, chromium, lead chromate and cadmium salts are used in various household items like kitchen utensils, house painting batteries etc., produce colours that vary from red to orange and yellow (Satarug et al., 2000). Due to various industrial and consumer wastes, some heavy metals such as cadmium (Cd) and lead (Pb) can infiltrate into the water, moreover contaminated the entire aquatic system (Zhang et al., 2005). These heavy metals are also added to plastic products although encapsulated in polymer matrix (Onwughara et al., 2010; Stenmarck et al., 2017) and are unable to chemically bind to polymer molecules and are gradually released into the environment (Dixit et al., 2015; Verma et al., 2016). While disposing off these plastic and electronic waste products either by incineration or earth filling methods, toxic metals reached into the atmosphere through leaching further bioaccumulated in living organisms (Verma et al., 2016). The accumulation of coloured plastics in the environment is a result of improper disposal or shipping spills. Plastic is durable and lightweight (Stenmarck et al., 2017); is capable of covering long distances (Verma et al., 2016); ended up in terrestrial environments, along shorelines, or floating in the open ocean (Zbyszewski and Corcoran, 2011). For example, pill bottles from India along with oil and detergent containers from Russia, Korea, and China have been found on the southern parts of Hawaii (Kostigen, 2008). Environment friendly handling of plastics and discarded electronic product material requires regular monitoring of toxic elements during their various stages of their production, recycling and disposal operations (Zbyszewski and Corcoran, 2011). As per the estimation recorded by Central Pollution Control Board (CPCB) of India, the plastic consumption in India is 8 million tons per annum and annually about 5.7 million tons of plastic is converted into non-biodegradable wastes (Rathi, 2006), which is a matter of serious concern.

Due to excessive release of these heavy metals into the water reservoirs in the form of coloured plastic and E-Wastes, further biomagnified in aquatic flora and fauna produce toxicity (Stenmarck et al., 2017). These toxicants created many disturbances in organism such as chromium IV has carcinogenic properties and is highly toxic in nature which generated many diseases.
such as pulmonary sensitization, sinus cancer and skin ulcers (Handa et al., 2019). Itai-itai disease and renal failure is occurred due to toxicity of cadmium (Kobayashi et al. 2009). Nervous breakdown and mental retardation can be caused due to the toxicity of Pb (Maehara et al., 1986). There is a great concern about the potential risk to human health which directly related to the consumption of such polluted biota (seafood) due to the accumulation of high doses of these heavy metals. Therefore, the main aim of the present work is to determine the concentration of heavy metals in *Channa punctatus*, consumed by a large section of population around the world as a popular source of nutritious healthy white meat.

2. Methods and materials

The study area is located at the basin of river Kosi, which pass through district Rampur, Uttar Pradesh (Fig. 1A) at longitudes 78°54' to 69°28'E and latitude 28°25' to 29°10'N. It covers an area approximately about 2367 sq. km. This region is very fertile and people are engaged in agriculture and small-scale industries are operating in nearby places. The water of Kosi River is used for agriculture, domestic and drinking purposes. In this area, illegal incineration and dumping of E-waste was probably noticed and the release of poisonous heavy metals in the river may have badly affected the quality of river. Three replicates of water samples were collected from the selected region in pre-clean and sterilized glass bottles from Kosi River region of Rampur U.P. India. Also, *Channa punctatus*, fish were collected from the local fish market and brought to Toxicology lab, Department of Zoology at Govt. Raza P.G. College Rampur U.P. India. The process of digestion and further procedure was adopted for the detection of heavy metal concentration in selected samples (Topping, 1973). *Channa punctatus* (length: 20 ± 5 cms; weight: 110 ± 10 gms) were sacrificed and kidneys were scratched out (Fig. 1B) further oven dried at 60 °C and crushed into fine powder with the help of pastel and mortar. For total metal analysis, water and dried fish organs were digested on hot plate using acid mixture (HNO₃ + HClO₄) in the ratio of 4:1. Acid digestion of water and fish was carried out in following way: Water sample: 100 ml of water samples was added with 20 ml acid mixture. Fish samples: 1 g of fish sample was added with 20 ml acid mixture. The digested samples were then filtered through Whatman filter paper no. 1 and made up to 25 ml with deionized water and stored at 4 °C. The metal concentrations in digested samples of water and fish kidneys were analyzed by using Atomic Absorption Spectrophotometer. Digested samples were analyzed three times for each metal.

Physiochemical parameters of water:

To evaluate the water quality parameters, the following methods are adopted-

a. Temperature was recorded by digital thermometer
b. The pH value was determined by digital pH meter
c. EC value was recorded by digital EC meter
d. BOD was determined by as per standard method
e. COD was determined by potassium dichromate open reflux method (NEERI, 1991).

![Fig. 1](image-url) [A] Location of Kosi River and allied regions. [B] Sacrificed *Channa punctatus* showing kidney [C] Concentration of heavy metals in water and comparison with the permissible limit (WHO, 2011). [D] Concentrations of heavy metals (mg/kg) in kidney of *Channa punctatus*. [E] Contamination factor of water samples. [F] Contamination factor of fish samples.
f. The total length (cm) and weight (g) were also measured in case of fish.

2.1. Statistical analysis

The data is statistical analyzed using ANOVA (Analysis of Variance) and also in the form of mean ± standard deviation. Standard Error was also calculated. Contamination factor was calculated by the formula given by Idrees et al. (2018):

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\text{Contamination factor} = \frac{\text{presentstudymean}}{\text{valueofWHO permissible limit}}
\]

3. Results and discussion

Table 1 indicates the mean data physicochemical parameters of water samples collected from six selected stations. Results showed that the mean temperature of water samples was 29.7 °C and the pH value was recorded as 7.6. However, the pH was recorded within the recommended values i.e. 6.0–8.5. Total Dissolved Solids value was found to be 369 mg/l. The conductivity was recorded as 467 μmho/cm. The BOD and COD recorded values were 37.9 mg/l and 153 mg/l respectively. Fig. 1(C) represented the concentration of Cd, Pb and Cr in water compared to the permissible limit set by WHO, 2011 as 0.003, 0.01 and 1 mg/l respectively, whereas in present study, the concentrations of Cd, Pb and Cr in water were found to be 0.051 ± 0.026, 0.019 ± 0.002 and 1.091 ± 0.408 mg/l respectively (Table 2, entries 1–3). Upon the comparison of the data with the permissible limit, the results inferred that the contamination factor of heavy metals in water samples were in the order of Pb > Cd > Cr (Fig. 1A). Fig. 1(E) describes the values of contamination factor of heavy metal in water where Cd was higher with the value of 17 followed by Pb (1.9) and Cr (1.09) after comparing to the permissible limit given by WHO i.e. Cd, Pb and Cr are 0.02, 1.5 and 0.34, respectively. The present results revealed that the concentrations of Cd, Pb and Cr in fish kidney were 0.076 ± 0.208, 0.127 ± 0.705 and 0.482 ± 0.059 respectively. As shown in results Cd and Cr stress is higher than Pb.

Fig. 1(F) displayed the contamination factor of heavy metals in fish samples. As compared to the Table 3, the data revealed that the contamination factor of cadmium was observed to be high in the kidney of Channa punctatus having the value of 3.8 followed by chromium and lead with the values of 1.42 and 0.09 respectively.

The present study revealed that the value of pH in the water samples was reported within the permissible limits. Various acid base reactions are significant in water due to their influence on the ion chemistry and pH. In acidic conditions, there are sufficient hydrogen ions that occupy many of the negatively charged surfaces and little space is left to bind heavy metals. Therefore, majority of heavy metals are in the soluble phase (Chapman, 1992). It is assumed that the soluble form of heavy metals is more harmful because it is more readily available to aquatic organism and more easily transported. Higher BOD and COD were recorded due to industrial pollution generated by industrial units situated in the north at Kashipur (Pande and Sharma, 1998). The level of recorded heavy metals in the river water samples were in the order of Cr > Cd > Pb. The reason may be due to the discharge of industrial effluents, the dumping of small scale discarded materials, agricultural wastes as well as burning of large amounts of plastic and E-wastes. The heavy metal accumulation in the kidneys of Channa punctatus were found to be in consonance with the values found in river water samples resulted that both samples are highly contaminated by these toxic metals, especially from the cadmium metal. Kidneys of fish might be considered as a good pollution indicator. In purification period, levels of kidney metal remain high or may even rise for some time, which is dependent on the kidneys role as excretory organs (Jezierska and Witeska, 2006).

This research work revealed high levels of concentrations of Cd, Pb and Cr in the seafood for human consumption. The general literature survey on lead toxicity indicates that, depending on the dose, lead exposure in children and adults can cause a wide spectrum of health problems, ranging from convulsions, coma, renal failure and death at the high end to subtle effects on metabolism and intelligence at the low end exposures (USATSDR, 1999). In contrast to children, adults are generally more exposed to higher amounts of lead. The health implications of cadmium exposure are exacerbated by the relative inability of human beings to excrete cadmium. Acute high dose exposures can cause severe respiratory irritation. The occupational levels of cadmium exposure prove to be a risk factor for chronic lung disease and testicular degeneration. Lower levels of exposure are mainly concerned with respect to toxicity of the kidney (Satarug et al., 2000).

In conclusion, the study emphasizes that some metal levels are higher than the acceptable values for human consumption of seafood set by various health organizations. The results showed that the findings are above the permissible limit set by

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\]

| Table 1 |
| --- |
| Physicochemical parameters of water samples. |
| S. No | Parameters | Values |
| 1 | Temperature | 29.7 °C |
| 2 | pH | 7.6 |
| 3 | TDS | 369 mg/l |
| 4 | Conductivity | 467 (μmho/cm) |
| 5 | BOD | 37.9 mg/l |
| 6 | COD | 153 mg/l |

BOD: Biological Oxygen Demand, TDS: Total Dissolved Solids, COD: Chemicals Oxygen Demand.
Contamination factor (CF) related to range values. The concentration of heavy metals in water and sediment from Channa punctatus kidney samples compared to the permissible limit set by WHO, 2011.

Table 2

| Sample number | Heavy Metal | Present study Water mg/L Mean ± SD | SE | Permissible limit | Present Study Fish mg/kg Mean ± SD | SE |
|---------------|-------------|-----------------------------------|----|-------------------|-----------------------------------|----|
| 1             | Cd          | 0.051 ± 0.026                     | 0.011 | 0.003             | 0.076 ± 0.208                     | 0.009 | 0.02 |
| 2             | Pb          | 0.019 ± 0.002                     | 0.001 | 0.01              | 0.127 ± 0.705                     | 0.031 | 1.5  |
| 3             | Cr          | 1.091 ± 0.408                     | 0.182 | 1.00              | 0.482 ± 0.059                     | 0.026 | 0.34 |

*: Standard Deviation, Cd: Cadmium, Pb: Lead, Cr: Chromium.

clinging is also an eco-friendly technique used to minimize the usage of the new resources due to reutilization of the by-products. Introducing recycling programs will considerably make a great impact in this direction. Several innovative systems may be initiated and extensive studies would require on unit design and follow up methodologies will pave the way to this emerging problem.

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Conflict of Interest

The authors declare no conflict of interest.

Ethical approval

"All applicable international, national, and/or institutional guidelines for the care and use of animals were followed by the authors."

References

Chapman, D., 1992. Water Quality Assessment. A guide to use of biota, sediments and water in environmental monitoring. Chapman and Hall Publishing, Cambridge.

Dixit, R., Malaviya, D., Pandiyank, K., Singh, U.B., Sahu, A., Shukla, R., Singh, B.P., Rai, J.P., Sharma, P.K., Lade, H., 2015. Bioremediation of heavy metals from soil and aquatic environment: an overview of principles and criteria of fundamental processes. Sustainability 7, 2189–2212.

Idrees, N. et al., 2018. Groundwater contamination with cadmium concentrations in some West U.P. Regions, India, Saudi J. Biol. Sci. 25 (7), 1365–1368. https://doi.org/10.1016/j.sjbs.2018.07.005.

Jezierska, B., Witeska, M., 2006. The metal uptake and accumulation in fish living in polluted waters. In: Twardowska (Ed.), Soil and Water Pollution Monitoring, Protection and Remediation, Springer, pp. 3–23.

Kostigen, T.M., 2008. The world’s largest dump: the great pacific garbage patch. Discover Magazine 10.

Kobayashi, E., Suwazono, Y., Dochi, M., Honda, R., Kido, T., 2009. Estimation of benchmark rice cadmium doses as threshold values for abnormal urinary findings with adjustment for consumption of Jinzu River water. Bull. Environ. Contam. Toxicol. 83, 102–107.

Handa, N., Kohli, S.K., Sharma, A., Thukral, A.K., Bhardwaj, R., Abd, Allah, E.F., Alqarawi, A.A., Ahmad, P., 2019. Selenium modulates dynamics of antioxidative defence expression, photosynthetic attributes and secondary metabolites to mitigate chromium toxicity in Brassica juncea L. plants. Environ. Exp. Bot. 161, 180–192.

Maehara, N., Uchino, E., Terayama, K., Ohno, H., Yamamura, K., 1986. Motor nerve conduction velocity (MCV) and lead content in sciatic nerve of lead-exposed rats. Bull. Environ. Contam. Toxicol. 37, 47–52.

NEERI, 1991. Manual on water and waste water analysis. Nation Environmental Engg. Research Institute, Nagpur.

Onwughara, N., Nnorom, I., Kanno, O., Chukwuma, R., 2010. Disposal methods and heavy metals released from certain electrical and electronic equipment wastes in Nigeria: adoption of environmental sound recycling system. Int. J. Environ. Sci. Dev. 1, 291–292.

Pande, K.S., Sharma, S.D., 1998. Studies of toxic pollutants from plastic waste: a review. Procedia Environ. Sci. 35, 701–708.

Rathi, S., 2006. Alternative approaches for better municipal solid waste management in Mumbai, India. J. Waste Manag. 26, 1192–1200.

Satarupa, S., Haswell-Elkins, M.R., Moore, M.R., 2000. Safe levels of cadmium intake to prevent renal toxicity in human subjects. Br. J. Nutr. 84, 791–802.

Stenmarck, A., Belleza, E.L., Frane, A., Busch, N., Larsen, A., Wahlström, M., 2017. Hazardous substances in plastics. Nordic Council of Ministers, Copenhagen, p. 119.

Topping, G., 1973. Heavy metals from Scottish water. Aquaculture 1, 379–384.

US Agency for Toxic Substances and Disease Registry, 1999. Lead Toxicological profiles. Centers for Disease Control and Prevention, Atlanta. PB/99/166704.

Verma, R., Vinoda, K.S., Papiareddy, M., Gowda, A.N.S., 2016. Toxic pollutants from plastic waste: a review. Procedia Environ. Sci. 35, 701–708.

Zbyszewski, M., Corcoran, P.L., 2011. Distribution and degradation of fresh water plastic particles along the beaches of Lake Huron, Canada. Water Air Soil Pollut. 220 (1), 365–372.

Zhang, Y.M., Huang, D.J., Wang, Y.Q., Liu, J.H., Yu, R.L., Long, J., 2005. Heavy metal accumulation and tissue damage in goldfish Carassius auratus. Bull. Environ. Contam. Toxicol. 75, 1191–1199.