



Original article

Bioaccumulation of heavy metals in *Channa punctatus* (Bloch) in river Ramganga (U.P.), IndiaRobeena Sarah^a, Baby Tabassum^{a,*}, Nida Idrees^a, Abeer Hashem^{b,c}, Elsayed Fathi Abd_Allah^d^aToxicology Laboratory, Department of Zoology, Govt. Raza P.G. College, Rampur 244901, U.P., India^bBotany and Microbiology Department, College of Science, King Saud University, P.O. Box. 2460, Riyadh 11451, Saudi Arabia^cMycology and Plant Disease Survey Department, Plant Pathology Research Institute, Agriculture Research Center, Giza, Egypt^dPlant Production Department, College of Food and Agricultural Sciences, King Saud University, P.O. Box. 2460, Riyadh 11451, Saudi Arabia

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ABSTRACT

Ganga is the largest riverine system of India with a fragile ecosystem. Its prone to anthropogenic disturbances because of its cultural, economic and environmental values. The contamination of river Ganga by heavy metals (HM) is due to biotic (anthropogenic sources) and abiotic (pesticides, fertilizers) sources that poses a devastating health hazard to human, plant and edible fish life. The chemical analysis with the help of atomic absorption spectrometer performed on its water samples demonstrated the accumulation of heavy metals such as Arsenic (As), Lead (Pb), Cadmium (Cd), Iron (Fe), Zinc (Zn). Moreover, the spectrophotometric analysis indicated clearly the accumulation of heavy metals in order of occurrence (Fe > As > Cd > Zn > Pb) in liver and (Zn > Fe > As > Cd > Pb) in kidney of edible fish *Channa punctatus*. The present study has been used to sensitively monitor the extent of heavy metals pollution in the biotic aqua life of river Ramganga system and its suggested that the bioaccumulation of heavy metal in *Channa punctatus* has reached above permissible limits for human consumption, indicating potential health risks. Necessary biological steps should be taken to handle such food pollution and prevent the environmental risk and food chain disruption.

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1. Introduction

Water is essential for all forms of life. Clean, clear & odorless freshwater used for drinking and other domestic purposes is the gift from the nature. From the entire water reserve of the earth, approximately 97% of water consists of seas and oceans while as freshwater resources contribute only 3% of water (Shrestha et al., 2017). from the earth's freshwater which is locked up in glaciers and ice caps on poles, 30.1% is groundwater (Adhikari and Mal, 2019). In India, the major source of water used for drinking purposes and domestic needs is the Groundwater. Life cannot be sustained more than few days without water, while an inadequate supply of water may change the pattern of distribution of organ-

isms as well as of human beings. But due to anthropogenic activities, the water necessary for our survival is becoming hazardous every day (Rao et al., 2018).

Ganga is the well-developed largest riverine system of India and the fifth longest in the world (Mukherjee and Pal, 2018; Sahu et al., 2018). It has several important cultural, economical and environmental values and provides water for approximately to 450 million people. Moreover, Ganga River is being used for fishing and aquaculture Gupta et al., 2018). Fishes in addition to its important source of protein have rich contents of essential minerals, vitamins and unsaturated fatty acids (Medeiros et al., 2012). They can normally accumulate heavy metals from food, water and sediments as they are situated at the top of aquatic food chain (Afshan et al., 2014). Due to rapid industrialization, this river is being continuously degrading due to direct discharge of industrial wastes, agricultural run-off and anthropogenic activity along the river bank (Jani et al., 2018). These wastes contain health hazard chemicals like salts of chromium, copper, cadmium, arsenic, mercury and lead which interact with aquatic environment and affect the river ecosystem (Usmani and Kumar, 2017; Singh et al., 2017; 2018). Heavy metals containing pollutants besides poses serious water pollution problem due to their toxicity, persistence and

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bioaccumulation, also accumulate in tissues of plants and animals leading to toxicity in aquatic biota (Chopra et al., 2011; Pandey et al., 2014). Fishes and humans being the top consumers in aquatic ecosystem and food chain are badly affected through the accumulation of these heavy metals (Afshan et al., 2014). Heavy metals are the metallic elements which are dense and heavy and are present in trace amounts (Singh et al., 2018). Heavy metals lead to alteration in physical, chemical & biological properties of water bodies (Gupta et al., 2016; Ahmad et al., 2019) as well as that of its ecosystem (Dudani et al., 2017; Sharma, 2019). Heavy metals thus discharged from the source, leach into underground waters, deposits in the aquifer, or are washed away by run-off into surface waters. Industrial wastes containing heavy metals on entering aquatic environment causes biochemical disturbances in the fish (Ansah et al., 2019; Varol and Sünbül, 2019).

The concentrations of heavy metals in aquatic environment and its organisms have been of considerable interest to understand because of their toxic effects (Wani et al., 2017; Satapathy and Panda, 2018). Over the last few decades, there has been growing interest in determining heavy metal concentration in the aquatic environment and its measurement of contamination levels in public food supplies, especially fishes (Velusamy et al., 2014; Fatima et al., 2015; Arulkumar et al., 2017; Pal and Maiti, 2018; Kumari et al., 2018).

The aim of this study was to evaluate the concentrations of heavy metals i.e. Fe, Zn, Cd and Pb in surface water of river Ramganga as well as groundwater of nearby regions and its influence on the tissues of inhabiting fresh water teleost fish, *Channa punctatus*. Further, their hazardous levels were compared with available certified safety guidelines proposed by World Health Organization (WHO) and Food and Agricultural Organization (FAO) for human consumption. *C. punctatus* was selected in this experiment for bio-monitoring the concentration of heavy metals in this region because of its hardy nature, high nutritional value and its round the year availability.

2. Material and methods

2.1. Description of study area

The study area was River Ramganga located in district Moradabad, Uttar Pradesh, India (Figs. 1A–B). The study was conducting at five different locations of the river and the nearby regions as

described clearly in Fig. 1. The selection was based on the severe anthropogenic activities like brass industries which is continuously discharging their effluents into the river and waste scrapping and illegal cremation of the dead bodies by the local people of Katghar, Jama Masjid and its nearby regions. Such activities have increased the concentration of heavy metals in the surface water as well as groundwater. These areas also received the domestic waste water of adjacent communities living therein..

2.2. Collection of samples

Water samples (five per each location) were collected in the month of September and October (2017) from the river and the nearby regions. One liter sterilized bottles were used to collect water samples for heavy metal analysis. The six-medium sized fresh water fish, (*Channa punctatus*) samples (five for each location) were collected with the help of local fisherman from the affected regions.

2.3. Sample preparation for heavy metal analysis

Water samples collected were filtered and acidified with Nitric acid and stored for heavy metal analysis. These six medium sized fish samples were sacrificed and the main target organ was removed. Fish tissue samples were dried at 105 °C and powdered using porcelain pestle and a mortar. Weighted amount of dried tissues was digested with a mixture of nitric acid and perchloric acid in the ratio of 3:1. Digested samples were then filtered with Whatman filter paper and made up to 25.0 ml with metal free double distilled water (Tabassum et al., 2016). The metals in fish and water samples were analyzed using Atomic Absorption Spectrometer and results are expressed in µg/g (for tissue samples) and mg/L (for water samples).

2.4. Statistical analysis

Statistical analysis of the five-sampled data was done analysis variance (ANOVA) using a statistical package, SPSS 22.0 (IBM Corporation, Chicago, IL, USA). The significance of the results was ascertained at $P < 0.05$.



Fig. 1A. Google map showing the locations of sampling areas.



Fig. 1B. Area near river Ramganga in Moradabad (UP), India.

3. Results

3.1. Heavy metals in water

The heavy metals detected in water were in the decreasing order Fe > Zn > Pb > As > Cd. The values of Fe, As, Cd and Pb detected was more than the maximum permissible limit when compared with the National and International Organizations like B.I.S and W.H.O respectively while that of Zn was under the permissible limit. Hence, water is not suitable for fish and human consumption. Results shown in Table 1 depicts the range, mean and standard deviation of heavy metal content in water whereas Table 2 shows the comparison of obtained values of water samples with W.H.O. and B.I.S. values (Fig. 2).

3.2. Bioaccumulation Factor (BAF)

Bioaccumulation Factor (BAF) is calculated as the ratio of concentration of a pollutant (heavy metal) accumulated in the tissue of an organism with respect to the concentration of that pollutant i.e. heavy metal in water body (Authman and Abbas, 2007). The order of bioaccumulation in fish liver was Fe > As > Cd > Zn > Pb while that in kidney Zn > Fe > As > Cd > Pb (Table 3). The values observed during the present study when compared with the recommended values for heavy metals i.e. Fe, Zn and Pb were found to be under the Maximum Permissible Limit (MPL) of WHO (1985) and FEPA (1991) while that of Cadmium is found to be 0.2 mg/kg and Arsenic is above 0.26 mg/kg recommended maximum permissible limit (Fig. 3). Hence, the results suggested that Arsenic and Cadmium has been accumulating in the tissues of fish inhabiting river Ramganga.

Table 1
Bioaccumulation of Heavy metals content (ug/L) in Water samples where.

Heavy Metals (ug/ L)	Range	Mean ± S.D.	S.E.
Fe	2.04	1.707 ± 0.74	0.33
Cd	0.14	0.101 ± 0.05	0.02
Pb	0.89	0.613 ± 0.33	0.19
Zn	2.49	1.384 ± 0.82	0.36
As	0.13	0.111 ± 0.06	0.04
LSD at 0.05	0.04	0.17	

Fe, Iron; Cd, Cadmium; Ph, Lead; Zn, Zinc; As, Arsenic; SD: Standard Deviation; S.E: Standard Error.

Table 2

Comparison of obtained values with Max. Permissible limit of W.H.O. and B.I.S.

Heavy Metals	Permissible limit of heavy metals (mg/L)		
	Conc. In water	W.H.O. limit	B.I.S. limit
Fe	1.707	0.3	1
Cd	0.101	0.003	0.01
Pb	0.408	0.01	0.05
Zn	1.384	3	5
As	0.111	0.01	0.05
LSD at 0.05	0.05	0.01	0.02

Fe, Iron; Cd, Cadmium; Ph, Lead; Zn, Zinc; As, Arsenic; W.H.O, World Health Organization; B.I.S., Bureau of Indian Standard.

4. Discussion

Presence of heavy metals in the environment can cause serious problems to all organisms and its bioaccumulation in the food chain can be highly dangerous to human health (Devi and Yadav, 2018; Adimalla and Wang, 2018; Ahmed et al., 2019). It can also possible that environmental toxicants may increase the susceptibility of aquatic animals to various diseases by interfering with the normal functioning of their immune, reproductive and developmental processes (Rezvanfar et al., 2016; Sang et al., 2018). Concentration of heavy metals in different tissues/organs of fishes is directly influenced by contamination in aquatic environment, its up-take, regulation and elimination inside the fish body (Yang et al., 2016; Brraich and Kaur, 2017). Fish have ability to concentrate metals in their muscles (Zhaoa et al., 2018; Juncos et al., 2019) and as they are a part of human nutrition. They need to be carefully screened to ensure unnecessary high level of these toxic trace metals which were transferred to man through its consumption (Sang et al., 2018). The content of these toxic heavy metals can counteract their beneficial effects and can lead to several adverse effects to human health (Castro-González and Méndez-Armenta, 2008). A known biological function indicates that Cadmium does not break down in the environment, remain in fish body for long periods of time and can bio-accumulate for many years after its exposure to low levels (Wang et al., 2018; Markowicz et al., 2019). Kwaansa-Ansah et al., (2019), proved that the fish liver is the target organ for Fe. Respiratory disruption due to physical clogging of the gills is suggested as a possible mechanism for iron toxicity (Wani et al., 2017).

Aquatic organisms have tendency to accumulate lead from water and diet, although there is evidence that origin of lead accumulation in fish, is most probably from contaminated water rather

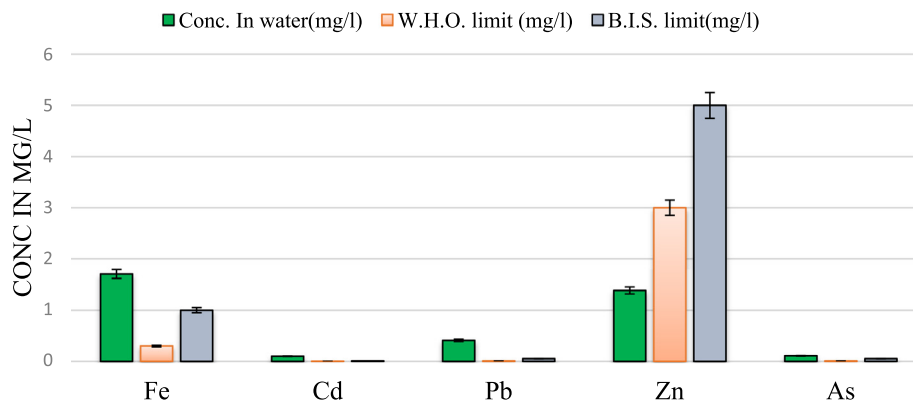


Fig. 2. Comparison of obtained values of heavy metals with max. permissible limit of W.H.O. (2011) and B.I.S. Fe, Iron; Cd, Cadmium; Ph, Lead; Zn, Zinc; As, Arsenic.

Table 3
Bioaccumulation Factor (BAF) of heavy metals in *C. punctatus* tissue samples.

Tissues	Bioaccumulation Factor (BAF) of heavy metals (ug/g)				
	Fe	Cd	Pb	Zn	As
Liver	2.087	0.514	0.075	0.427	0.590
Kidney	0.987	0.336	0.299	1.392	0.747
LSD at 0.05	0.46	0.07	0.03	0.24	0.08

Fe, Iron; Cd, Cadmium; Ph, Lead; Zn, Zinc; As, Arsenic.

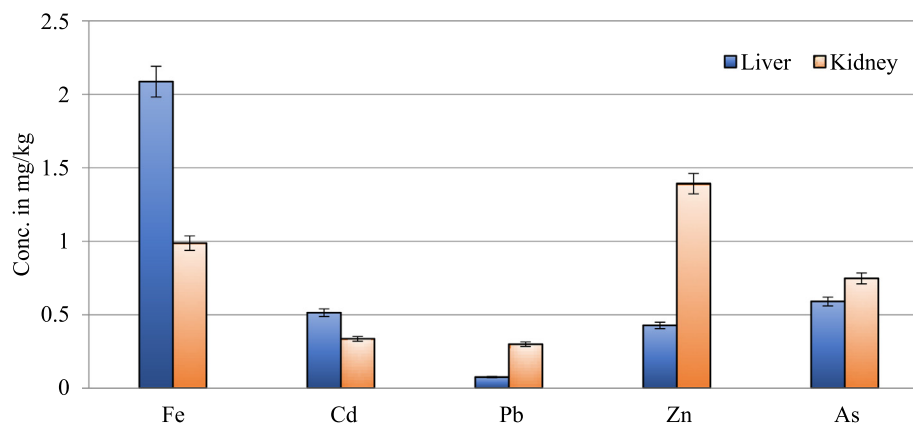


Fig. 3. Bioaccumulation factor of heavy metals in liver and kidney of *C. punctatus*. Values are expressed in mg/kg.

than that of diet (Velusamy et al., 2014; Dudani et al., 2017; Ahmed et al., 2019).

The aquatic ecosystem is contaminated by arsenicals and their effect on the aquatic organisms has now emerged as a serious threat to environment (Chopra et al., 2011; Gupta et al., 2016; Dudani et al., 2017). Aquatic ecosystem is too complex and hence indicators are useful for its effective bio-monitoring. The environmental monitoring programmes were evolved to measure impact of stress inducers on aquatic fauna (Chopra et al., 2011). Fish is a useful bio-indicator for the determination of heavy metal pollution in aquatic ecosystems Al Sayegh Petkovšek et al., 2011). Pal et al. (2014) and Punetha et al. (2015) found that Moradabad district also had high concentrations of Cd in its water samples because these areas are densely populated, industrialized and are hubs of electronic industries, so the possibility of Cadmium accumulation is high in this region.

5. Conclusion

The purpose of this investigation is to detect the concentration of heavy metals i.e. Fe, Cd, As, Pb and Zn in river Ramganga

of district Moradabad, Uttar Pradesh (India). Results showed that the river is highly contaminated with heavy metals accumulated in water as well as fish. The values of Fe, As, Cd and Pb detected was more than the maximum permissible limit when compared with the National and International Organizations like B.I.S and W.H.O respectively while that of Zn is under the permissible limit. As we know that Moradabad is a famous city for its brass work. The cause of such accumulation is mainly due to illegal dumping of wastes from various small-scale industries, scraping and illegal burning of wastes near the banks of the river. Hence, water is not suitable for fish and human consumption. On the other hand, Fe, Zn and Pb were found to be under the Maximum Permissible Limit (MPL) of WHO (1985) and FEPA (1991) in fish tissue samples while that of Cd and As is above the MPL range. Therefore, results suggested that Cadmium and Arsenic is accumulating in the tissues of fish through contaminated river water and thus, it might be transferring via food chain to humans. So it is necessary to monitor the quality of water at regular intervals and more research work is needed to find suitable eco-friendly and cheaper antagonist of heavy metal pollution.

Conflict of interest

The authors declare that they have 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.”

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