Biological Forum – An International Journal **15(3): 645-654(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Seasonal Variation in the Levels of Heavy Metals in Surface Water of River Basantar and various Tissues of *Barilius vagra,* J&K

Sapana Jangral[1]*, Monika Sharma[1], Kunal Sharma[1], Anita Sharma[2] and Roopma Gandotra[3]
[1]Ph.D. Research Scholar, Department of Zoology, University of Jammu, (J&K), India.
[2]Assistant Professor, Department of Zoology, GDC Boys, Udhampur (J&K), India.
[3]Professor, Department of Zoology, University of Jammu (J&K), India.

(Corresponding author: Sapana Jangral)*
(Received: 23 January 2023; Revised: 21 February 2023; Accepted: 24 February 2023; Published: 22 March 2023)
(Published by Research Trend)

ABSTRACT: The present study was conducted to evaluate the concentration of heavy metals (in ppm) of Cu, Zn, Fe, and Pb in water samples and various tissues (muscle, gonads, gills, and intestine) of *Barilius vagra* collected from the river Basantar, Samba, India. The declining trend of Fe>Zn>Cu>Pb was seen in the average concentration of the examined metals in surface water. The findings indicated that Fe was accumulated most and Pb least in river water. The trend of accumulation of zinc in different tissues of fish was found to be gonads>intestine>muscle>gills. The distribution of copper in different tissues of *B. vagra* followed the order: intestinal >gonads> muscle >gills. The trend of distribution of iron in different tissues was intestine>gills>muscle>gonads. The order of accumulation of metals in different tissues emerged as intestinal>gills>gonads>muscle. Further, the order of accumulation of different metals was observed to be Fe>Zn>Cu>Pb in muscle, gonads, and intestine, while in gill tissue it followed the order Fe>Zn>Pb>Cu. The order of accumulation of studied metals might be a result of the fact that different metals tend to accumulate differently in tissues according to their active role in physiological processes. Although the bioaccumulation of heavy metals at the experimental sites did not exceed the acceptable limits recommended by agencies such as FAO and WHO. The present results showed an increasing trend of accumulation during the second year of study, which unquestionably poses a serious threat to the aquatic organism's ability to survive in the study area. The situation will worsen and may result in the loss of the valuable fish diversity if timely remedial measures are not taken. Therefore, industrial discharges should be cleaned before entering the river, and fish fauna should be regularly inspected to resolve this serious issue.

Keywords: *Barilius vagra*, Heavy metals, Bioaccumulation, Pollution.

INTRODUCTION

Rivers are the important components of the Earth's dynamic processes and are essential to the economy and human health. Rivers often provide water for agriculture, transportation, sanitation, drinking, electricity generation and recreation, and are habitat for a wide variety of animals and plants. Life cannot survive for more than a few days without water, while inadequate water supplies can alter the distribution patterns of organisms as well as humans. But because of human activities, the water necessary for our survival become dangerous every day (Rao *et al.*, 2018).

Moreover, during the past several decades, due to urbanization, industrialization, increase in the use of the metal industry has resulted in heavy metal contamination of local water bodies. Metal pollution may damage the aquatic fauna at the cellular level and possibly affects ecological balance. Exposure and ingestion of polluted aquatic products such as fish can cause health problems in humans and animals including reproductive and neurological problems.

Heavy metals can be easily converted by bacteria into more toxic organic forms, some of which can be harmful to humans and aquatic organisms (Xu *et al.*, 2016; Zhao *et al.*, 2016; Sharma *et al.*, 2021). Heavy metal pollution can cause serious health problems for humans such as kidney failure, cardiovascsular disease, and liver damage (Rahman *et al.*, 2012; Kin *et al.*, 2019; Sharma *et al.*, 2021, Manzoor and Kaware 2022). Heavy metals bioaccumulation in fresh water fishes depends upon various factors such as characteristics and environmental factors. Heavy metals have acquired the soft and hard tissues of the fish via the process of bioaccumulation and the degree of bioaccumulation in various fish tissues mainly depends on the tissue activity. The accumulation of heavy metals in fish is used as a bioindicators to detect the concentration of heavy metals in aquatic bodies. These metals are transported from fish to their predators in the food chain (Gupta *et al.*, 2009; Valkova *et al.*, 2022).

Heavy metal pollution is caused by wastewater from large and small industries, automotive waste, and surface runoff from neighbouring areas (Fatima and

Usmani 2013). Further, heavy metal pollution in aquatic systems has attracted worldwide attention due to their toxicity, persistence, and bioaccumulation in the food chain, which can pose a threat to organisms and entire ecosystems (Kumar *et al.,* 2015; Kumar *et al.*, 2017; Ali *et al.*, 2019; Kumar *et al.*, 2020). In water bodies, metals can be found in dissolved and suspended form and their level in surface water depends on some physicochemical parameters such as pH, redox potential, temperature, DO, salinity, conductivity (Hassan *et al.* 2015; Sim *et al.* 2016; Farsani *et al.*, 2019; Kumar *et al.*, 2020).

The Basantar River is an important lifeline for the city of Samba and the surrounding area, serving as a source of drinking water for Samba residents and a source of local fish but due to increasing pollution day by day, its condition is deteriorating due to addition of dumping of agricultural wastes, municipal wastes, untreated sewage, etc. So, the present study was carried out to investigate the heavy metal concentration *viz.* Copper (Cu), Zinc (Zn), Iron (Fe), and Lead (Pb) in surface water of river Basantar and bioaccumulation in different tissues *viz*., Muscle, gonads, gills, and intestine of indigenous fish, *Barilius vagra* for the period of two years (2015-2017).

MATERIAL AND METHODS

A. For water sample

A water sample was taken in 1L polyethylene bottles from selected stations and brought to the laboratory and concentrated HNO_3 was added to the sample in order to make pH -2.0, so that no microbial growth takes place and also prevent water from any degradation (APHA, 1998). The samples were finally kept in refrigerator (4°C) prior to analysis through AAS model no. Shimadzu AA7000. No digestion of water sample was performed.

B. For fish sample

Sample collection and preparation. Fish samples were caught through a cast net with the help of a fisherman from the selected station and brought to the laboratory for tissue (muscle, gonads, gills and intestine) analysis. Dried muscle and gonads ground into a fine powder with a mortar and pestle, then weighed. The gills and intestine were converted into ash by keeping them in a muffle furnace at 450°C for 6 hours. All the samples were then stored in a Teflon vessel and kept at – 4°C temperature prior to analysis.

Sample analysis. Before analysis through AAS, the tissue samples (in triplicates) were acid digested. The digestion was done as described by Bat *et al.* (2012); Ashraf *et al.* (2012) with some modifications. To 1gm of each powder sample, 8ml of concentrated HNO_3 (Grade 69%) was added and kept on a hot plate with a magnetic stirrer until a clear solution is obtained. The solution was then filtered using whatmann filter paper no. 41 in a volumetric flask and dilute to 25 ml.

C. Statistical analysis

Microsoft Excel 2007 and SPSS software program have been used for statistical analysis.

RESULTS AND DISCUSSIONS

A. Heavy metals in water and fish tissues

Perusal of Table 1, 2 & Fig. 1, 2, depicted the seasonal variation in the mean concentration of heavy metals in the surface water of river Basantar (near Chichi Mata Temple) and the results showed that the average maximum concentrations of heavy metals were observed during the pre-monsoon period while the minimum values were observed during the winter. The average concentration of studied metals in surface water followed the decreasing trend of Fe>Zn>Cu>Pb. The results also indicated that Pb was least deposited in the river while Fe was most accumulated. The findings also indicate that in 2016–2017, there was a greater build-up of heavy metals in the water than in 2015–16.

Also, in this study (Tables 3 and 4), the average bioaccumulation capacity of heavy metals (Zn, Cu, Fe and Pb) in muscle tissue was found to be 0.412±0.11ppm, 0.059±0.01 ppm, 1.269±0.14 ppm, 0.037±0.01 ppm for the year 2015-16 and was observed to be 0.443±0.07 ppm, 0.0457±0.01 ppm, 1.497±0.26 ppm and 0.065±0.01 ppm respectively for the year 2016-17. In addition, average bioaccumulation of heavy metals (Zn, Cu, Fe and Pb) in gonads was observed to be 0.527±0.08 ppm, 0.076±0.03 ppm, 1.094±0.50 ppm, 0.0451±0.01 ppm for the year 2015-16 and for 2016-2017 it was 0.663±0.16 ppm, 0.078±0.01 ppm, 1.473±0.40 ppm and 0.063±0.01 ppm, respectively.

Also, the average bioaccumulation of heavy metals (Zn, Cu, Fe and Pb) in gills was found to be 0.249±0.06 ppm, 0.046±0.01 ppm, 1.463±0.35 ppm, 0.048±0.01 ppm respectively for 2015-16 and 0.445±0.05 ppm, 0.080±0.01 ppm, 1.535±0.45 ppm, 0.069±0.01 ppm respectively for the second year i.e. 2016-17. Further, mean bioaccumulation of heavy metals (Zn, Cu, Fe and Pb) in the intestine was 0.448±0.05 ppm, 0.084±0.01 ppm, 4.839±1.34 ppm, 0.056±0.01 ppm for the first year of study i.e. 2015-16 and 0.494±0.07 ppm, 0.096±0.02 ppm, 7.236±2.01 ppm, 0.083±0.01 ppm respectively for the second year i.e. 2016-17.

Seasonally all the metals showed high accumulation during pre-monsoon seasons in all the tissues of *B. vagra* for both the study years with some exceptions that iron showed maximum concentration during post-monsoon in muscle tissue and during monsoon in gonads and gills of *B. vagra*. The trend of accumulation of zinc was found to be gonads>intestine>muscle>gills. The distribution of copper in different tissue of *B. vagra* followed the order Intestine>gonads>Muscle>gills. The trend of distribution of iron in different tissue was emerged as intestine>gills>muscle>gonads. The order of Pb accumulation was emerged as Intestine>gills>gonads>muscle. In addition, the order of accumulation of different metals was observed to be Fe>Zn>Cu>Pb in muscle, gonads, and intestine while in gill tissue it followed the order Fe>Zn>Pb>Cu. Also, the results revealed that the concentration of heavy metals were higher during the second year of the study i.e. 2016-17 than 2015-16 (Fig. 3) due to an increase in pollution day by day.

The order of accumulation of the studied metals may be due to the fact that different metals accumulate differently in tissues according to their active role in physiological processes. It may also be related to swimming, feeding habit, and metabolic activity of the individual and species. The concentration of Fe was found higher than other elements in all the tissues, however it did not exceed the limit prescribed by WHO as given in Table 5.

In this study, the highest heavy metal concentrations were observed in water samples in the pre-monsoon season. The increased heavy metal concentrations in the pre-monsoon season may be due to increased heavy metal leaching from sediments to surface waters due to exposure to high temperatures. Additionally, it is brought on by varying quantities released into water bodies by households, and industrial wastewater. Ellahi and Hossain (2011); Zhao *et al.*, (2016); Bhuyan and Bakar (2017); Jitesh and Radhakrishnan (2017); Sharma *et al.* (2021) provided comparable results. Also, in the present study zinc and iron showed high concentrations in water samples as compared to copper and lead. Zinc is a naturally occurring element present as a common contaminant in agricultural and food waste, pesticide production, and antifouling paints (Badr *et al.*, 2009). Zinc is released into rivers in the form of effluents from galvanic production, wastewater discharges and flooding of coloured idols. Zinc toxicity causes vomiting, diarrhoea, and liver and kidney damage (Boxall *et al*., 2000; Gautam *et al*., 2015). Iron enters into water from natural geological resources, industrial waste, and domestic sewage. Excess iron can cause blood clots in blood vessels, drowsiness and high blood pressure. Zinc and iron are slightly higher than other elements in fish organs as they are essential metals in living tissues (Traina *et al.*, 2019). Lead discharge from various industries, agricultural fields, street runoff, lead dust and municipal wastewater that directly come to the aquatic environment and cause toxicity for the aquatic life (Sepe *et al*., 2003; Garai *et al.*, 2021). High levels of Pb causes cognitive impairment and developmental delay in children (Kaur, 2012; Malik *et al*., 2014).

The solubility of lead in water is depending upon pH, salinity, hardness etc. Also, the effects of lead might be attributed to its ability to generate reactive toxic action oxygen species. Lead induces oxidative damage in multiple tissues by promoting lipid peroxidation, which readily occurs in tissues due to the presence of polyunsaturated fatty acid-rich membranes (Mahmuda *et al.*, 2020; Yacoub *et al.*, 2021; Simukoko *et al.*, 2022). Sources of copper in water bodies can include copper smelting, ore processing, and windblown dust, which commonly cause headache, nausea, vomiting, diarrhoea, and kidney damage (Gautam *et al.*, 2015). High levels of copper during pre-monsoon may be attributed to intensified usage of pesticides in the nearby cultivation lands or might be high precipitation in pre-monsoon and presence of decaying organic matter. Similar observations were made by Ahmed *et al.* (2013) and Prem Nawaz *et al.* (2017).

Such studies have been conducted by several researchers *viz.*, Gulfraz *et al.*, 2001; Paliwal *et al.*, 2007; Malik *et al.*, 2014; Mohamed *et al.*, 2014; Ahmed *et al.*, 2015; Singh *et al.*, 2019; Mishra *et al.*, 2020 in order to determine heavy metal content in river water to evaluate the water quality. Fish are considered the standard organism for determining bioaccumulation and exposure to heavy metal contamination. So far, the bioaccumulation of heavy metals in various fish tissues has been evaluated by several researchers (Mohamed 2000; Subartha and Karuppasamy 2008; Javed and Usmani 2011; Malik *et al.*, 2014; Shaikh 2014; Noor and Zutshi 2016; Jia *et al.*, 2017; Mubarakh and Ali 2020; Kumar *et al*., 2020; Sharma *et al*., 2021).

It is generally assumed that the metal is absorbed in an ionic form and is affected by various environmental factors such as pH and temperature (Ibrahim and Omar, 2013). In addition, in the present study, increased bioaccumulation of heavy metals in fish tissues was reported during the pre-monsoon period due to the increase in temperature due to the depletion of dissolved oxygen, energy demand and the increased amount leads to an increase in the rate of respiration in the fish body, leading to rapid assimilation of waste (Salem *et al*., 2014). In addition, the increase in water temperature during the pre-monsoon period increases the metabolic rate and predation activity of the fish, leading to increased uptake and accumulation of metals in tissues (Obasohan, 2008). Such seasonal trends in tissue bioaccumulation of heavy metals were supported by the findings of Khaled (2004); Bahnasawy *et al.* (2009), Bahnasawy and Khidr (2011) and Ibrahim and Omar (2013). Also, the concentration of all metals in different tissues (muscle, gonads, gills, and intestine) of *Barilius vagra* was found to be increased during the second year irrespective of the first year of study, thus revealing that pollution is increasing day by day and this is all due to our ignorance towards the disposal of all wastewater from industries, domestic, religious anthropogenic and agriculture that will ultimately impact aquatic life and human beings directly and indirectly.

Heavy metal concentrations in water samples and different fish tissues (*Barilius vagra*) were compared with the maximum allowable limit (MPL) for human consumption set by different organizations (US EPA 1976, FAO) 1983, WHO 1984, 2008/2011). The results showed that heavy metal concentrations in the water samples and various fish tissues were found to be satisfactorily below the standard limit, except that the concentration of iron (Fe) in the water samples was shown to be high compared to the standard limits suggested by WHO 2008/2011 and FAO 1983.

B. Statistical analysis of heavy metals in fish tissues and surface water

The Pearson correlation matrix in Tables 6 and 7 illustrates the relationship between heavy metals in water and heavy metals in edible fish tissue. A strong positive correlation was found between Int. Fe, Int. Cu with WFe ($r=0.999$, 0.991 resp. $p<0.01$) and also Go Pb and Gi Zn with WCu ($r=0.998$, 0.993 resp. $p<0.01$

resp.). Also, strong positive correlation was found between GiFe with WZn (r= 0.998, p<0.01) and between MFe with WFe (r= 0.996, p<0.01). Pearson's correlation matrix between heavy metals in water and fish tissue shows that most metals are positively correlated with each other showing that the concentration of metals in an organism depends upon the concentration in its environment surrounding them.

C. Bioaccumulation Factor

To study ecological risk assessment, the bioaccumulation factor (BAF) is studied to know the concentration of heavy metals transferred from aquatic organisms from the surrounding aquatic environment. The average concentrations of metals in water and fish viscera were used to determine BAF, the results of which are shown in Fig. 4. Bioconcentration is the accumulation of contaminants by aquatic organisms through non-dietary routes of absorption, i.e. from the dissolved phase.

The concentration of heavy metals in fish is directly proportional to the removal of waste from the water. The accumulation of heavy metals by fish depends on ecological needs, metabolic processes and other factors such as water, feed and sediment pollution. If the values of BCF found to be greater than 1000, it is indicated that metals are highly bioaccumulated and biomagnified (Suheryanto and Ismarti 2018). According to Potipat *et al.* (2015), heavy metal BAFs are classified as BAF>1000, very high, BAF 100-1000, high, BAF 30-100, moderate, and BAF<30, low. Therefore, in this study, all heavy metal BAFs were less than 1000 (BAF<1000) according to the category, indicating no possibility.

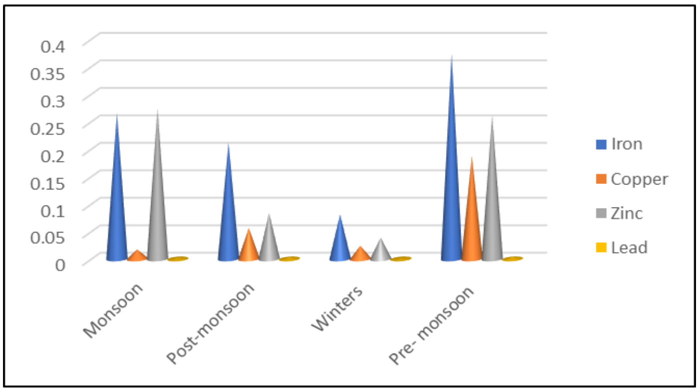

Fig. 1. Graphical representation of seasonal variation in heavy metal concentration (ppm) in water sample (June 015 to May 2016).

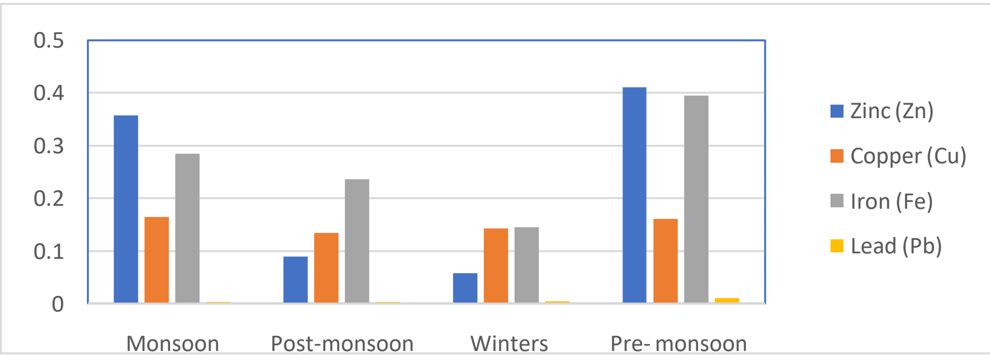

Fig. 2. Graphical representation of seasonal variation in heavy metal concentration (ppm) in water sample (June 2016 to May 2017).

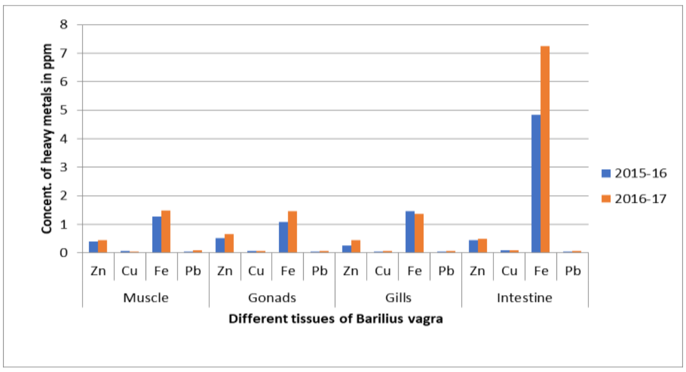

Fig. 3. Comparative seasonal variation in bioaccumulation of metals (ppm) in *Barilius vagra* (June 2015 - May 2017).

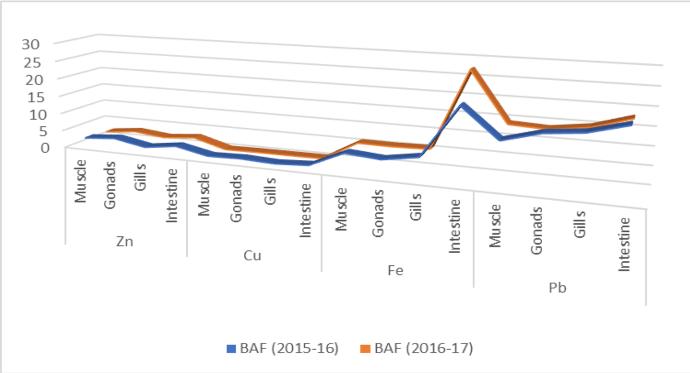

Fig. 4. Bioaccumulation factor (BAF).

Table 1: Seasonal variation in heavy metal concentration (ppm) in water (June 2015 to May 2016).

Metals	Basantar (2015-16)			
	Monsoon	Post-monsoon	Winters	Pre- monsoon
Zinc (Zn)	0.2741±0.25	0.0838±0.01	0.0389±0.01	0.2623±0.09
Copper (Cu)	0.0173±0.06	0.0566±0.02	0.0240±0.01	0.1880±0.27
Iron (Fe)	0.2652±0.18	0.2117±0.01	0.0813±0.02	0.3739±0.11
Lead (Pb)	0.0027±0.18	0.0033±0.01	0.0023±0.01	0.0037±0.02

Table 2: Seasonal variation in heavy metal concentration (ppm) in water sample (June 2016 to May 2017).

Metals	Basantar (2016- 2017)			
	Monsoon	Post-monsoon	Winters	Pre- monsoon
Zinc (Zn)	0.3565±0.088	0.0881±0.014	0.0569±0.021	0.4099±0.194
Copper (Cu)	0.1635±0.084	0.1338±0.050	0.1419±0.011	0.1602±0.182
Iron (Fe)	0.2835±0.014	0.2360±0.027	0.1441±0.052	0.3939±0.091
Lead (Pb)	0.0030±0.001	0.0027±0.001	0.0035±0.001	0.0093±0.001

Table 3: Seasonal variation in bioaccumulation of metals (ppm) in *Barilius vagra* (June 2015-May 2016).

		Barilius vagra (2015-16)			
Tissues	Metal	Monsoon	Post- Monsoon	Winters	Pre-monsoon
Muscle	Zn	0.2917±0.21	0.4696±0.04	0.3376±0.03	0.5471±0.11
	Cu	0.0591±0.03	0.0590±0.01	0.0448±0.01	0.0767±0.02
	Fe	1.0959±0.24	1.4066±0.26	1.22±0.56	1.3545±0.09
	Pb	0.0345±0.02	0.0392±0.01	0.0207±0.02	0.0548±0.01
Gonads	Zn	0.409±0.13	0.5699±0.13	0.5187±0.32	0.6100±0.06
	Cu	0.0666±0.02	0.0704±0.01	0.0486±0.01	0.119±0.04
	Fe	1.6098±0.33	0.6148±0.19	0.7129±0.33	1.4398±0.17
	Pb	0.0385±0.01	0.0424±0.01	0.0394±0.01	0.0604±0.01
Gills	Zn	0.2002±0.09	0.2479±0.06	0.2012±0.05	0.3481±0.16
	Cu	0.0475±0.20	0.0540±0.01	0.0252±0.02	0.0560±0.36
	Fe	1.7121±0.05	1.5938±0.056	0.9354±0.06	1.6126±0.48
	Pb	0.0426±0.02	0.0472±0.01	0.0467±0.01	0.0569±0.01
Intestine	Zn	0.3948±0.09	0.4583±0.03	0.4279±0.06	0.5119±0.08
	Cu	0.0859±0.01	0.0829±0.01	0.0767±0.01	0.0921±0.46
	Fe	5.2149±1.739	4.3411±0.511	3.3221±0.86	6.4814±1.78
	Pb	0.0424±0.02	0.0587±0.01	0.0438±0.01	0.0775±0.01

Table 4: Seasonal variation in bioaccumulation of metals (ppm) in *Barilius vagra* (June 2016-May 2017).

		Barilius vagra (2016-17)			
Tissues	Metal	Monsoon	Post- Monsoon	Winters	Pre-monsoon
Muscle	Zn	0.3845±0.16	0.437±0.03	0.3930±0.07	0.5563±0.05
	Cu	0.0369±0.01	0.0402±0.01	0.0379±0.01	0.0679±0.01
	Fe	1.5222±0.17	1.4593±0.18	1.1839±0.61	1.8236±0.28
	Pb	0.0639±.004	0.0666±0.01	0.0482±0.01	0.0835±0.01
Gonads	Zn	0.4575±0.11	0.6512±0.07	0.6995±0.01	0.8445±0.04
	Cu	0.0806±0.45	0.0849±0.01	0.0617±0.01	0.0861±0.04
	Fe	1.6922±0.15	1.5938±0.056	0.8714±0.08	1.7344±0.092
	Pb	0.0577±0.03	0.0639±0.01	0.0507±0.01	0.0795±0.03
Gills	Zn	0.3956±0.29	0.4703±0.035	0.4176±0.02	0.4991±0.12
	Cu	0.0819±0.01	0.0770±0.01	0.0722±0.01	0.0921±0.078
	Fe	1.7292±0.32	1.6562±0.24	0.9812±0.02	1.7756±0.35
	Pb	0.0611±0.01	0.0661±0.01	0.0555±0.01	0.0936±0.11
Intestine	Zn	0.4369±0.25	0.5111±0.08	0.4415±0.02	0.5865±0.11
	Cu	0.0838±0.01	0.0840±0.01	0.0806±0.01	0.1357±0.054
	Fe	8.1947±0.51	8.4486±0.41	4.2317±0.31	8.0697±2.14
	Pb	0.0796±0.03	0.0779±0.03	0.0754±0.01	0.0992±0.01

Table 5: Desirable limits of heavy metals concentration (ppm) in water and fish.

Heavy metal	Water (ppm)		Fish (ppm)
	BIS (2012)	BIS (2012) WHO (2008)	FAO/WHO (1984,1989)
Zinc	5.0	3.0	40
Copper	0.05	1.2	30
Iron	0.3	0.3	30
Lead	0.01	0.01	30

Table 6: Correlations of heavy metals in water and different tissues of *Barilius vagra* at station II during (June 2015-May 2016).

	W Fe	W Cu	W Zn	W Pb	M Fe	M Cu	M Zn	M Pb	Go Fe	go Cu	Go Zn	Go Pb	Gi Fe	Gi Cu	Gi Zn	Gi Pb	In Fe	In Cu	In Zn	In Pb
W Fe	1																			
W Cu	0.765	1																		
W Zn	0.863	0.437	1																	
W Pb	0.257	0.633	0.241	1																
M Fe	0.215	0.588	-0.307	0.003	1															
M Cu	.976*	0.876	0.744	0.332	0.4	1														
M Zn	0.587	0.887	0.111	0.31	0.89	0.745	1													
M Pb	0.946	0.879	0.654	0.258	0.518	.990*	0.815	1												
Go Fe	0.726	0.313	.968*	0.328	-0.507	0.587	-0.082	0.472												
Go Cu	0.913	.961*	0.647	0.51	0.465	.974*	0.814	.963*	0.509	1										
Go Zn	0.26	0.762	-0.229	0.376	0.927	0.462	0.927	0.545	-0.377	0.594	1									
Go Pb	0.764	.998**	0.457	0.671	0.547	0.87	0.862	0.866	0.345	.959*	0.737									
Gi Fe	0.819	0.318	0.756	-0.331	0.091	0.729	0.295	0.728	0.593	0.554	-0.075	0.3	1							
Gi Cu	0.862	0.579	0.607	-0.201	0.459	0.856	0.637	0.892	0.39	0.738	0.317	0.551	0.921	1						
Gi Zn	0.776	.993**	0.414	0.543	0.656	0.891	0.927	0.908	0.265	.962*	0.79	.986*	0.374	0.647	1					
Gi Pb	0.585	.970*	0.23	0.709	0.649	0.734	0.889	0.747	0.128	0.865	0.855	.969*	0.088	0.397	.956*	1				
In Fe	.991**	0.783	0.89	0.372	0.144	.965*	0.551	0.918	0.78	0.921	0.238	0.789	0.751	0.785	0.778	0.614	1			
In Cu	.999**	0.787	0.863	0.308	0.212	.979*	0.595	0.946	0.733	0.927	0.276	0.789	0.789	0.838	0.793	0.615	.996**	1		
In Zn	0.558	0.937	0.117	0.511	0.819	0.724	.975*	0.772	-0.035	0.833	0.939	0.922	0.156	0.503	.952*	.966*	0.552	0.577	1	
In Pb	0.735	.969*	0.325	0.445	0.753	0.864	.970*	0.901	0.153	0.928	0.844	.953*	0.379	0.677	.990*	0.938	0.72	0.748	.971*	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
[W- water, M- Muscle, Go- gonads, Gi- gills, In- intestine]

Table 7: Correlations of heavy metals in water and different tissues of *Barilius vagra* at station II during (June 2016-May 2017).

	W Fe	W Cu	W Zn	W Pb	M Fe	M Cu	M Zn	M Pb	Go Fe	go Cu	Go Zn	Go Pb	Gi Fe	Gi Cu	Gi Zn	Gi Pb	In Fe	In Cu	In Zn	In Pb
W Fe	1																			
W Cu	0.578	1																		
W Zn	0.889	0.174	1																	
W Pb	0.382	-0.153	0.378	1																
M Fe	.996**	0.651	0.846	0.34	1															
M Cu	0.821	0.553	0.583	0.721	0.828	1														
M Zn	0.8	0.703	0.489	0.59	0.825	.979*	1													
M Pb	0.908	0.518	0.731	0.687	0.904	.980*	0.943	1												
Go Fe	0.846	0.655	0.761	-0.165	0.861	0.438	0.479	0.561	1											
Go Cu	0.81	0.824	0.613	-0.204	0.846	0.488	0.572	0.568	.967*	1										
Go Zn	0.312	0.449	-0.03	0.683	0.343	0.789	0.812	0.653	-0.108	0.048	1									
Go Pb	0.911	0.793	0.627	0.4	0.938	0.921	.956*	0.93	0.714	0.782	0.615	1								
Gi Fe	0.889	0.195	.998**	0.327	0.849	0.557	0.471	0.71	0.791	0.644	-0.065	0.623	1							
Gi Cu	.990*	0.502	0.894	0.509	.978*	0.868	0.826	0.947	0.764	0.72	0.381	0.903	0.886	1						
Gi Zn	0.584	0.876	0.154	0.299	0.643	0.809	0.909	0.723	0.396	0.577	0.821	0.866	0.148	0.575	1					
Gi Pb	0.899	0.676	0.644	0.571	0.914	.978*	.981*	.980*	0.606	0.659	0.694	.981*	0.63	0.918	0.838	1				
In Fe	0.723	0.716	0.602	-0.361	0.753	0.3	0.38	0.409	.975*	.975*	-0.176	0.631	0.641	0.618	0.387	0.49	1			
In Cu	0.86	0.518	0.656	0.726	0.859	.995**	.962*	.994**	0.482	0.509	0.731	0.92	0.632	0.906	0.76	.979*	0.333	1		
In Zn	0.762	0.833	0.394	0.418	0.804	0.916	.978*	0.869	0.529	0.658	0.782	.960*	0.385	0.762	.968*	0.948	0.473	0.889	1	
In Pb	.965*	0.768	0.742	0.286	.985*	0.843	0.871	0.893	0.847	0.877	0.426	.975*	0.746	0.938	0.755	0.935	0.766	0.859	0.879	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed

CONCLUSIONS

Present study revealed that the concentration of all studied metal *viz.* Fe, Zn, Cu and Pb in surface water were within permissible limits except Fe which was found above the permissible limits. Further, in fish tissues the concentration of metals in different tissues (Muscle, Gonad, Intestine, gills) were within permissible limits and more metal accumulation was observed in non-edible tissues like gonads, intestine, and gills thus affecting the fish physiology, development and reproduction of fish. It was observed in the present study that bioconcentration of heavy metals found higher during the second year of study due to increase in the pollution level. Further low concentration of metals in edible tissue i.e. muscle was observed during the present study, so consumption of fish from river Basantar is still safe. But if metal concentration goes on increasing in the river water, it may cause impact on human beings in near future. So, in order to monitoring and evaluation of ecological condition of fishes, such type of fish accumulation pattern can be helpful.

Acknowledgement. The author is grateful to Prof. Roopma Gandotra, HOD Zoology, University of Jammu for providing the necessary experimental facilities. Also, I would like to thank UGC-RGNF-JRF/SRF for providing financial support.
Conflicts of Interest. None.

REFERENCES

Ahmed, M. K., Baki, M. A., Islam, M.S, Kundru, G. K., Sarkar, S. K. and Hossain, M. M. (2015). Human health risk assessment of heavy metals in tropical fish and shell fish collected from the river Buriganga, Bangladesh. *Environmental Science and Pollution Research, 4*, 236-244.

Ahmed, M. K., Habibullah-Al-Mamun, M., Parvin, E., Akter, M. S. and Khan, M. S. (2013)**.** Arsenic induced toxicity and histopathological changes in gill and liver tissue of freshwater fish, tilapia (*Oreochromis mossambicus*). *Experimental and Toxicologic Pathology, 65*(6), 903-909.

Ali, H., Khan, E. and Ilahi, I. (2019). Environmental chemistry and ecotoxicology of hazardous heavy metals, environmental persistence, toxicity and bioaccumulation. *Journal of Chemistry*, 1-14.

APHA (1998). Standard methods for the examination of water and waste water American Public Health Association. 874pp.

Ashraf, M. A., Maah, M. J. and Yusoff, I. (2012)**.** Bioaccumulation of heavy metals in fish species collected from former tin mining catchment. *Int. J. Environ. Res., 6*(1), 209-218.

Badr, N. B. E., El-Fiky, A.A., Mostafa, A. R. and Al-Mur B. A. (2009). Metal pollution records in core sediments of some Red Sea coastal areas, Kingdom of Saudi Arabia. *Environ. Monit. Assess., 155*(1), pp. 509-526,

Bahnasawy, M. and Khidr, A. N. (2011). Assessment of heavy metals in water, plankton and fish of Lake, Manzala, Egypt. *Turkish Journal of Zoology, 35*(2), 271-280.

Bahnasawy, M., Khidr, A. and Dheina, N. (2009)**.** Seasonal variations of heavy metal concentrations in Mullet, *Mugil cephalus* and *Liza ramada* (Mugilidae) from Lake Manzala, Egypt. *Egyptian Journal of Applied Science and Research, 5*(7), 845-852.

Bat, L., Sezgin, M., Ustun, F. and Şahin F. (2012). Heavy metal concentrations in ten species of fishes caught in Sinop coastal waters of the Black Sea, Turkey. *Turk. J. Fish. Aquat. Sci., 12*, 371-376.

Bhuyan, M. S. and Bakar, M. A. (2017). Seasonal variations of heavy metals in water and sediments in the Halda River, Chittagong, Bangladesh. Book Eds, *Environmental Science and Pollution Research*, pp. 227-242.

Boxall, A. B. A., Comer, S. D., Conrad, A. U., Howcroft, J. and Zaman, N. (2000). Inputs, monitoring and fate modelings of antifouling biocides in U K estuaries. *Marine Pollution Bulletin, 40*, 898-905.

Ellahi, M. M. A. and Hossain, A. M. I. (2011). Assessment of spatial and temporal variations of water quality in the coastal areas of Bangladesh. B.Sc. Engg. Thesis. Department of Civil Engineering, Khulna University of Engineering and Technology, Bangladesh.

Farsani, N. M., Haghparast, J. R., Naserabad, S. S., Moghadas, F., Bagheri, T. and Gerami, H. (2019). Seasonal heavy metals monitoring of water, sediment and common carp (*Cyprinus carpio*) in Aras Dam Lake of Iran. *International Journal of Aquatic Biology, 7*(3), 123-133.

Fatima, M. and Usmani, N. (2013)**.** Histopathology and bioaccumulation of heavy metals (Cr, Ni and Pb) in fish (*Channa striatus* and *Heteropneustes fossilis*) tissue, a study for toxicity and ecological Impacts. *Pakistan Journal of Biological Sciences, 16*, 412-420.

Food and Agriculture Organization (1983). Compilation of legal limits for hazardous substances in fish and fishery production, *FAO Fishery Circular, 464,* 5-100.

Garai, P., Banerjee, P., Mondal, P. and Saha, N. C. (2021). Effect of heavy metals on fishes: toxicity and bioaccumulation. *Journal of Clinical Toxicology*, *11* (S18), 1-10.

Goutam, R. K., Sharma, S. K., Mahiya, S. and Chattopadhyaya, M.C. (2015). Contamination of heavy metals in aquatic media, transport, toxicity and technology for remediation. In, heavy metals in water, presence, removal and safety. The Royal Society of Chemistry, London, 1-24.

Gulfraz, M., Arhad, M. and Ahmed, T. (2001). Determination of selected trace metals in the fish and relevant water of river Soan (Pakistan). *Pakistan Journal of Agricultural Sciences, 4*(1-2), 105-159.

Gupta A., Rai, D. K., Pandey, R. S., and Sharma, B. (2009). Analysis of some heavy metals in the riverine water, sediments, and fish from river Ganges at Allahabad. *Environmental Monitoring and Assessment*, *157*(1–4) 449–458.

Hassan, M., Rahman, M. A., Saha, B. and Kamal, A. K. I. (2015). Status of heavy metals in water and sediment of the Meghna River, Bangladesh. *Am J Environ Sci*., *11*(6), 427–439.

Ibrahim, A. T. A. and Omar, H. M. (2013). Seasonal variation of heavy metal accumulation in muscles of African catfish *Clarias gariepinus,* River Nile water and sediments at Assiut Governorate, Egypt. *Journal of Biological and Earth Sciences*, *3*(2), 236-248.

Javed, M. and Usmani, N. (2011). Accumulation of heavy metals in fishes, a human health concern. *International Journal of Environmental Sciences, 2*(2), 659-668.

Manzoor, J. and Kaware, S. P. (2022). Impact of Heavy Metals on Water Quality and Human Health. *International Journal on Emerging Technologies, 13*(2): 12–17.

Jia, Y., Wang, L. Qu, Z., Wang, C. and Yang, Z. (2017). Effects on heavy metal accumulation in freshwater fishes, species, tissues, and sizes. *Environmental Science and Pollution Research*, *24,* 9379-9386.

Jitesh, M. and Radhakrishnan, M. V. (2017). Seasonal variation in accumulation of metals in selected tissue of Ribbon fish, *Trichiurus lepturus,* collected from the Chaliyar river, Kerala, India. *Journal of Entomology and Zoology Studies, 5*(1), 51-56.

Kaur, S. (2012). Assessment of heavy metals in summer & winter seasons in river Yamuna segment flowing through Delhi, India. *Journal of Environment and Ecology*, *3*(1), 149-165.

Khaled, A. (2004). Heavy metal concentration in certain tissues of five commercially important fishes from El-Max bay, Alaxandria, Egypt. *Egyptian Journal of Aquatic Biology and Fisheries, 8*(1), 51-64.

Kin, J. J., Kim, Y. S. and Kumar, V. (2019). Heavy metal toxicity, An update of chelating therapeutic strategies. *Journal of Trace Elements in Medicine and Biology*, *54*, 226-231.

Kumar, A., Seema and Kumar, V. (2017). Human health risk of heavy metals in vegetables grown in contaminated soil irrigated with sewage water. *American Journal of Food Science and Nutrition, 4*(4), 23-35.

Kumar, A. and Jha, S.K. (2020). Distribution and bioaccumulation of heavy metals in water, sediment and fish tissue from the river Mahananda, North Bihar, India. *International Journal of Aquatic Biology*, *8*(2), 109-125.

Kumar, V., Chopra, A. K., Kumar, S., Singh, J. and Thakur, R. K. (2015). Effects of pulp and paper mill effluent disposal on soil characteristics in the vicinity of Uttaranchal Pulp and Paper Mill, Haridwar (Uttarakhand), India. *International Journal of Agriculture Science and Research, 4*, 117-125.

Mahmuda, M., Rahman, M. H., Bashar, A., Rohani, M. F., and Hossain, M. S. (2020). Heavy metal contamination in tilapia, *Oreochromis niloticus* collected from different fish markets of Mymensingh district. *Journal of Agriculture, Food and Environment, 1*(4), 1-5.

Malik, D., Singh, S., Thakur, J., Singh, R.K., Kaur, A. and Nijhawan, S. (2014). Heavy metal pollution of Yamuna River, An Introspection. *International Journal of Current Microbiology and Applied Sciences, 3*(10), 856-863.

Mishra, S., Kumar, A. and Shukla, P. (2020). Estimation of heavy metal contamination in the Hindon River, India, An Environmentric approach. *Applied Water Science*, *11*(2).

Mohamed, E. G., Ali, M. H., Ibrahim, A., Abdel-M., Ayman, H. F. and Saliem, M. 2014. Evaluation of surface water quality and heavy metal indices of Islamia canal, Nile River, Egypt. *Egyptian Journal of Aquatic Research*, *40*, 225-233.

Mohammed, F.A.S. (2000). Toxicity and bioaccumulation of Cu, Zn and Cd in some aquatic organisms. *Bulletin of Environmental Contamination and Toxicology*, *64*(5), 740-747.

Mubarakh, A. T. and Ali, A. M. (2020). Determination of some heavy metal content in the body of two popular fish species, *O. niloticus* and *L. niloticus,* in lake Nubia, wadi Halfa, Sudan. *Journal of Aquaculture and Marine Biology*, *9*(5), 170-175.

Noor, M. and Zutshi, B. (2016). Bioaccumulation of trace metals in tissues of Rohu fish for Environmental Risk Assessment. *Journal of Water Resource and Protection, 8,* 472-481.

Obasohan, E. E. (2008). Heavy metal concentration in the gill, muscle and liver of fresh water mud fish (*Parachanna obscura*) from Ogha River, Benin city, Nigeria. *African Journal of Biotechnology, 6,* 2620-2627.

Paliwal, R., Sharma, P. and Kansal, A. (2007). Water quality modeling of the river Yamuna (India) using QUAL2EUNCAS. *Journal of Environmental Management, 83*(2), 131-44.

Prem Nawaz, M., Raja Mohamed, S., Ayeshamariam, A. and Mohamed Rafi, K. (2017). Assessment of heavy metals in surface water of Adirampattinam seashore, Thanjavur District, Tamilnadu, India. *Fluid Mech Open Acc*, *4*(147), 2476-2296.

Rahman, M. S., Molla, R. H., Saha, N. and Rahman, A. (2012). Study on heavy metals levels and its risk assessment in some edible fishes from Bangshi River, Savar, Dhaka, Bangladesh. *Food Chemistry, 134*(4), 1847-1854.

Salem, Z.B., Capelli, N., Laffrey, X. and Elise, G. (2014). Seasonal variation of heavy metals in water, sediments and roach tissues in a landfill draining system pond. *Ecological Engineering*, *69*, 25-37.

Sepe, A., Ciaralli, L., Ciprotti, M., Giordano, R., Funari, E., Costantini, S. (2003). Determination of cadmium, chromium, lead and vanadium in six fish species from the Adriatic Sea. *Food Addit Contam., 20*(6), 543–552.

Shaikh, M. (2014). Bioaccumulation of heavy metals in tissues of *Labeo rohita* from nathsagar dam, near Aurangabad Maharshtra. *International Journal of advances in Agricultural and Environmental Engineering, 1*(1), 53-55.

Sharma, M., Gandotra, R. and Jangral, S. (2021). Quantification of heavy metal accumulation in water and edible fish tissue samples collected from the River Tawi, Jammu, India. *J. Bio-Sci., 29*(2), 19-29.

Sim, S. F., Ling T. Y., Nyanti L., Gerunsin N., Wong Y. E., and Kho L. P (2016). Assessment of heavy metals in water, sediment, and fishes of a large tropical hydroelectric dam in Sarawak, Malaysia. *Hindawi Publishing Corporation Journal of Chemistry*, pp 1-10.

Simukoko, C. K., Mwakalapa, E. B., Bwalya, P., Muzandu, K., Berg, V., Mutoloki, S., Polder, A., and Lyche, J. L. (2022). Assessment of heavy metals in wild and farmed tilapia (*Oreochromis niloticus)* on Lake Kariba, Zambia: implications for human and fish health. *Food Additives & Contaminants*, *39*(1), 74-91.

Singh, V., Sharma, M.P., Sharma, S. and Mishra, S. (2019). Bioassessment of River Ujh using benthic macro invertebrates as bioindicators, India. *International Journal of River Basin Management, 17,* 79-87.

Subathra, S. and Karuppasamy, R. (2008). Bioaccumulation and depuration pattern of copper in different tissues of *Mystus vittatus*, related to various size groups. *Environmental Contamination and Toxicology*, *54*, 236-244.

United State Environmental Protection Agency (1976). Quality criteria for water, USEPA, Washington DC *440*, 76-123.

Valkova, E., Atanasov, V. and Tzanova, M. (2022). Content of Pb and Zn in sediments and hydrobionts as ecological markers for pollution assessment of freshwater objects in Bulgaria-a review. *International journal of environmental research and public health*, *19*(15), 9600.

WHO (1984). Guidelines for drinking-water quality, volume 1, recommendations.

WHO (2008). Guidelines for drinking water quality, World Health Organization. Geneva, Switzerland.

WHO (2011). Guidelines for Drinking Water Quality, 4th Edition, World Health Organization. Geneva, Switzerland.

Xu, J., Wang, H., Liu, Y., Ma, M., Zhang, T. and Zheng, X. (2016). Ecological risk assessment of heavy metals in soils surrounding oil waste disposal areas. *Environmental Monitoring and Assessment*, *188*(125).

Yacoub, A. M., Mahmoud, S. A., and Abdel-Satar, A. M. (2021). Accumulation of heavy metals in tilapia fish species and related histopathological changes in muscles, gills and liver of *Oreochromis niloticus* occurring in the area of Qahr El-Bahr, Lake Al-Manzalah, Egypt. *Oceanological and Hydrobiological Studies, 50*(1), 1-15.

Zhao, G., Ye, S., Yuan, H. Ding, X. and Wang, J. (2016). Distribution and contamination of heavy metals in surface sediments of the Daya Bay and adjacent shelf, China. *Marine Pollution Bulletin, 112*, 420-426.

How to cite this article: Sapana Jangral, Monika Sharma, Kunal Sharma, Anita Sharma and Roopma Gandotra (2023). Seasonal Variation in the Levels of Heavy Metals in Surface Water of River Basantar and various Tissues of *Barilius vagra*, J&K. *Biological Forum – An International Journal, 15*(3): 645-654.