

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

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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, cardiovascular disease, and liver damage (Rahman *et al.*, 2012; Kin *et al.*, 2019; Sharma *et al.*, 2021). 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 HNO₃ 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 HNO₃ (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 G_iFe 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.

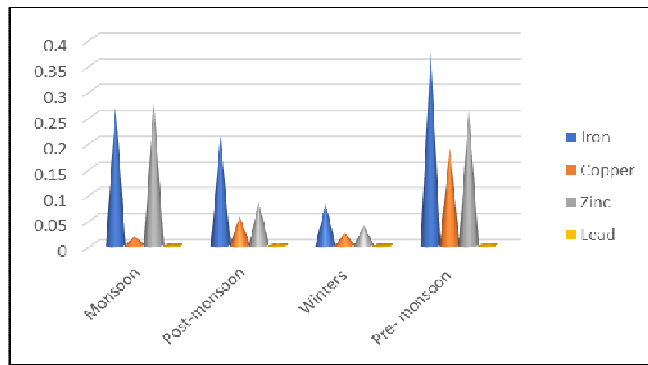


Fig. 1. Graphical representation of seasonal variation in heavy metal concentration (ppm) in water sample (June 015 to May 2016).

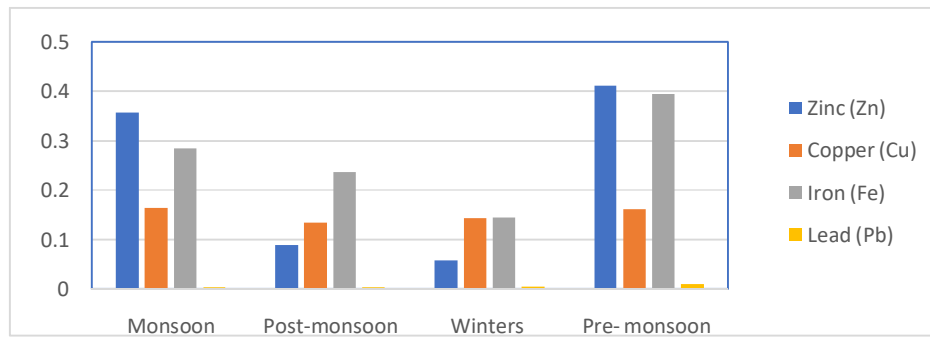


Fig. 2. Graphical representation of seasonal variation in heavy metal concentration (ppm) in water sample (June 2016 to May 2017).

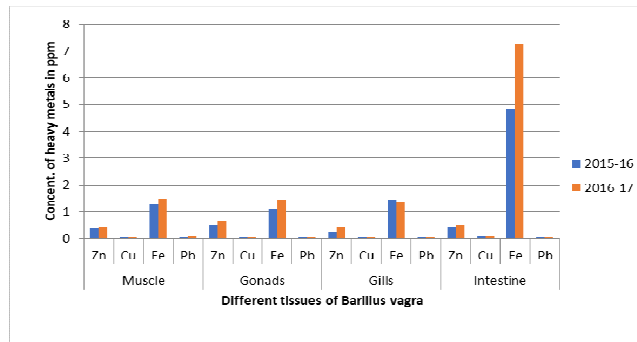


Fig. 3. Comparative seasonal variation in bioaccumulation of metals (ppm) in *Barilius vagra* (June 2015 - May 2017).

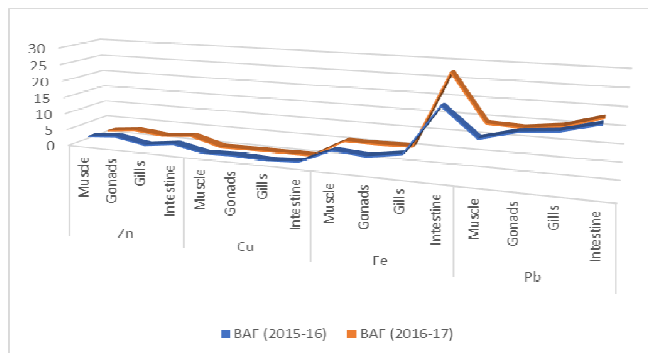


Fig. 4. Bioaccumulation factor (BAF).

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).

Tissues	Metal	<i>Barilius vagra</i> (2015-16)			
		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).

Tissues	Metal	<i>Barilius vagra</i> (2016-17)			
		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±0.04	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.

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Conflicts of Interest. None.

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