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AN EVALUATION OF BIOACCUMULATION FACTOR FOR HEAVY METALS IN BANDHWA DAM ON MURNA RIVER WITH REFERENCE TO FISH TISSUES, SHAHDOL DIVISION IN CENTRAL INDIA

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ABSTRACT This research work was conducted to assess the concentration of heavy metals namely Cu, Zn, Fe, Pb and Hg in the Muscle, liver, gills, kidney and gonad of fish species collected from Bandhwa Dam constructed on Murna River, Shahdol district, Shahdol division in central India. The levels of heavy metals varied significantly among fish species and organs. Muscles possessed the lowest concentration of metals. Higher concentration of the essential metals as Cu were accumulated mainly in liver and gonad, Zn accumulated mainly in Gills and Kidney, Fe were accumulated in gills and muscles as well as Pb accumulated mainly in muscle and gill and the highest concentration of Hg found in mainly Gonad and gills. The concentration of metals in the present fish organs within the permissible limits given by WHO and FAO but in case of Pb and Hg these are higher than the limits. This is also noticeable that the concentration of metals is higher in summer and winter seasons while lowest concentrations are found in rainy season. This study indicated that as far as these metals are concerned, the fish is unfit for human consumption. The Bioaccumulation Factor values of the heavy metals analyzed in this study showed that bioaccumulation has occurred in the fish in the alarming rate. According to previous study, muscles are not active site for the accumulation of metals but in our study it showed that muscles are also the site where metals can be accumulated in maximum level and it also showed that particular organs are not responsible for the accumulation of particular metal, every studied organ shows accumulation of all studied metals in different level of concentrations. Consequently, close monitoring of metal pollution and consumption of the fishes of Bandhwa dam is recommended with a view to minimizing the risk of health of the population that depend on the river for their water and fish supply.

KEYWORDS : Pollution, Heavy metals, Fish, Bandhwa Dam, Bioaccumulation Factor, health threats

INTRODUCTION

Heavy metals are considered the most important form of pollution of the aquatic environment because of their toxicity and accumulation by aquatic organisms. The fish may be more greatly affected by anthropogenic pollution sources. Fish are highly exposed from the heavy metals, like mercury (Hg), leading to severe toxicity, both in the fish and human beings. The fish accumulate substantial concentrations of Hg in their tissues, and thus the fish are the single largest sources of Hg for humans through fish eating. The organic forms of Hg (e.g., methyl Hg) are more toxic than the inorganic forms due to ease of absorption into the human system. Communities that relied on fish intake for daily nutrient sustenance may be at risk from chronic, high exposure to methyl Hg, as well as other persistent organic environmental pollutants. The organic Hg compounds are most toxic to central nervous system (CNS), and may also affect the kidneys and immune system. The main symptoms of Hg poisoning in humans include kidney damage, disruption of nervous system, damage to brain functions, DNA and chromosomal damage, allergic reactions, sperm damage, birth defects, and miscarriages. The methyl Hg content of fish varies by species and size of the fish as well as harvest location. The WHO level of concern for Hg in fish is 0.6 ppm. The fish with levels higher than this should probably be avoided by everyone. [13]

The pollution of the aquatic environment with heavy metals has become a worldwide problem in recent years, because they are indestructible and most of them have toxic effect on organisms.[20] In the recent years, world consumption of fish has increased simultaneously with the growing concern of their nutritional and therapeutic benefits. In addition to its important source of protein, fish typically have rich contents of essential minerals, vitamins and unsaturated fatty acids.[21] The American Heart Association recommended eating fish at least twice per week in order to reach the daily intake of omega-3 fatty acids. However, fish are relatively situated at the top of the aquatic food chain; therefore they normally can accumulate heavy metals from food, water and sediments.[10]

In the last few decades, the concentrations of the heavy metals in fish have been extensively studied in different parts of the world.[15] Most of these studies concentrated mainly on the heavy metals in the edible parts that is fish muscles however other studies reported the distribution of metals in different organs like the liver, kidney, hearts, gonads, bone, digestive tract, gills and brain. The content of toxic heavy metals in fish can counteract their beneficial effects and may cause many adverse effects on human health this may include serious threats like renal failure, liver damage, cardiovascular diseases and even death.[18]

Heavy metals are implicated in neurological disorders especially in the foetus and in children, which can lead to behavioural changes and impaired performance in intelligent quotient (IQ) test.[17] The quality of the ecosystem has been degrading due to agriculture and human activities. The Hg can be found in many different lamps, including black lights and is used in the industrial production of chloride and sodium hydroxide. Some mercury compounds are used as ingredients in skin cream, antiseptics, diuretics, fungicites, insecticides and as a preservative in vaccines. The Hg compounds were even once used in the treatment of Syphilis. The Hg is a naturally occurring heavy metal and a waste product of industries such as coal-burning power plants. The natural sources of Hg vapour include volcanoes, as well as rocks, soils and water surfaces. The Hg is also found naturally in cinnabar, the major ore for the production of Hg. Anthropogenic sources of Hg vapour include emissions from coal-burning power plants, municipal incinerators and through the recycling of automobiles.[05] Once Hg enters the water; it is consumed by microorganisms, which are eaten by small fish, and these, in turn, by bigger fish. At each step up the food chain, the Hg is retained in the muscle meat of the fish, resulting in the highest in large fishes.

Fish is an important component of the human diet in many villages and cities in Shahdol division and Bandhwa Dam (Murna River) is the very enormous source of fish, for this reason this study will be very informative related to heavy metal toxicity. Because this dam is used for irrigation (total irrigation area 240 Ha) as well as fish culture by fisheries departments and in this area, many people are dependent on fish as a food, especially fisher mans and it may cause severe health hazards.

Figure: 1- Image showing Bandhwa Dam with four different sites (white spots) in Google map.

MATERIALS AND METHODS

Fish Sampling

12 water samples and 20 fish samples were used for study in three seasons of the year summer, winter and rainy, during two years (from 2015-16 to 2016-17) from four different sites of dam. The collected species were *Labeo rohita, Anabas testudineus and Oreochromis niloticus*. These fish species represent different biotopes and are economically important. Collected fish were immediately preserved in an ice box and transferred to the laboratory where they were classified, weighed, measured by total length and kept frozen at −20 °C until further analysis. The fish and water samples collected from this site and analyzed at laboratory. Atomic Absorption Spectrophotometer (AAS model ELICO, SL-168) was used for the determination of the heavy metals in the tissue and water samples.

Determination of Metal Concentrations

Preparation of subsamples and analysis were made for metal analysis, frozen fish were partially thawed and each fish was dissected using stainless steel instruments. Muscles, Liver, Gills, Kidney and Gonad were taken out and dehydrated it, in oven; samples of 2–5 g were used for subsequent analysis.

The samples were digested with ultra pure nitric acid at 100°C until the solution become clear. The solution was made up to known volume with deionized distilled water and filtered, using 0.45 micron Filter paper with the help of swinex and analyzed for Cu, Zn, Pb, Fe and Hg using the Atomic Absorption Spectrophotometer (AAS model ELICO, SL-168) the obtained results were expressed as mg/kg.

Heavy metals Cu, Zn, Pb, Fe and Hg concentration in water also measured using the Atomic Absorption Spectrophotometer (AAS model ELICO, SL-168), the obtained results were expressed as ppm (mg/l).

Determination of Bioaccumulation Factor

Bioaccumulation of metal occurs through uptake and retention of a substance from water through body surfaces and gill membrane. Bioaccumulation factor was determined by the ratio of metal concentration in organ and its concentration in the water, according to Kalfakakour and Akrida-Demertzi, 2000.

BAF = M tissue/M water.

Where; M tissue is the metal concentration in fish tissue mg/kg and M water, metal concentration in water mg/L.

Statistical Analysis

Results were generally expressed as mean ± standard deviation and one way ANOVA test was used to compare the data among seasons at the level of 0.05.

Observations

Concentrations of heavy metals (Cu, Zn, Pb, Fe and Hg) in the muscles, liver, gill, kidney and gonad of fish collected from the Bandhwa Dam on Murna River.

As shown in Table-01, the contamination levels of these five metals were shown remarkable variation in tissues. Specially, the concentration of Pb and Hg exceeding, FAO and WHO target values and low Fe level also indicate, that Consumption of water as well as fish may create health problems related with Fe, Pb and Hg contamination.

The accumulation of metals in a single species showed significant inter-specific variations in all metals. However it can be noticed that, different organs exhibited different patterns in metals accumulation.

In other words, no single type of fish showed the highest metals in all organs. Therefore, concentrations of metals among species were analyzed in same organs; all results showed significant variations between species. Variations of metals distribution in the studied fish can be summarized as the following:-

Table-01:- Table showing mean (±SD) concentrations of heavy metals (mg/kg) in some organs of fish species collected from Bandhwa Dam (Murna River).

Fish Species	Organs	Metals	Cu	Zn	Fe	Pb	Hg
Labeo rohita	Muscles	Summer	1.022± 0.002	0.826± 0.014	1.820± 0.002	1.742± 0.023	0.602± 0.009
		Rainy	1.020± 0.000	0.807± 0.008	1.817± 0.000	1.738± 0.012	0.537± 0.003
		Winter	1.021± 0.002	0.819± 0.011	1.759± 0.000	1.732± 0.021	0.522± 0.006
	Liver	Summer	2.369± 0.001	0.899± 0.010	1.941± 0.003	1.698± 0.035	0.535± 0.004
		Rainy	2.357± 0.001	0.892± 0.005	1.895± 0.002	1.567± 0.002	0.463± 0.001
		Winter	1.349± 0.002	0.889± 0.012	1.899± 0.001	1.588± 0.002	0.487± 0.000
	Gills	Summer	2.352± 0.002	0.902± 0.006	1.965± 0.001	1.709± 0.010	0.521± 0.004
		Rainy	1.369± 0.001	0.898± 0.006	1.967± 0.002	1.703± 0.001	0.511± 0.004
		Winter	1.355± 0.002	0.880± 0.011	1.972± 0.000	1.632± 0.003	0.536± 0.001
	Kidney	Summer	1.275± 0.004	0.863± 0.009	0.799± 0.005	1.643± 0.000	0.494± 0.005
		Rainy	1.282± 0.002	0.857± 0.012	0.684± 0.002	1.587± 0.000	0.501± 0.000
		Winter	1.269± 0.003	0.855± 0.010	0.679± 0.000	1.549± 0.002	0.506± 0.000
	Gonad	Summer	4.340± 0.001	0.854± 0.001	0.980± 0.004	1.639± 0.005	0.520± 0.004
		Rainy	2.354± 0.003	0.848± 0.000	0.981± 0.001	1.582± 0.002	1.467± 0.001
		Winter	2.350± 0.000	0.789± 0.004	0.975± 0.002	1.550± 0.001	1.500± 0.001
Anabas testudineus	Muscles	Summer	1.272± 0.002	0.582± 0.006	1.478± 0.003	1.872± 0.005	0.830± 0.003
		Rainy	1.268± 0.004	0.591± 0.002	1.455± 0.000	1.878± 0.001	0.835± 0.002
		Winter	1.263± 0.001	0.594± 0.002	1.462± 0.000	1.869± 0.001	0.798± 0.005

	Liver	Summer	0.891±0.004	0.589±0.004	0.431±0.002	1.543±0.003	0.623±0.003
		Rainy	0.888±0.002	0.498±0.004	0.429±0.004	1.522±0.000	0.566±0.002
		Winter	0.869±0.002	0.573±0.000	0.427±0.001	1.548±0.001	0.602±0.000
	Gills	Summer	1.370±0.001	0.277±0.004	0.901±0.006	1.869±0.007	0.890±0.004
		Rainy	1.371±0.001	0.270±0.001	0.846±0.002	1.899±0.003	0.768±0.001
		Winter	1.299±0.000	0.273±0.001	0.877±0.000	1.836±0.002	0.761±0.001
	Kidney	Summer	0.921±0.002	0.620±0.003	0.823±0.004	1.588±0.004	0.798±0.004
		Rainy	0.922±0.000	0.625±0.000	0.825±0.002	1.576±0.002	0.679±0.000
		Winter	0.920±0.003	0.622±0.000	0.818±0.002	1.572±0.002	0.652±0.000
	Gonad	Summer	0.980±0.001	0.329±0.006	0.524±0.003	0.590±0.004	1.603±0.005
		Rainy	0.973±0.000	0.320±0.003	0.623±0.000	1.321±0.001	0.899±0.002
		Winter	0.975±0.002	0.328±0.002	0.612±0.001	1.329±0.002	1.657±0.000
Oreochromis niloticus	Muscles	Summer	0.650±0.004	0.723±0.004	2.010±0.003	1.776±0.003	0.524±0.003
		Rainy	0.640±0.002	0.720±0.002	2.002±0.002	1.780±0.001	0.385±0.001
		Winter	0.642±0.004	0.628±0.001	1.988±0.002	1.754±0.002	0.299±0.003
	Liver	Summer	0.532±0.001	0.590±0.004	1.320±0.004	1.702±0.004	0.268±0.004
		Rainy	0.536±0.000	0.589±0.000	1.329±0.003	0.899±0.000	0.249±0.005
		Winter	0.536±0.000	0.585±0.000	1.317±0.003	0.856±0.000	0.300±0.002
	Gills	Summer	0.600±0.002	1.025±0.003	1.502±0.004	1.889±0.005	0.620±0.012
		Rainy	0.603±0.003	1.027±0.002	1.457±0.003	1.852±0.001	0.587±0.000
		Winter	0.578±0.001	1.028±0.002	1.422±0.003	1.858±0.001	0.603±0.000
	Kidney	Summer	0.623±0.002	0.517±0.016	0.852±0.000	1.837±0.004	0.608±0.006
		Rainy	0.615±0.004	0.520±0.001	0.824±0.000	1.799±0.002	0.612±0.001
		Winter	0.620±0.002	0.527±0.012	0.821±0.002	1.812±0.000	0.546±0.002
	Gonad	Summer	0.507±0.002	0.660±0.053	0.836±0.001	1.798±0.006	0.590±0.000
		Rainy	0.469±0.003	0.661±0.040	0.829±0.002	1.792±0.002	0.533±0.002
		Winter	0.500±0.000	0.654±0.051	0.754±0.002	1.787±0.005	0.567±0.003

Table-02:-Table showing maximum permissible limit (MPL) of heavy metals in fish tissues (mg/kg) according to international standards.

	Cu	Zn	Fe	Pb	Hg
FAO/WHO limit(2011)	30	40	43	0.5	
*FAO(1983)	30	30	---	0.5	
**WHO 1989	30	100	100	2	
***FSAI(2009)	-	-	-	0.3	
****FSSAI(2011)	30	50		2.5	
ANSG	0.5			0.5	1.0
EU Regulation1881/2006/EU				0.30	0.5
European Commission Decision 93/351/EEC					0.5

*Food and Agriculture Organization, **World Health Organization

***Food Safety Authority of Ireland, ****Food Safety and Standard Authority of India

ANSG- Australian national seafood (fish, molluscs and crustaceans) guidelines for heavy metals

Table-03:-Table showing mean (±SD) concentrations of heavy metals (ppm) in water collected from Bandhwa Dam, Shahdol division

Heavy Metals	Cu	Zn	Fe	Pb	Hg
Summer	0.787±0.002	0.080±0.000	0.493±0.002	5.838±0.000	5.846±0.003
Rainy	0.679±0.001	0.121±0.001	0.773±0.001	2.838±0.000	5.309±0.010
Winter	0.780±0.000	0.081±0.010	0.713±0.000	0.827±0.001	3.300±0.001
Permissible limits (WHO) 2017	2	NG	No Guideline	0.01	0.006
IS(2012)	0.05	5.0	0.3	0.01	0.001

Table-04:-Table showing bioaccumulation factors of heavy metals in fishes collected from Bandhwa Dam

Fish Species	Organs	Cu	Zn	Fe	Pb	Hg
Labeo rohita	Muscles	1.363	8.695	2.725	0.549	0.115
	Liver	2.704	9.503	2.896	0.511	0.103
	Gills	2.259	9.504	2.982	0.531	0.108
	Kidney	1.703	9.131	1.091	0.503	0.104
	Gonad	4.025	8.833	1.483	0.502	0.241
Anabas testudineus	Muscles	1.692	6.266	2.220	0.591	0.170
	Liver	1.179	5.887	0.65	0.485	0.124
	Gills	1.798	2.908	1.325	0.590	0.167
	Kidney	1.367	6.620	1.245	0.498	0.147
	Gonad	1.303	3.464	0.888	0.341	0.288
Oreochromis niloticus	Muscles	0.860	7.344	3.03	0.559	0.084
	Liver	0.714	6.255	2.003	0.364	0.042
	Gills	0.882	10.92	2.213	0.589	0.125
	Kidney	0.827	5.546	1.261	0.573	0.122
	Gonad	0.657	7.003	1.221	0.566	0.117

Heavy Metal Analysis in Tissues

Copper (Cu)

The copper concentration in the tissues of *Labeo rohita* is highest in the summer season in about all organs taken for observation .Copper concentrations are reached the highest level in gonad in summer (4.340±0.010) whereas lowest concentrations are found in muscles in rainy season (1.020±0.000).In *Anabas testudineus* copper concentration reached the highest in gills in rainy (1.371±0.001) and lowest are found in liver in winter season (0.869±0.002) and in *Oreochromis niloticus* highest concentration is in muscles (0.650±0.004) in summer season, whereas lowest is in gonads in rainy season (0.469±0.003). Copper concentrations varied significantly ($P<0.050$) from season to season in organs of all experimental fishes.

Zinc (Zn)

The Zinc concentration in the tissues of *Labeo rohita* is highest in summer whereas lowest concentrations are found in winter. Zn concentrations are reached the highest level in gills in summer (0.902±0.006) whereas lowest concentrations are found in gonad in winter (0.789±0.004).Zn concentrations varied highly significantly ($P<0.001$) from season to season in organs of *Labeo rohita*. In *Anabas testudineus* Zn concentration reached the highest in kidney in rainy (0.625±0.000) and lowest are found in gills in Rainy season (0.270±0.001) and in *Oreochromis niloticus* highest concentration is in gills (1.028±0.002) in winter season, whereas lowest is in kidney in summer season (0.517±0.016). Zn concentrations varied significantly ($P<0.050$) from season to season in organs of *Anabas* and *Oreochromis*.

Iron (Fe)

Fe concentrations are reached the highest level in gills in winter (1.972±0.000) whereas lowest concentrations are found in Kidney in winter season (0.679±0.000).Fe concentrations varied highly significantly ($P<0.001$) from season to season in organs of *Labeo rohita*. In *Anabas testudineus* Fe concentration reached the highest in muscles in summer (1.478±0.003) and lowest are found in liver in winter season (0.427±0.001). Fe concentrations varied highly significantly ($P<0.001$) from season to season in organs of *Anabas testudineus* and in *Oreochromis niloticus* highest concentration is in muscle (2.010±0.003) in summer whereas lowest is in gonad in winter seasons (0.754±0.002). Fe concentrations varied highly significantly ($P=0.001$) from season to season in organs of *Oreochromis niloticus*.

Lead (Pb)

The Pb concentration in the tissues of *Labeo rohita* is highest in summer whereas lowest concentrations are found in winter. Pb concentrations are reached the highest level in muscles in summer (1.742±0.023) whereas lowest concentrations are found in kidney in winter season (1.549±0.001).Pb concentrations varied highly significantly ($P<0.05$) from season to season in organs of *Labeo rohita*. In *Anabas testudineus* Pb concentration reached the highest in gills in rainy (1.899±0.003) and lowest are found in gonad in summer season (0.590±0.004). Pb concentrations varied highly significantly ($P<0.001$) from season to season in organs of *Anabas testudineus* and in *Oreochromis niloticus* highest concentration is in gills (1.889±0.005) in summer season whereas lowest is in liver in winter seasons (0.856±0.000). Pb concentrations varied significantly ($P<0.05$) from season to season in organs of *Oreochromis niloticus*.

Mercury (Hg)

The Hg concentration in the tissues of *Labeo rohita* is highest in winter whereas lowest concentrations are found in rainy. Hg concentrations are reached the highest level in gonad in winter season (1.500±0.001) whereas lowest concentrations are found in liver in rainy season (0.463±0.001). Hg concentrations varied significantly ($P<0.05$) from season to season in organs of *Labeo rohita*. In *Anabas testudineus* Hg concentration reached the highest in gonad in winter (1.657±0.000) and lowest are found in liver in rainy season (0.566±0.002). Hg concentrations varied significantly ($P<0.05$) from season to season in organs of *Anabas testudineus* and in *Oreochromis niloticus* highest concentration is in gills (0.620±0.012) in summer season whereas lowest is in liver in rainy seasons (0.249±0.005).Hg concentrations varied highly significantly ($P<0.001$) from season to season in organs of *Oreochromis niloticus*.

Heavy Metals Analysis in water

The Lead and Mercury concentrations in the water are highest in the summer season whereas lowest concentrations are found in winter season. Iron and Zinc are found in highest concentration in Rainy while lowest in summer. Copper (Cu) is one of the metal, which are essential to human health. It's presence in the aquatic environment may be due to accumulation of domestic and agricultural wastes, Cu is found in highest concentration in summer whereas lowest in rainy season. The concentration of Zn in this site is under permissible limit. It is an essential mineral of importance to both plants and animals.

In this study, lead levels were above the recommended limits (0.01ppm) for water. Pb is a toxic element, which has no significant biological function and shows their carcinogenic effects on aquatic biota and humans even at low exposures. Pb exposure is known to cause musculo-skeletal, renal, ocular, neurological, immunological, reproductive and developmental effects. Mercury is a highly toxic element that is found both naturally and as an introduced contaminant in the environment. The concentration of Hg in water is highest than prescribed limits by WHO (0.006), Indian Council of Medical Research (mg/l) and BIS, IS: 10500- Desirable (mg/l) (0.001ppm).According to Indian standards Fe and Cu concentrations are also higher than desirable limits. In present study mining, fertilizers, domestic waste products and activities of boats are main reasons of heavy metal contamination, which is responsible for the many health hazards in population living across the Dam.

Bioaccumulation factor

The concentration of chemicals in aquatic organism can be calculated by Bioconcentration factors and Bioaccumulation factors. Both factors demonstrate the partitioning of a chemical between water and aquatic organisms (often fish) at abiding state conditions.BCF refers to levels in organisms only due to uptake of surrounding water whereas BAF refers to levels in organisms not only due to uptake from the surrounding water from food also.

BCF in animals can therefore only be measured in laboratory studies, where uptake from food can be restricted, whereas the ratios measured in field are BAF.Bioaccumulation factors are commonly used in assessment models, as they provide a pollution-scale independent parameter. Bioaccumulation factors are easy to calculate. In aquatic systems the factors are usually expressed in the unit L/kg based on concentrations measured as mg/kg and mg/L, respectively. Although, it is known that bioaccumulation factors (BAF) for a given element vary widely among organisms as well as environments, they are often treated as spatially and temporally constants.

In *Labeo rohita*, Cu profile for BAF in the fish was Gonad>Liver>Gills>Kidney>Muscles. Zn profile was Gill> Liver>Kidney> Gonad> Muscles. The profile of Fe in the study was Gill> Liver> Muscles> Gonad> Kidney.Pd profile for BAF in the fish was muscles>Gills>Liver>Kidney> Gonad and the profile of Hg in the study was Gonad> Muscles > Gills> Kidney >Liver. In this study the accumulation of metals were found maximum in gonads, Gills and Muscles.

In *Anabas testudineus*, the profile of Cu in the fish was Gills> Kidney> Gonad > Muscles>Liver. Zn profile was Kidney> Muscles>Liver> Gonad >Gills. The profile of Fe in the study was Muscles> Gill> Kidney > Gonad> Liver. Profile of Pb was Muscle>Gill> Kidney> Liver> Gonad and the Hg profile was Gonad> Muscle> Gill> Kidney> Liver.

In *Oreochromis niloticus*, BAF Profile for Cu in this fish was Gills> Muscle> Kidney> Liver> Gonad. The profile of Zn was Gills> Muscles> Gonad> Liver> Kidney. Fe profile in the fish was Muscles> Gill> Liver> Kidney> Gonad. Profile of Pb was Gill> Kidney>Gonad> Muscle>Liver and the Hg profile was Gill>Kidney> Gonad> Muscle > Liver.

DISCUSSIONS

Bandhwa has been subjected to a lot of anthropogenic pollutants capable of impairing the healthy status of the Dam. This study showed that all the metals analyzed were found in water and fish samples in the dam. Amongst all the metals analyzed, Pb and Hg observed to have mean values higher than the recommended limits.

Copper (Cu) is one of the metal, which are essential to human health. It's presence in the aquatic environment may be due to accumulation of domestic and agricultural wastes. Copper combines with certain protein to produce some enzymes that act as catalyst to help in the body functions and it's also necessary for the synthesis of Haemoglobin. Since the copper recorded in this study is less than 30.00mg/kg that is the WHO permissible limit, the fish of this dam can be consumed without the fear of poisoning from this metal. However, very high intake of copper can cause adverse health effects for most living organisms.

The higher concentration of Zn in this study could be associated with human activities and vehicle (boat) movement that occur in the environment. Human activities such as the use of chemicals and Zinc based fertilizers by farmers could also enhance a high concentration of this metal in soil and water. It is an essential mineral of importance to both plants and animals. Its deficiency may be responsible for retarded growth, loss of taste and hypogonadism, leading to decreased fertility. It is necessary for embryo development and is important for reproductive organs.

Fe is involved in the haemoglobin in the RBC of blood, Fe also help with RBC production. It is a necessary element in human diet and plays a significant role in metabolic processes. In this study the observed mean value of Fe in the fish parts less than WHO recommended limits in fish foods. Though an essential heavy metal, Fe has the tendency to become toxic to living organisms, even when exposure is low.

Lead level recorded in this study is due to its relatively toxicity which can be probably due to contamination of the river by the activities of fisherman's and paints which is used to colour the boats. In this study, lead levels were above the recommended limits for fish foods. Pb is a toxic element, which has no significant biological function and shows their carcinogenic effects on aquatic biota and humans even at low exposures. Pb exposure is known to cause musculo-skeletal, renal, ocular, neurological, immunological, reproductive and developmental effects.

Mercury is a highly toxic element that is found both naturally and as an introduced contaminant in the environment. Although its potential for toxicity in highly contaminated areas such as Minamata Bay, Japan, in the 1950's and 1960's, is well documented, research has shown that mercury can be a threat to the health of people and wildlife in many environments that are not obviously polluted. The risk is determined by the likelihood of exposure, the form of mercury present (some forms are more toxic than others), and the geochemical and ecological factors that influence how mercury moves and changes form in the environment. Alkali and metal processing, incineration of coal, and medical and other waste, and mining of gold and mercury contribute greatly to mercury concentrations in some areas, but atmospheric deposition is the dominant source of mercury over most of the landscape. Once in the atmosphere, mercury is widely disseminated and can circulate for years, accounting for its wide-spread distribution. Natural sources of atmospheric mercury include volcanoes, geologic deposits of mercury, and volatilization from the ocean. Although all rocks, sediments, water, and soils naturally contain small but varying amounts of mercury, scientists have found some local mineral occurrences and thermal springs that are naturally high in mercury. People are exposed to methylmercury almost entirely by eating contaminated fish and wildlife that are at the top of aquatic food chains.

The National Research Council, in its 2000 report on the toxicological effects of methylmercury, pointed out that the population at highest risk is the offspring of women who consume large amounts of fish and seafood. The report went on to estimate that more than 60,000 children are born each year at risk for adverse neurodevelopment effects due to in utero exposure to methylmercury. In its 1997 Mercury Study Report to Congress, the U.S. Environmental Protection Agency concluded that mercury also may pose a risk to some adults and wildlife populations that consume large amounts of fish that is contaminated by mercury. In present study mining, fertilizers and domestic waste products are main reasons of Mercury contamination which is responsible for the many health hazards in population living across the Dam.

CONCLUSIONS

The Bioaccumulation Factor values of the heavy metals analyzed in this study showed that bioaccumulation has occurred in the fish in the alarming rate. According to previous study muscles are not active site for the accumulation of metals but in our study it showed that muscles are also the site where metals can be accumulated in maximum level and it also showed that particular organs are not responsible for the accumulation of particular metal, every studied organ shows accumulation of all studied metals in different level of concentrations.

The concentration of metals in the present fish organs within the permissible limits but in case of Pb and Hg these are higher than the limits and Fe is very low in concentration. So health risk analysis of heavy metals in the edible part (muscle) of the fish indicated unsafe levels for human consumption and concentrations in the muscles are not accepted by the international legislation limits in case of Hg and Pb, however, whole fish with all organs specially small size fishes and the ovary is consumed by people's of this region, so study showed that fishes found in this site are not suitable for human consumption it may cause severe health threats.

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