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Health risk assessment of heavy metal accumulation in the food fish, *Channa striata* from Krishna river, Andhra Pradesh

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Abstract

The new threats to human health from heavy metals are associated with exposure to some selected metals. The study identifies and assessment of the accumulation and levels of five heavy metals (Cd, Cr, Ni, Pb and Zn) in food fish *Channa striata* of Krishna river, collected from three stations during four seasons of the year i.e June,2019- May 2020. The range of metal concentrations recorded were: Cd 1.12- 3.35, Cr 1.41-2.89, Ni 1.51 -3.72 ,Pb 3.29- 7.69 and Zn 13.8 – 29.1 in case of muscle and in case of liver goes to Cd 2.21 – 4.43, Cr 1.74- 3.68, Ni 1.96-3.71, Pb 3.52- 8.09 and Zn 14.5 – 32.6. The spatial variation in concentrations and comparison among seasons indicated that there are significant differences in the concentrations of metals in the muscle and liver for all seasons. The mean metal concentrations varied temporally; metal masses were relatively constant with fluctuations in metal concentrations related to fluctuations in metal body burdens. The metal contamination had significantly higher in both the tissues of Zn and Pb concentrations. According to the guideline values, the concentrations of metals studied do not pose any threat to the health of fish consumers.

Keywords: heavy metals accumulation. fish, human health risk

Introduction

Heavy metals are stable and persist environmental contaminants of aquatic environments and their organisms. They occur in the environment both as a result of natural processes and as pollutants from human activities ^[1]. The rapid growth of developmental activities in recent time has created important environmental challenges for human beings and these environmental changes has become an integral part of modern life of human beings ^[2]. Typically, pollutants are materials/substances that affect the physical, chemical and biological characteristics of biotic components of the ecosystem as well as the abiotic constituents, thereby posing a threat to human health, animals and plants ^[2]. According to Krishna *et al.*,^[3] metal occur in less than 1% of the earth's crust, with trace amounts generally found in the environment and when these concentrations exceed a stipulated limit, they may become toxic to the surrounding environment and when these concentrations exceed a stipulated limit, they may become toxic to the surrounding environment. Rivers are contaminated due metal pollution from anthropogenic and industrial activities. Unfortunately, these contaminants may then pass into the food chain causing toxic effects to human health (Krishna *et al* ^[4-7]). Adverse effects on the river environment highly polluted due to anthropogenic, organic and other developmental activities ^[2]. The discharge of these wastes without adequate treatment often contaminate the river waters with conservative pollutants (like heavy metals), many of which accumulate in the tissues of the resident organisms like fishes and other aquatic organisms. To a larger extent, pollution is caused in developing nation due to inadequate or improper waste management strategies. Wastes are generated in all sector of any nation's economy in large chunks. The unsafe waste disposal is a threat to the ambient environmental condition. Three wastes streams exist including solid wastes (plastic, remains of food processing, agricultural residues), liquid (effluents from industries, food sector etc) and gaseous emissions (pollutant gases from processing or manufacturing sector).

Fish, as human food, is considered as source of protein, polyunsaturated fatty acids particularly omega-3 fatty acids, & minerals like Calcium, Zinc and Iron [8]. And it is considered one of the high nutrient sources for humans that contribute the lower the blood cholesterol and reduce the risk of stroke and heart diseases [9, 10]. Murrels is not only the healthy diet to eat and relish but are often utilized as medicine for various diseases [11]. It is a one of the most common food fish among the local population with traditionally identified pharmacological benefits in treating wound and pain and in boosting energy of the diseased person. Murrels are fully explored source of medicines, despite they are well known ingredients for many popular medicines and also recognized by current and past pharmacopoeias around the world [12].

The fish *Channa striata* carnivorous and consumes fish larvae, earthworms, Insect larva and tad poles [13]. The popularity of *C. striata* as a therapeutic agent is related to folk belief in its efficacy in treating wounds, relieving pain and boosting energy, and herein lead to the, patients recovering from surgical operations [13]. This fish has high quality food sources and they are playing high role of functional foods, which provide health benefit beyond basic nutrition [14]. It is a good source of medicinal food because it contains high level of amino acids and fatty acids. Amino acids might have contributed to its pharmacological properties because the fish include glycine, lysine and arginine, whereas its fatty acids are arachidonic acid, palmitic acid and docosahexaenoic acid [15, 16]. Extracts of the fish are produced from whole muscle, skin and mucus of the fish. They appear to effect their influences through the formation of several types of bioactive molecules [14]. *Channa striata* fish extract could improve the cosmetic appearance of wounds and achieve better patient satisfaction [17]. Among the aquatic fauna, fish is most susceptible to heavy metal contamination than any other aquatic fauna. It is well known that fish are good indicator of chemical pollution and as a result they long been used to monitor metal pollution in river and marine environment [7]. So, the fishes were considered as better specimens for use in the investigation of metal pollution load than the water sample because of the significant levels of metals they bio accumulate. Hence, harmful substances like heavy metals, released by anthropogenic activities will be accumulated in marine organisms through the food chain; as result, human health can be at risk because of consumption of fish contaminated by toxic chemicals.

Keeping in view of the potential toxicity, persistent nature, as well as the environmental pollution, it is deemed necessary to have the base line environmental data on potential metal contamination so that pollutants can be judged in the environment. This paper presents the data of heavy metal (Zn, Pb, Ni, Cr and Cd) concentration in fish, from *Channa striata* of Krishna river

Materials and Methods

Fish samples was collected from 3 stations: i.e Station –I fish landing centre at Prakasam barrage, Station –II Thummalapalem and Station –III Ibrahimpatnam. The fish samples transported to the laboratory in ice boxes and stored at -10°C until subjected for future analysis. The fishes were dissected and care was taken to avoid external contaminated to the samples. Rust free stainless steel kit was sterilized to dissect the fishes. Double distilled water was used for making up the sample and for analysis in the Atomic Absorption Spectrophotometer (ASS). The gut content, gill and muscles

were separated and dried to constant weight and both wet and dry weight recorded. 25% was used as blank samples accompanied every run of the analysis. Each sample was analyzed in triple to ensure accuracy and precision for the analytical procedure.

$$\text{Estimated daily intake (EDI): } \frac{E_F \times E_D \times F_{IR} \times C_f \times C_m}{W_{AB} \times T_A} \times 10^{-3}$$

E_F = The exposure frequency 365 days/year

E_D = The exposure duration, equal to average life time (65 years)

F_{IR} = The fresh food ingestion rate (g/person/day) which is considered to be India 55/g/person/day. [18]

C_f = The conversion factor = 0.208

C_m = The heavy metal concentration in food stuffs mg/kg d-w)

W_{AB} = average body weight (bw) (average body weight to be 60kg)

T_A = Is the average exposure of time for non carciniges (It is equal to ($E_F \times E_D$) as used by in many previews studies [19])

Target hazard quotient:

$$THQ = \frac{EDI}{Rfd}$$

Rfd: Oral reference dose (mg/kg bw/day)

A THQ below 1 means the exposed population is unlikely to experience obviously adverse effects, whereas a THQ above means that there is a chance of non-carcinogenic effects, with an increasing probability as the value increases.

Results and Discussion

The purpose of this work to determined the presence of a particular group of metals in the *Channa striata* of the Krishna River area. Heaving record to the possibility of bioaccumulation of these metals in tissues of fish it was necessary to find out whether the metals determined in the samples were to be accumulated in the fish (ts), the risk imposed on a local population was evaluated. The research presented herein had been conducted in the determination heavy metals concentration of Muscle and liver sample of *Channa striata* of Krishna river. The mean concentrations of heavy metal in fish muscle and liver are presented Table No. 1 and 2. The order of heavy metal concentration was Zn>Pb>Ni>Cd>Cr.

Zinc (Zn)

Zinc is an essential element in animal's diet but it is regarded as potential hazard for both animals and human health [20]. Zinc is present in natural water only as a minor consultant because lack of solubility of free metal and its oxides [21]. It is a very high concentration only it may causes some toxic effects. A normal human body contains 1.4 to 2.3 g of Zinc. Recommend daily dietary intake of Zn is about 15mg for adults and 10mg for children over a year old. The average diary intake of zinc is India is about 16.1mg [22] (Krishnan, 1995). It is relatively non toxic and concentrations of zinc up to 25mg/l have shown few adverse effects [23]. Zinc may be toxic aquatic organisms but the degree of toxicity varies greatly, depending on water quality characteristics as well as species being considered [24]. The present study shows that the

average concentration of muscle goes to 13.8 to 29.1 and liver goes to 14.5 to 32.6 mg/kg of Zn much higher than WHO standards [25].

Lead (Pb)

Pb is considered as a toxic but non-essential metal implying that it has no known function in the biochemical processes [26]. Lead enters the aquatic environment through soil erosion and leaching gasoline combustion, municipal and industrial wastes and runoff [27]. Pregnant women exposed to lead were found to have high rates of still births and miscarriages [28]. Lead has caused mental retardation among children. Hypertension caused by Pb exposure has also been reported [29]. Lead poisoning is accompanied by symptoms of intestinal cramps, peripheral nerve paralysis anaemia, and fatigue [30]. The concentration of lead in natural water increases mainly through anthropogenic activities [31].

In the present study Pb concentration goes to 3.29 to 7.69 mg/kg in the muscle and the liver goes to 3.52 to 8.09 mg/kg. According to WHO [25] the maximum accepted limit is 2mg/kg for food fish. The present results indicated that the concentration levels of Pb was mostly higher than the permissible limits set for human consumption by various regulatory agencies and therefore indicated possible health risks associated with consumption of these fish. At high levels of Pb exposure these is damaged to almost all organ systems. Most importantly the central nervous system kidneys, and blood, culminating in death, if levels are excessive. At low levels, heme synthesis and other biochemical processes are affected and psychological and neurobehavioral functions are impaired [31].

Nickel(Ni)

Nickel is a ubiquitous trace metal and occurs in soil, water, air, and in the biosphere. It is emitted into the environment from both natural and man-made sources. Nickel is released during nickel mining and by industries that convert scrap or new nickel into alloys or nickel compounds or by industries that use nickel and its compounds. These industries may also discharge nickel in wastewater. Nickel is also released by oil-burning power plants, coal-burning power plants and trash incinerators [33]. Once released to the environment, nickel readily forms complexes with many ligands, making it more mobile than most heavy metals [34].

Cadmium (Cd)

Cadmium production, consumption and emissions to the environment have increased dramatically during the 20th century, due to its industrial use (batteries, electroplating, plastic stabilizers, pigment), and consequently lead to contamination of aquatic habitats [35]. The use of cadmium containing fertilizer, agricultural chemicals, pesticides and sewage sludge in farm land, might also contribute to the contamination of water. As a nondegradable cumulative pollutant, Cd is considered capable of altering aquatic trophic levels for centuries [36-38]. Cadmium is toxic element which shows their carcinogenic effect on aquatic biota and humans. It is widely distributed at low levels in the environment and is not an essential element for humans, animals and plants. In the present study Cd shows 1.12 to 3.35 mg/kg in case of muscle and liver was 2.26 to 4.43 mg/kg.

Chromium (Cr)

Chromium concentration in natural waters is usually very

small. Elevated concentration can result from industrial and mining processes [24]. Fish are usually more resistant to Cr than other aquatic organisms, but they can be affected sublethally where exposed to concentration increases. In the present study Cr also above permissible levels set by WHO [25].

The present study it was observed that total concentration of Zn was significantly higher in both organs of when compare with other metals. The differences was noticed in the levels of accumulation in both organs of fish can be attributed to the difference in their physiological roles towards maintaining homeostatic feeding habits, regulatory ability and behaviour of fish [33]. The heavy metals causing concern is that they may be transferred and accumulated in the bodies of animals or human beings through food chain, which will probably cause DNA damage and carcinogenic effects due to their mutagenic ability [39]. Heavy metal exposure of the population may cause neurobehavioral disorders. Such as fatigue insomnia decreased concentration, depression, irritability, sensory and motor symptoms [40]. Exposure to heavy metals has been linked to developmental retardation, various types of cancer, kidney damage, autoimmunity and even death in some instances of exposure to very high concentrations [41]. Cadmium enters into the human body through intake of contaminated foodstuffs such as mushrooms, liver and sea weeds [35]. It gets transported into liver through blood circulation where it binds with metal binding protein metallothionein that sequesters it and transports to the kidney. In kidney, it accumulates and interferes with blood purification mechanisms. It causes kidney and liver damage and deformation of bones [42]. Cadmium has been reported to be mutagenic, carcinogenic, teratogenic, embryo toxic, hyperglycemic agents and anemia inducing agents and has reduced immuno potency [43].

In some cases fish catches were banned for human consumption because their heavy metal concentrations exceeded the maximum limits recommended by the Food and Agriculture organization (FAO) and world health organization (WHO). Among sea foods, fish are commonly consumed and hence, are a connecting link for the transfer of toxic heavy metals in human beings. Bhuvaneshwari *et al.*, [44] concluded that the metals are an inherent component of the environment that pose a potential hazard to human beings and animals. The consumption of fish from the polluted site may result in accumulation of persistent pollutants in ultimate recent of food web. The effluents from the textile factory, the tannery and the floriculture farm probably contain harmful contaminants such as dye stuffs, benzothiazole, sulphonated polyphenols and pesticides. These compounds could bioaccumulate and affect the health of aquatic organisms and subsequently, the health of humans, as consumers of these fish [45].

In the fish, we analysed reveal some metals concentrations potentially toxic if they enter the food chain. However, since their toxicity for human is given by the ingestion rate, data obtained on THQs values (; Zn-1.58; Pb-0.42; Ni-0.38; Cd-0.26 and Cr-0.21) indicated that the contractions is found in the sample of fish represent a risk for human are very limited. The THQ is higher than one only in ZN. Of course, it is just a Primary step; fish contamination levels should be carefully monitored on a regular basis, to detect any change in their patterns that could become a hazard on human safety. Similar results observed by Ambedkar and Maniyan, [46]. Adams [47] concluded that the heavy metal concentrations were above the

maximum levels recommended by regulatory agencies and, depending on daily intake by consumers, might represent a risk for human health.

Table 1: Status of Heavy Metals in Muscle of *Channa striata* (mg/kg)

Metals	South West Monsoon			Post Monsoon			North East Monsoon			Summer		
	St-I	St-II	St-III	St-I	St-II	St-III	St-I	St-II	St-III	St-I	St-II	St-III
Cadmium [Cd]	3.01±0.21	1.42±0.03	2.42±0.18	1.93±0.13	2.01±0.6	1.12±0.04	1.51±0.08	3.01±0.21	3.01±0.21	2.91±0.85	2.75±0.79	3.12±0.99
Chromium [Cr]	2.71±0.17	1.51±0.06	2.11±0.11	1.96±0.14	2.35±0.72	1.44±0.11	1.41±0.07	2.71±0.17	2.71±0.17	2.53±0.76	2.45±0.72	2.83±0.96
Nickel [Ni]	3.21±0.33	1.51±0.06	2.33±0.21	2.54±0.21	2.57±0.83	1.49±0.12	1.63±0.09	3.21±0.33	3.21±0.33	3.15±0.9	3.42±1.11	3.37±1.13
Lead [Pb]	6.92±1.33	3.29±0.45	5.12±1.01	5.15±1.23	5.61±1.35	3.61±0.54	3.59±0.44	6.92±1.33	6.92±1.33	5.79±1.2	5.98±1.3	5.95±1.26
Zinc [Zn]	27.1±3.89	14.9±2.87	22.4±3.22	23.1±3.4	23.7±3.45	13.8±2.65	13.6±2.41	27.1±3.89	27.1±3.89	25.5±3.51	27.2±3.62	29.1±4.0

Table 2: Status of Heavy Metals in Liver of *Channa striata* (mg/kg)

Metals	South West Monsoon			Post Monsoon			North East Monsoon			Summer		
	St-I	St-II	St-III	St-I	St-II	St-III	St-I	St-II	St-III	St-I	St-II	St-III
Cadmium [Cd]	4.21±0.56	4.02 ± 0.59	4.43±0.51	2.21±0.32	2.31±0.35	2.01±0.26	3.21±0.42	3.05±0.51	3.33±0.55	3.9±0.43	3.52±0.49	3.96±0.50
Chromium [Cr]	3.11 ± 0.3	3.22± 0.41	3.68± 0.33	1.74±0.2	1.62±0.13	1.79±0.11	2.33±0.4	2.46 ±0.42	2.61±0.52	2.99±0.71	3.11±0.8	3.5±0.77
Nickel [Ni]	3.71±0.66	4.21± 0.71	4.43± 0.67	1.96±0.2	2.01 ±0.23	2.11 ±0.32	2.98±0.18	3.01 ±0.21	3.31±0.46	3.52±1.09	3.73±1.15	3.91±1.21
Lead [Pb]	7.76 ± 1.12	7.91±1.2	8.09±1.26	3.52±1.07	3.99 ±1.17	3.86 ±1.14	5.47±1.22	5.30±1.19	5.79±1.32	6.46±1.56	6.38 ±1.42	6.71 ±1.82
Zinc [Zn]	29 ± 3.8	29.9 ± 3.7	32.6±3.9	15.4±3.6	14.6 ±3.4	14.5 ±3.2	26.2±4.1	24.1 ±3.8	23.1±3.6	29.9±4.2	29.5±4.1	29 ±4.0

Conclusions

The international official regulatory agencies like WHO have set limits for heavy metal contaminations above which the fish and fishery products are unsuitable for human consumption. However, in the Indian subcontinent there are no safe levels of heavy metal in fish tissues although the Indian population is the major fish consumers in the tropics with a weekly annual rate of 55kg/person. Finally, we recommended that a long-term continuous monitoring to check metals pollution, in order to control of metal in water and fish, control and assessment of the metal content in water of Krishna river, which are supplied by water used agriculture, aquaculture, industries (particularly dies factories), quality of water farmlands. In addition, guidance of people and farmers of both agriculture and aquaculture, about the instruction for use of pesticides, chemicals, drugs and control of house wastewater spreading in rivers and crops are necessary.

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