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Heavy Metals Concentration in Fish *Mugil cephalus* from Machilipatnam Coast and Possible Health Risks to Fish Consumers

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Authors' contributions

This work was carried out in collaboration between all authors. Author PVK designed the concentration of heavy metals study, performed the risk analysis to fish consumers, wrote the protocol, and wrote the first draft of the manuscript. Authors KMR and VS managed the analyses of the study. Author DSR managed the literature, final correct the manuscript. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Heavy metals are dangerous to aquatic organisms and it can be bioaccumulated in the food chain leading to diseases in humans. Cumulative effects of metals or chronic poisoning may occur as a result of long term expore even to low concentrations. The accumulation of heavy metals conditions depending upon the species, environmental conditions and inhibitory processes. Considering the human health risk due to the consumption of fish, the concentration of heavy metals (Zn, Pb, Mn, Cu, Cr and Hg) are investigated in fish samples collected from the Machilipatnam coast. The fish was examined for metal constituents are the basis on the human nutrition in the study area. These metal concentrations were exceeding the limits set by the world health organization (WHO). The study provides an insight into the potential impact of increased levels of metals in the environmental as well as estimated of the contaminated of fish tissues with metals.

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1. INTRODUCTION

Heavy metals are stable and persist in 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 activity [1]. According to World Health Organization (1991), metal occur in less than 1% of the earths 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 [2]. From an environmental point of view, coastal zones can be considered as the geographic space of interaction between terrestrial and marine species. The coastal zones are received a large amount of metal pollution from agricultural runoff, aquaculture chemicals and other industrial activities. Adverse anthropogenic effects on the coastal environment include eutrophrication, heavy metals, organic and microbial pollution, and port activities. The discharge of these wastes without adequate treatment often contaminate the estuarine and coastal waters with conservative pollutants (like heavy metals), may of which accumulate in the tissues of the resident organisms like fishes and other aquatic organisms
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Fish, as human food, are considered source of protein, polyunsaturated fatty acids particularly omega-3 fatty acids, Calcium, Zinc and Iron [3]. 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 [4,5]. 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 coastal and marine environment. So, fishes were considered as better specimens for use in the investigation of pollution load than the water sample because of the significant levels of metals they bioaccumulate. 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 inview 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 on heavy metal (Zn, Pb, Mn, Cu, Cr and Hg) concentration in fish, *Mugil cephalus* from Machilipatnam coast.

2. MATERIALS AND METHODS

Water and fish samples collected from fish landing centre, Machilipatnam (Lat. 16º 11′ 01 N and Long. 81º 10′ 42.3 E). The fish samples transported to the laboratory in ice boxes and stored at -10ºC 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 precession for the analytical procedure.

2.1 Health Risk Assessment

Estimated daily intake (EDI):

$$EDI = \frac{E_F \times E_D \times F_{IR} \times C_f \times C_m}{W_{AB} \times T_A} \times 10^{-3}$$

E_F = The exposure frequency 365 days/year
E_D = The exposure duration, equalent 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 [6].
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)
TA = Is the average exposure of time for non carcinogens (It is equal to ($E_F \times E_D$) as used by in many previous studies [7].

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.

3. RESULTS AND DISCUSSION

The purpose of this work to determined the presence of a particular group of metals in the water ecosystem of the Nizampatnam harbor area. Heaving record to the possibility of bioaccumulation of these metals in tissues of living organisms, including fish it was necessary to find out whether the metals determined in the water samples were to be accumulated in the fish fillet (Edible parts), the risk imposed on a local population was evaluated. The research presented herein had been conducted in the determination heavy metals concentration in fish fillet (Muscle) sample.

3.1 Heavy Metals in Fishes

The mean concentrations of heavy metal in fish muscle are presented Table 1, Fig. 1. The order of heavy metal concentration was Zn>Pb>Mn>Cu>Cr>Hg. This data indicated Zinc accumulated.

3.1.1 Zinc (Zn)

Zinc is an essential element in animal's diet but it is regarded as potential hazard for both animals and human health [8]. Insignificant seasonal variation is observed with slight higher concentration during monsoon season.

Table 1. Average (Mn, Pb, Cu, Zn, Hg and Cr) concentrations in Liver and Muscle of fish collected from Machilipatnam coast (mg/kg dry weight)

Fish	No.	Mn			Pb			Cu			Zn			Hg			Cr		
		M	L	A	M	L	A	M	L	A	M	L	A	M	L	A	M	L	A
M. cephalus	60	6.3	11.5	8.9	8.4	13.2	10.8	5.5	7.3	6.4	25.2	39.6	32.4	1.5	2.9	2.2	1.6	3.0	2.3

No.: Number; M: Muscle; L: Liver; A: Average

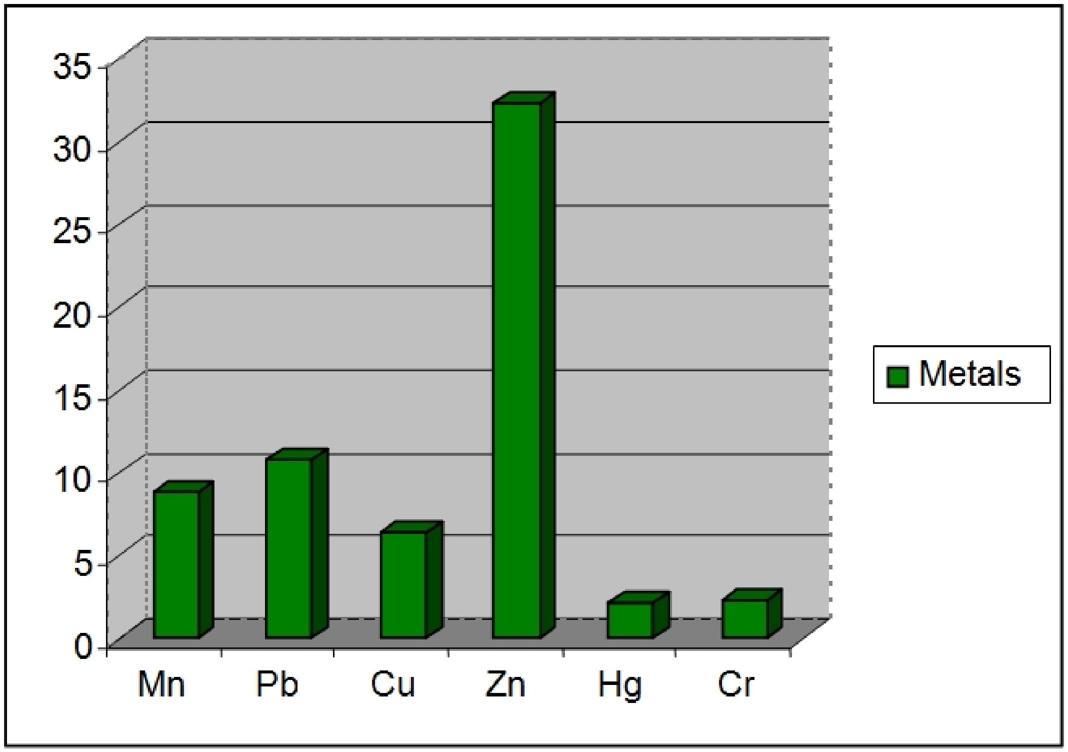

Fig. 1. Different concentrations of heavy metals in fish (mg/kg, dry weight)

Zinc is present in natural water only as a miner consultant because lack of solubility of free metal and its oxides [9]. 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 Zinc is about 15mg for adults and 10mg for children over a year old. The average diary intake of zinc in India is about 16.1mg [10]. It is relatively non toxic and concentrations of Zinc up to 25mg/l have shown few adverse effects [11]. Zinc may be toxic aquatic organisms but the degree of toxicity varies greatly, depending on water quality characteristics as well as species being considered [12]. The present study shows that the average concentration 32mg/kg of Zn much higher than WHO standards [13].

3.1.2 Lead (Pb)

Pb is considered as a toxic but non-essential metal implying that it has no known function in the biochemical processes [14]. Lead enters the aquatic environment through soil erosion and leaching gasoline combustion, municipal and industrial wastes and runoff [15]. Pregnant women exposed to lead were found to have high rates of still births and miscarriages [16]. Lead has caused mental retardation among children. Hyper tension caused by Pb exposure has also been reported [17]. Lead poising is a accompanied by symptoms of intestinal cramps, peripheral nerve paralysis anemia, and fatiage [18]. The concentration of lead in natural water increases mainly through anthropogenic activities [19].

In the present study Pb concentration goes to 10.8mg/kg in the fish muscle. According to WHO [13], 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, haeme synthesis and other biochemical processes are affected and psychological and neurobehavioral functions are impaired [20,21].

3.1.3 Manganese (Mn)

Manganese is an essential micro nutrient, as it functions as a co factor for many enzyme activities [22]. High Mn concentration interferes with central nervous system of vertebrates by inhibiting dopamine formation as well as interfere ring with other metabolic pathways such as Na regulation which ultimately can cause death. High Mn levels are a matter of concern as the consumption of Mn contaminated fish could result in the Mn related disorders in the consumers. In the present study manganese goes to 8.9 mg/kg in the fish muscle which is higher than the permissible limits set by WHO [13]

3.1.4 Copper (Cu)

Copper in aqueous systems received attention mostly because of its toxic effects on biota. Excess of Cu in human body is toxic and hypertension and causes some disorders. Cu also produces pathological changes in brain tissues [23]. The average concentration of Cu in the present study goes to 6.4mg/kg in fish muscle who is above permissible limits.

3.1.5 Chromium (Cr)

Chromium concentration in natural waters is usually low. Elevated concentration can result from industrial and mining processes (12). Fish are usually more resistant to Cr than other aquatic organisms, but they can be affected sub-lethally where exposed to concentration increases. In the present study Cr also above permissible levels set by WHO [13]

3.1.6 Mercury (Hg)

Mercury is known to be latent neurotoxin compared to other metal like lead, cadmium, copper. A high dietary intake of mercury from consumption of fish and fishery has been hypothesized increase the risk of coronary heart disease [24]. When deposited in biota, mercury undergoes biotransformation, in which organic mercury (methyl/ mercury). Microbes subsequently concentrate mercury through the food chain in the tissues of fish and marine animals [25]. According to results obtained, the mercury levels of muscle of *M. cephalus* were found to be 2.2 mg/kg which was higher than permissible levels of WHO [13]. Data we found well the expected levels of concentration in the sample area in relation to the national and international contributions and to those of anthropogenic origin. The last few decades were witness to several reports on the toxicity of heavy metals in human beings, due to the contamination in aquatic organisms. Predominantly, fish toxicological and environmental studies have prompted interest in the development of toxic elements in sea food [26].

The increasing demand of food safety has accelerated researching regarding the risk associated with food consumption contaminated by heavy metal [27]. Lon term intake of contaminated sea food could lead to toxicity of heavy metals in human beings. There are reports of high levels of heavy metals are natural components of food stuffs but also because of environmental contamination and contamination during processing [28]. Industrial effluents agriculture runoff, aquaculture chemicals and drugs, animal and human excretion, and geological weathering and domestic waste contribute to the heavy metal in the water bodies [29]. With the exception of occupational exposure, fish are acknowledge to be single largest source of mercury and other heavy metals (lead and chromium) affecting human beings. Lead poisoning in children causes neurological damage leading to reduced intelligence, loss of short-term memory, learning disabilities and coordination problems. The threat of heavy metal to human and animal health is aggravated by their long-term persistence in the environment [30].

Further, 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 [31]. Heavy metal exposure of the population may cause neurobehavioral disorders. Such as fatigue insomnia decreased concentration, depression, irritability, sensory and motor symptoms [32]. 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 [33]. 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. [34] 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, bonzothiozole, 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 [35]. Türkmen et al. [36] reported that metals in tissues of fish species from Akyatan Lagoon. Türkmen et al. [37] observed that the metals in tissues of fish from Paradeniz Lagoon in the Coastal Area of Northern East Mediterranean. Türkmen et al. [38] worked on heavy metal levels in Blue Crab (*Callinectes sapidus)* and Mullet (*Mugil cephalus*) in İskenderun Bay (North Eastern Mediterranean, Turkey). In the present study Machilipatnam coast also effected pollutants particularly dyes factory, agriculture and aquaculture chemicals.

The fish, we analysed revel 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 (Mn-4.6; Pb-5.6; Cu-3.3; Zn-16.8; Hg-1.15; Cr-1.2) indicated that the contractions we found in the sample of fish represent a risk for human health because all metals THQ is higher than one. 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 [39]. They 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.

4. CONCLUSION

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 is no safety 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 Machilipatnam area which are supplied by water used agriculture, aquaculture, industries (particularly dies factories), quality of water farmlands. And also quality control of input and output water into coastal zones in Machilipatnam area has widely importance. 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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