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Heavy metal bioaccumulation in the *Channa marulius* from Lake Kolleru and human health risk assessment

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Abstract
Water contamination is one of the seriously concerned pollutions that affect the ecosystem with high concentration of the heavy metals. The accumulation of heavy metals which are byproducts of industries have created great health hazards in aquatic organisms particularly fishes. A study was conducted between January 2016 to December,2016 to assess the concentration of Cu, Cr, Pb, Hg, Fe and Zn in liver and muscle of selected food fish *Channa marulius* from Kolleru Lake, Andhra Pradesh. The concentration of metals in the liver was significantly higher than that of the muscle. The highest metal concentrations found in the organs of the fish lead to the oxidative stress which shortens the lifespan and quality of the meat of the fish postulated primary results from anthropogenic activities, fish/shrimp pond effluents and sewage water and effluents from local industrial activities in the Kolleru Lake. Target Hazard Quotient (THQ) was calculated to evaluate the health risk of fish consumers in the Kolleru area.

Keywords: heavy metals, *Channa marulius*, health risk assesssment, Kolleru lake

Introduction
Heavy metal pollution in aquatic ecosystem has been recognized as a serious environmental problem. In many cases, heavy metals occur in coastal water bodies at levels, even below their toxic thresholds, however, due to their non-degradable nature, such low concentrations may still pose risk of damage via uptake and subsequent bioaccumulation by organisms. Under certain environmental conditions, heavy metals can accumulate to toxic concentrations and cause ecological damage [1]. So, heavy metals acquired through the food chain as a result of anthropogenic activities and pollution are potential chemical hazards that can threaten consumers. Metals such as zinc, copper and manganese are essential metal since they play important role in biological systems. Whereas lead and mercury are toxic even in small amount. Aquatic organisms have the ability to accumulate heavy metals from various sources including sediments, soil erosion and run off air deposition of pollutants and discharges of wastewater [2]. Therefore, accumulation of heavy metals in aquatic organisms can pose a long lasting effect on biogeochemical cycling in the ecosphere. According to world health organization [3], metals occurs less than 1% of the earth’s crust, with trace amount generally found in the environment and when these concentrations exceed a stipulated limit, they may toxic to the surrounding environment. The last three decades were witness to several reports on the toxicity of heavy metals in human beings, due to the contamination in the fish and fishery organisms (Batvari *et al*., [4], Mohamad,[5]; Krishna *et al*.,[6], Bat and Arici [7].

Kolleru Lake, is one of the largest fresh water lake in India and a Ramsar site is situated between the two major river basins of the Krishna and Godavari, Andhra Pradesh and it opens into the Bay of Bengal through Upputeru which is 72 km long. The catchment of the lake extended up to 6121 km^2 of which 4763 km^2comprised of upland 1358km^2 are deltaic. Release of the industrial and aquaculture effluents have been reported to the influence of aquatic organisms. Particularly residence of the lake is greatly affected [8]. *Channa marulius* has high nutritive value, recuperative medical qualities and huge demand in this area. Therefore, the present study would be provide a base line data related to the heavy metal pollution in the Kolleru Lake and could be designing strategies aimed at the management of the control of the metal pollution and associated with health risk.

Materials and Methods
Fish samples, *Channa marulius* (Fig-1) are collected from fish landing centre, at Kolleru and transported to the laboratory in ice boxes and stored at -10°C until subjected for further 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. None edible parts (Fins, scales, intestine) removed and parts like muscle and liver was chopped in to small pieces before air drying and then dried on an oven at 60°C until constant weight was obtained. The dried samples were powdered with pestle and mortar. The resulting fine powder was stored until chemical analysis. The samples (triplicate) were analyzed to each metal (Zn, Pb, Cr, Cu, Hg, and Fe) and the detected samples of fish muscle recoded in mg/kg according to APHA [9] using an Atomic Absorption Spectrophotometer (GBC Avanthe model, Australia). Statistical analyses were performed using SPSS 12.0 software for windows. Mean and standard deviation (±) of heavy metal concentrations in µg/kg dry weight of fish muscle and liver were calculated.

Health risk assessment
Health risk assessment was calculated only for fish muscle.

The liver was eliminated according to common house hold practices in this area.
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, equivalent to average years).life time (65
F_{IR} = The fresh food ingestion rate (g/person/day) which is considered to be India 150 g/person/day [10].
C_f = The conversion factor (= 0.208) (The content of fresh weight (fw) to dry weight (dw) considering 79% of moisture content).
C_m = The heavy metal concentration in food stuffs (mg/kg dw).
W_{AB} = Average body weight (bw) (average body weight to be 60kg).
T_A = 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 [11].

Target hazard quotient

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

RfD: Oral reference dose (mg/kg bw/day).
"THQ" below 1 means the exposed population is unlikely to experience obviously adverse effects, whereas "THQ" above means that there is a chance of non-carcinogenic effects, with an increasing probability as the value increases.

Results and Discussions

The average concentration of heavy metals (Zn, Pb, Cr, Cu, Hg and Fe) determined in fish muscle and liver are given (Table.1). The highest concentration of the metal in liver and muscle tissue of was recorded in Zn, followed by Cu, Cr, Pb, Hg and Fe. Higher concentration metals was recorded in the liver compare with muscle tissues (Fig-1). Zn is essential element and is an important component of the human body. Zinc is an essential nutrient for all living things. For this reason, algae growing in streams and lakes can absorb a large part of the zinc dissolved in water. Zn showed protective effect against the Cd and Pd toxicity. In the present study shows that the average concentration of fish muscle goes to 24.2 mg/kg and fish liver goes to 30.2 mg/kg of zinc and it contain within the permissible limits of WHO [12]. Standards. Lead is a heavy metal that occurs in nature mainly lead sulphide. This metal is extremely insoluble and is readily absorbed by organic matter, especially under reducing conditions, Buckley and Hargrave [13] reported that the lead sources of environmental contamination are from mining, smelting and reprocessing operation and as a combustion product of lead additives in gasoline. Lead has also been used in a variety of paints and is a common constituent in municipal and industrial wastes. Lead was causes mental retardation among children and also hyper tension in pregnant women [14]. Lead poising causes by symptoms of intestinal cramps, anemic condition and fatigue [15]. Lead is highly toxic to aquatic organisms, especially fish [16]. The biological effects of sub lethal concentrations of lead included delayed embryonic development, suppressed reproduction and inhibition of growth, increased mucous formation, neurological problems, enzyme inhalation and kidney dysfunction [17]. In the present study the level of average lead in muscle and liver goes to 5.6 and 6.2 mg/kg respectively. According to WHO [18]. the maximum accepted limit was 2 mg/kg for food fish. The present study indicated that the concentration of lead levels was higher than permissible limits.

Fig 1: *Channa marulius*

Table 1: Average heavy metals concentration (mg/kg dry weight) in liver and muscle of *Channa marulius* collected from Kolleru Lake.

S. No.	Heavy Metals	(No. Specimens-20)	
		Muscle (Means ± SD)	Liver (Means ± SD)
1.	Zinc (Zn)	24.2±2.5	32.2±2.9
2.	Lead (Pb)	5.6±1.4	6.2±1.6
3.	Cromium (Cr)	7.9±1.2	9.3±1.9
4.	Cupper (Cu)	8.2±1.5	11.5±1.8
5.	Mercury (Hg)	1.3±0.19	1.6±0.19
6.	Iron (Fe)	1.2±0.25	1.4±0.28

Table 2: THQ values of muscle in *Channa marulius* collected from Kolleru Lake.

S. No.	Heavy Metals	(No. Specimens-20)
		Muscle THQ ± SD
1.	Zinc (Zn)	13.6±3.21
2.	Lead (Pb)	3.16±0.75
3.	Cromium (Cr)	4.4±0.84
4.	Cupper (Cu)	4.6±0.95
5.	Mercury (Hg)	0.7±0.12
6.	Iron (Fe)	0.6±0.13

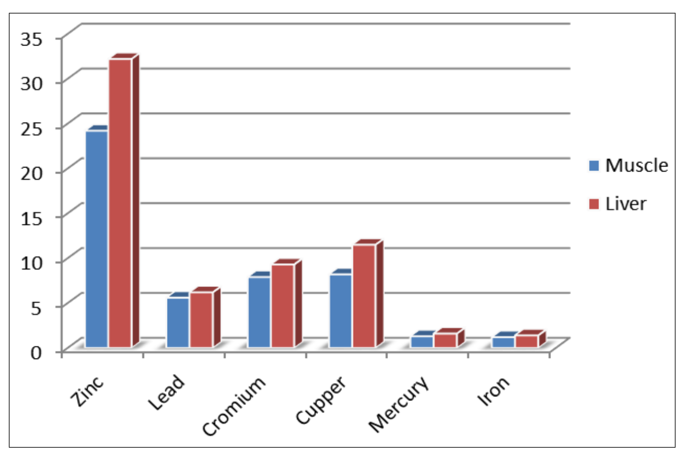

Fig 2: Comparision of heavy metals concentration in liver and muscle of Channa marulius collected from Kolleru Lake

Copper is an essential metal of number of enzymes, and also higher levels of copper leads to toxic effects on aquatic biota. Excessive intake of this metal results in its accumulating in the liver. Sources of contamination in natural sediments are often related to mining wastes, industrial metal manufacturing and processing, corrosion products or as a result of excessive use of antifouling paints in marine areas. Copper is also often association with sewage sludge, where it is most likely complexes with a variety of organic compounds. In the present study the results shows that the average concentration of copper in fish muscle goes to 8.2 mg/kg (body weight) in case of muscle whereas liver goes to 11.5 mg/kg, which is higher than the permissible limits set by WHO [18]. Chromium concentration is natural waters is usually very small. Elevated concentration can result from industrial and mining processes [19]. 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 [18]. In the present study the level of average lead in muscle and liver goes to 7.9 and 9.3 mg/kg respectively. Iron is prevalent component of industrial and mining effluents that are often discharged into aquatic environment [20]. He precipitated iron compounds has serious effect starting from reduce the gill area available for respiration, damage the respiratory epithelium and ending with suffocate the fish and death.

Mercury (Hg) is generally consider as one of the major pollutants of aquatic environment. When the deposited in the biota, mercury under goes to biotransformation, inform of organic mercury (Methyl mercury). It is highly dangerous as it readily bio accumulates in the aquatic organisms. Methyl-Hg the most toxic form of mercury is a known neurotoxin. Consumption of Hg contaminated fish on regular basis therefore has been recognized to cause of severe health problems. Mercury concentration of above permissible levels in fish muscle can be associated with emaciation, decreasing in coordination, losing appetite and mortality in fish [21]. Mercury pollution in aquatic ecosystems has received great attention since the discovery of mercury as the cause of Minamata disease in Japan in the 1950's. Mercury poisoning in the adult brain is characterized by damage of discrete visual cortex areas and neuronal loss in the cerebellum granule layer [22]. Further, mercury poisoning during the early stages of nervous system development may cause catastrophic consequences for infants who exhibit widespread neural impairment [23]. In the present study mercury average concentration was 1.3 mg/kg in muscle tissue and 1.6 mg/kg in the liver which was little bit higher than permissible levels of WHO [18].

Heavy metals are one of the more serious pollutants in our natural environment due to their toxicity. The efficiency of metal up take from polluted water may different ecological need, metabolism and contaminated level, food and sediment as well as other environmental factors such as temperature, salinity and interacting gent [24]. When the organisms are exposed to high level metal in an aquatic environment, they can absorb the available metals directly from the environment via the gills or contaminated water and food, thus accumulated them in their tissues and enter the food chain and extend to so many other problems to humans [25].

Fish is one of the most important food sources and thus, intake of trace elements form capture fish, especially toxic elements if one of great concern for human health. To evaluate the health risk to people in Kolleru area, the "Target Hazard Quotient" (THQ) of heavy metal was estimated on the concentrations of metal in fish muscle and daily fish consumption. Chapman *et al.*, [26] reported that the predominant pathways for heavy metal uptake, target organs, and organisms sensitivity are highly variable and are dependent of factors such as metal concentrations, age, site, physiological status, habitat preferences, feeding behavior and growth rates of fish. The risks associated with the metals were evaluated based on the toxicity unit approach was studied by (Cardoso-Silva *et al.*,) [27]. The increasing demand of food safety has accelerated researching regarding the risk associated with consumption contaminated by heavy metal [28]. In the present study our results clearly showed that the all observed metals are higher than that of results reported by Li *et al*. [29], Mohamad & Osman [5], and Krishna *et al*., [6].

The estimated Target Hazard Quotient of the observed heavy metals through consumption of fish was given in table 2. THQ has been recognized as a useful parameter for evaluation of risk associated with the consumption of metal contaminated food. High potential health risks of heavy metal exposure from rice consumption were depicted based on the estimated daily intake (EDI) of heavy metals and the Target Hazard Quotient (THQ). The average "THQ" values for individual heavy metal are above 1, except mercury and Iron. Ambedkar and Maniyan [30] concluded that the heavy metal concentration were above the maximum levels recommended by regulatory agencies and depending on daily intake by consumers, might represent a risk for human health. Li *et al*., [29] reported that highest total "THQ" value poses relatively higher potential health risks of human beings, particularly for the people residing in the areas with serious metal pollution.

Finally, we conclude that long term continuous monitoring is essential of metal pollution in Kolleru Lake. The "THQ" values of the all the studied metals in fish samples were above 1 except Mercury and Iron. It is suggesting that the concentration of the metals in fish muscle from this area pose to health hazards to the local consumers. Relevant data for this study are still limited, and the implications for human health should be identified by a further detailed study.

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