RESEARCH ARTICLE

Analysis of some Heavy Metals in Water, Soil and Fish from Pulliyankannu Lake at Ranipet, Vellore Dist., Tamilnadu, India

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ABSTRACT

The present study deals with the occurrence and bioaccumulation of heavy metals (Cu, Cr, Cd, Pb, Zn, Al, Fe and Mn) in the lake water, soil, and the muscles of three fish species, procured from the Pulluyankannu lake at Ranipet, Vellore Dt., Tamilnadu. The data obtained, after water analysis, reflected the order of occurrence of heavy metals to be Fe > Mn > Al > Cu> Cr> Zn> Pb> Cd, respectively. The analysis of heavy metals in soil indicated that among the eight heavy metals tested; Fe was noted to be comparatively accumulated higher than Cu, Cr, Cd, Pb, Zn, Al and Mn. The order of heavy metals accumulation in fish muscles was found to be similar to that of the soil and water tested earlier i.e. Fe > Mn > Al > Cu> Cr> Zn> Pb> Cd. Data indicated that Fe accumulated higher in the sediment as well as in the muscles of three fish species studied in comparison to other metals.

INTRODUCTION

Pollution is an undesirable change in the physical, chemical and biological characteristics of our air, land and water that may or will affect human life or that of desirable species (Odum 1971).Water is the elixir of life, a precious gift of nature to mankind and millions of other species living on the earth. It is fast becoming a scare commodity in most parts of the world (Usharani *et al*., 2010).

In recent years the accumulation of heavy metals in aquatic systems has become a problem of great concern throughout the world. These metals may accumulate a very high toxic levels and cause severe impact on the aquatic organisms without any visible sign. Increase in population, urbanization, industrialization and agricultural practices have further aggravated the situation. Heavy metals thus discharged persist in the aquatic bodies and bioaccumulate along the food chain. Metals present in the environment in minute quantities become part of various food chains through bio-magnification and their concentration increases to such a level that may prove to be toxic to both humans and other living organisms. The bioaccumulation of hazardous heavy metals in fish species from different aquatic systems is related to their foraging habitats.

Sedimentary fish species live in stagnant water in muddy streams, feed at the bottom and exhibit higher levels of heavy metals.

With rapid development in industrialization, soil contamination has become a serious problem in many countries. Contamination and negative impact on the quality of air, water, and soil by population growth, rapid urbanization, and industrial activities have been stated by several works. Among the most significant soil contaminants resulting from both natural and manmade sources, heavy metals are of prime importance due to their long-term toxic effects. Due to their contaminant effect, heavy metals are the main focus of recent works. Metal content in soils is the combination of metals arising from human activities and natural processes. Addition of anthropogenic metals to the soil is much greater than contribution of metals from natural sources. Increase of metal content in soils is generally observed in areas of intense industrial activity. Metal accumulations in these areas are a few times higher than uncontaminated sites. However, due to long-distance atmospheric transport, high metal concentrations may also be detected in distal parts of industrial centers.

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Unlike some organic materials, heavy metals do not vanish with time and although at certain levels they are essential for living they show toxic effect if they exceed the limit values. The most important impact of soil pollution on environmental health is that contaminants in soil can be introduced into the food chain by plants and by their direct use or consumption by animals feeding on them. Heavy metals taken into the human body at doses higher than the limit values proposed by the World Health Organization (WHO) are known to cause carcinogenic, teratogenic, toxic, or cardiovascular problems. Therefore, metal pollution in areas of agricultural activities is of great concern (GultenYaylali and Abanuz, 2011).

The most important forms of aquatic pollution are heavy metals since they accumulate in aquatic organisms and may transfer to humans in the food chain. Fish are very important human food, but they are exposed to chemicals in polluted and contaminated waters. Therefore, they may accumulate potentially toxic minerals and represent one of the major sources of heavy metals for humans. Predator fish, in particular, may accumulate these substances more than the others. It is known that fish may also be contaminated by heavy metals during commercial processing like canning. So, information on the metal content in canned fish is important to ensure that it is safe for human consumption. Therefore most countries monitor the levels of heavy metals that may occur due to the commercial handling and processing (Suhendans Mol, 2011).

MATERIALS AND METHODS

Study area
The water, soil and fish samples were collected from Pulliyankannu Lake, Ranipet, Vellore Dt., Tamilnadu, India. Ranipet is an industrial town on the Chennai – Bangalore highway 130 kms away from Chennai. The present investigation was carried out to estimate the heavy metals content of the water, soil and fish in the above mentioned lake. Ecologically, Ranipet is the most strategic place where many industries started mushrooming. The development of industries contaminates the aquatic sources affecting the aquatic fauna.

Water samples were collected for one year covering four seasons (Summer, Pre monsoon, and Monsoon and Post monsoon) from September 2011 to August 2012. One liter sterilized containers were used to collect water samples for heavy metal analysis.

Soil samples were collected from five locations from each lake during the four seasons. Samples were dried at 60°C in a hot air oven for 24 hrs and ground into fine powder using mortar and pestle and passed through 150 µm sieves and stored for further chemical analysis.

Selected fish samples were collected with the help of local fishermen. Collected samples were stored at -20°C prior to further analysis. Samples were thoroughly washed with Mili-Q water; whole tissue was dried at 110°C in a hot air oven. They were powdered with mortar and pestle and stored for further chemical analysis.

Sampling Methods
For total metal analysis, water, soil and fish samples were digested on hot plate using acid mixture (10-ml HNO_3+5-ml $HCLO_4$). Acid digestion of water, soil and fish was carried out in following way:

Water sample: 100ml of water samples was added with 20 ml acid mixture.
Soil sample : 0.5 g of dried soil sample was added with 20 ml acid mixture.
Fish sample : 1 g of fish sample was added with 20 ml acid mixture.

The digested samples were then filtered through Whatman filters paper and made up to 25 ml with deionized water and stored 4ºC. The metals in water, soil and fish samples were analyzed using Atomic Absorption Spectrometer.

RESULTS

Heavy metals in water
The variation of different heavy metals in water from Pulliankannu lake presented as the mean annual average values concentration of Al, Cd, Cr, Cu, Fe, Mn, Pb and Zn were 1.804, 0.022, 0.642, 1.611, 2.364, 1.944, 0.153 and 0.358 respectively. The order of heavy metals accumulation in the lake water was Fe > Mn > Al > Cu > Cr > Zn > Pb >Cd.

Table 1: The mean value of the heavy metals

Metals	Water (mg/l)	Soil (mg/kg)	Fishes (mg/kg)		
			Catla catla	*Ictalurus punctatus (Cat fish)*	*Oreochromis mossambicus*
Al	1.804±0.7	352.2±12.4	0.42±0.21	0.42±0.18	0.39±0.22
Cd	0.022±0.01	0.047±0.01	0.56±0.02	0.50±0.01	0.48±0.01

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Cr	0.642±0.60	1.391±0.30	0.38±0.12	0.31±0.13	0.27±0.08
Cu	1.611±0.87	3.073±0.98	0.61±0.10	0.79±0.09	0.65±0.08
Fe	2.364±0.89	199.1±14.8	0.71±0.07	0.69±0.07	0.58±0.05
Mn	1.944±0.18	2.946±0.27	0.66±0.78	0.71±0.6	0.56±0.10
Pb	0.153±0.04	1.261±0.25	0.76±0.08	0.60±0.06	0.67±0.03
Zn	0.358±0.08	3.095±0.13	0.64±0.06	0.74±0.03	0.44±0.04

Heavy metals in soil

The variation of different heavy metals in soil from Pulliankannu lake presented as the mean annual average values concentration of Al, Cd, Cr, Cu, Fe, Mn, Pb and Zn were 352.2, 0.047, 1.391, 3.073, 199.1, 2.946, 1.261 and 3.095 respectively. The order of heavy metals accumulation in the lake soil was Al > Fe > Zn > Cu > Mn > Cr > Pb >Cd.

Heavy metals in fish muscles

The bimonthly variation in the level of heavy metals in the muscles of three different fish species, *Catla catla, Ictalurus punctatus (Cat fish) and Oreochromis mossambicus* , are shown in Table 1. The heavy metals annual average values of *Catla catla* such as Al, Cd, Cr, Cu, Fe, Mn, Pb and Zn were in the 0.42, 0.56, 0.38, 0.61, 0.71, 0.66, 0.76 and 0.64 respectively. The order of heavy metals accumulation in the *Catla catla* was Pb > Fe > Mn > Zn > Cu > Cd > Al >Cr. The heavy metals annual average values of *Ictalurus punctatus (Cat fish)* such as Al, Cd, Cr, Cu, Fe, Mn, Pb and Zn were in the 0.42, 0.50, 0.31, 0.79, 0.69, 0.71, 0.60 and 0.74 respectively. The order of heavy metals accumulation in the *Ictalurus punctatus (Cat fish)* was Cu > Zn > Mn > Fe > Pb > Cd > Al >Cr. The heavy metals annual average values of *Oreochromis mossambicus* such as Al, Cd, Cr, Cu, Fe, Mn, Pb and Zn were in the 0.39, 0.48, 0.27, 0.65, 0.58, 0.56, 0.64 and 0.44 respectively. The order of heavy metals accumulation in the *Oreochromis mossambicus* was Pb > Cu > Fe > Mn > Cd > Zn > Al > Cr. The trend of accumulation was similar to that observed in sediment and water. For comparison, the annual average accumulation of heavy metals in water, sediment and muscles of three different fish species was estimated.

DISCUSSION

Toxic levels of heavy metals in waters may impose serious threat to aquatic species as well as humans. The concentration of heavy metals in natural water bodies are often elevated due to anthropogenic interferences. Investigations on heavy metals in natural water have received considerable attention as they provide a coded history of a lake's environment (Ajay *et al*. 2008). Waste water management is problematic in

tanneries and represents major inputs of suspended and dissolved metals, most importantly chromium sulphate and other inorganic salts and sulphur. In the process of leather tanning, fresh sludge has only trivalent chromium which is not toxic but undergoes oxidation with MnO_2 and there is formation of hexavalent chromium which is highly toxic and mutagenic (Manju Rawat *et al*. 2009).

The bio toxic effects of heavy metals refer to the harmful effects of heavy metals to the body when consumed above the bio-recommended limits. Although individual metals exhibit specific signs of their toxicity, the following have been reported as general signs associated with cadmium, lead, arsenic, zinc and copper poisoning: gastrointestinal disorders, diarrhea, stomatitis, tremor, hemoglobinuria giving a rust–red colur to stool, ataxia, paralysis, vomiting and convulsion, depression, and pneumonia when volatile vapors and fumes are inhaled. The nature of effects could be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic. Cadmium is toxic at extremely low levels. In humans, long term exposure results in renal dysfunction, characterized by tubular proteinuria (Duruibe *et al.,* 2007).

Soil is the most important environmental component because it is not only a geochemical sink for contaminants, but also because it acts as a natural buffer by controlling the transport of chemical elements and substances to the atmosphere, hydrosphere and biosphere. The anthropogenic impact on the soil has been very broad and complex, which may lead to the irreversible changes by disturbing the natural balance of the ecosystem that has been formed over a long period of time. These changes most often lead to a degradation of the natural environment (Javed Lqbal *et al.,* 2011). Soil can behave as a sink for heavy metals resulting from the deposition of particles emitted by urban and industrial activities, vehicle exhausts and agricultural practices. Increased inputs of the metals and synthetic chemicals in the terrestrial environment due to rapid industrialization coupled with inadequate environmental management in developing countries, has led to large-scale

pollution of the environment. Elevated concentrations of trace elements can have adverse effects on soil biology and functions. Soil pollution can have implications in toxicity at high concentrations and result in the transfer of heavy metals to the human diet through food chain, which poses a significant risk to the human health (Javed Lqbal *et al*., 2011).

Metal concentration in the tissue of fish indicates that the aquatic system is contaminated heavily due to metal exposure from the industries. Fish constitute an important source of protein, minerals and vitamins (e.g. A and D); they contain omega-3 fatty acids that help reduce the risk of certain types of cancer and cardiovascular diseases. On the other hand, the intake of trace elements in the human body does increase with fish consumption. Worldwide, fish products represent only up to 10% of human diet; nevertheless, they represent the main uptake routes of metals into the human body. Human health risk due to the consumption of fish loaded with metals is the subject of many recent studies, further more; it has been shown that in some cases the intake of fish should be regulated. In addition, fish are a useful bio indicator for the determination of metal pollution in aquatic ecosystems (Samar AI Sayegh Petkovsek *et al.,* 2011).

Metals in the fish are then transported by blood stream, which brings it in contact with the various organs in tissues. Muscle was second in the overall metals bioaccumulation in the present investigation. Muscle is the major tissue of interest under routine monitoring of environmental contamination with metal. In the present study metals burden was the least in the muscle when compared to the other organs.

Toxic heavy metals can cause dermatological diseases, skin cancer and internal cancers (liver, kidney, lung and bladder), cardiovascular disease, diabetes, and anemia, as well as reproductive, developmental, immunological and neurological affects in the human body. Metal contamination sources are typically derived from natural sources: mining, industrial waste discharges, sewage effluent, harbor activities and agrochemicals etc. It is also possible that environmental toxicants may increase the susceptibility of aquatic animals to various diseases by interfering with the normal functioning of their immune, reproductive and developmental processes (Couch and John, 1978).

CONCLUSION

The purpose of this study was to assess the heavy metal pollution level in Pulliyankannu Lake at Ranipet, Vellore (Dist)., Tamilnadu, India. Results thus indicated relatively higher level of heavy metals in water, soil and fish at different samples. Industrial discharges appeared as the major source of heavy metals in this area. A spatial variation in heavy metal levels among these sampling stations suggested the diverse sources of heavy metals in lake.

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