Bioaccumulation of some heavy metals in indigenous fishes found in Vashi Creek and an insight on socioeconomic status of local fishermen

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Abstract : Fish constitutes an important and cheap source of animal protein to human beings and a large number of people depend on fish and fishing activities for their livelihood. Increasing human influences through heavy metal pollution have however, led to the depletion of our fish resources and substantial reduction in the nutritive values. The danger of these heavy metals is their persistent nature as they remain in the biota for long period of time when they are released into the environment. As a result of the heavy metal pollution several endemic fish species have become threatened. Realizing this, assessment of heavy metals in the tissues of fish species is increasingly gaining ground throughout the world.

Considering the above facts the current research was carried out at Vashi Creek. The creek is highly polluted and thus the fishes from this creek were selected which includes *Harpadon nehereus*, *Mugil* spp, *Terapon theraps*, *Mystus gulio*, *Macrobrachium idae*, *Clupeidae* and *Tilapia mossambica*. The fish muscle were tested for their nutritive value and presence of several metals like Hg, Pb, Cd, Cr, As, Ni and Fe.

Key words : Fish, Vashi creek, heavy metals, nutritive value.

Introduction

The pollution of the aquatic environment with heavy metals has become a world wide problem during recent years because they are indestructible and most of them have toxic effects on organisms. Among environmental pollutants, metals are of particular concern due to their potential toxic effect and ability to bioaccumulate in aquatic ecosystems. The presence of heavy metals in aquatic ecosystems is the result of two main sources of contamination; natural processes or natural occurring deposits and anthropogenic activities. The main sources of heavy metal pollution to life forms are invariably the result of anthropogenic activities. In the fresh water environment, toxic metals are potentially accumulated in sediments and marine organisms and subsequently transferred to man through the food chain. Heavy metal concentration in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediments and biota (Camusso *et al.*, 1995) which generally exist in low levels in water and attain considerable concentration in sediments and biota. Heavy metals including both essential and non essential elements have a particular significance in ecotoxicology, since they are highly persistent and all have the potential to be toxic to living organisms.

Essential heavy metals are absolutely required by an organism to grow and complete its life cycle, become toxic when its concentration levels exceed those required for correct nutritional response by factors varying between 40 and 200 folds (Venugopal *et al*., 1975). Meanwhile, some other metals such as Pb, Hg and Cd are toxic at quite low concentrations (Ogino and Yang, 1978;1980). Metal accumulation by marine organisms is influenced by a number of intrinsic factors such as size, age, sex, feeding behavior and growth rate and extrinsic factors as metal concentrations and speciation in surrounding waters, salinity, hardness and temperature (McCarty and Van Henry, 1978; Pastor *et al*., 1994). The main objective of this study was to evaluate the concentrations of heavy metals (Hg, Pb, Cd, Zn, Cr, As, Ni and Fe) in muscle tissues of seven fish species (*Harpadon nehereus*, *Mugil* spp, *Terapon theraps*, *Mystus gulio*, *Macrobrachium idae*, *Clupeidae* and *Tilapia mossambica*) collected from Vashi creek, Thane. The results obtained from this study would also provide information for background levels of metals in the water, sediments and fish species of the river contributing to the effective monitoring of both environmental quality and health of the organisms inhabiting the creek.

Materials and methods

Sampling

Sampling area was Vashi Creek. Seven samples of seven fish species were collected. The collection period was early post-monsoon. Fish samples were labelled, they were preserved using ice and transported to the main laboratory. Weighed muscle tissue was further pre-treated for estimation of heavy metals. The weighed wet tissue was also used for estimation of proteins and lipid.

Pre-treatment of Sample

Samples were thoroughly washed with sterile distilled water after removing the scales and muscle portion, which was taken for acid digestion.

Following methods were adopted for analysis of heavy metals and nutrients.

Table 1: Various parameters and methods of their analysis

Parameter	Method
Moisture Content	Evaporation
Protein	Follin Lowry
Total Lipids	Bligh and Dyer
Nickel	Atomic Absorption
Arsenic	Atomic Absorption
Chromium	Atomic Absorption
Iron	Atomic Absorption
Mercury	Atomic Absorption
Lead	Atomic Absorption
Cadmium	Atomic Absorption

Study of Socio-economic Status of Fishermen Staying in Vicinity of the Creek

A survey based on questionnaire was done to study the socioeconomic status of local fishermen staying in the vicinity of the creek.

Result and Discussion

While considering the heavy metals concentrations in fish species, the most important aspect is their toxicity to humans and their suitability for human consumption.

Nickel is found in all soils and is emitted from volcanoes. Nickel is used as an alloy in the steel industry, electroplating, Ni/Cd batteries, arc-welding, rods, pigments for paints and ceramics, surgical and dental prosthesis, moulds for ceramic and glass containers, computer components and catalysts (Bradi, 2005). At very trace levels, Nickel is considered as an essential trace element (Hussain, 1991 and Sivaperumal *et al.*,2007). It acts as an activator of some enzyme systems but its toxicity at higher levels is more prominent. High levels of Nickel can cause respiratory problems and it is carcinogenic (Sivaperumal *et al.*,2007; Ikema and Egieborb, 2005; ATSDR, 2005). According to WHO (1989), the maximum acceptable limit is 0.5-1.00 µg/g. The present study does not indicate any alarming concentration of Nickel (Table 3).

Arsenic has been recognized as a human poison for centuries. Ingestion of arsenic has been linked with skin, liver, bladder and prostate cancer. Humans are exposed to arsenic by eating food, drinking water and breathing air. Contaminated food is usually the largest source of arsenic. Marine organisms, especially shellfish, are known to contain relatively high concentrations of arsenic, while arsenic concentrations in freshwater organisms are much more variable (Cullen and Reimer, 1989). The present study indicates very low concentration of Arsenic (Table 3) in fish tissue and is safe to consume.

Chromium is a dietary requirement for a number of organisms. This however, only applies to trivalent chromium. Hexavalent chromium is very toxic to flora and fauna. The amount of dissolved Cr^{3+} ions is relatively low, because these form stable complexes. In natural waters trivalent chromium is most abundant. Hexavalent chromium is known for its negative health and environmental impact and its extreme toxicity. It is 1000 times more toxic than trivalent chromium. It is carcinogenic and causes allergic and asthmatic reactions. Health effects related to hexavalent chromium exposure include diarrhoea, stomach and intestinal bleedings, cramps and liver and kidney damage. Hexavalent chromium is mutagenic. Phytoplankton contains approximately 4 ppm chromium, sea fish contain between 0.03 and 2 ppm, and oyster tissue contains approximately 0.7 ppm (all values dry mass). Phytoplankton has a bio concentration factor of approximately 104 in seawater.

Table 2: Concentration of heavy metals in fish tissue in ppm

Name of Fish	Ni	As	Cr	Fe	Hg	Pb	Cd
Mugil spp.	4.3×10^{-5}	3.9×10^{-5}	6.7×10^{-5}	1×10^{-5}	1.7×10^{-5}	1.6×10^{-5}	1.2×10^{-5}
Harpadon nehereus	6×10^{-6}	4.2×10^{-5}	6×10^{-5}	3×10^{-4}	4×10^{-5}	4.5×10^{-5}	1.4×10^{-5}
Tilapia mossambica	2×10^{-5}	6×10^{-5}	8.2×10^{-5}	2×10^{-4}	7×10^{-5}	1.9×10^{-5}	6×10^{-6}
Macrobrachium idae	3.5×10^{-5}	3.1×10^{-5}	1.6×10^{-5}	3.2×10^{-3}	2×10^{-5}	4.2×10^{-5}	1.8×10^{-5}
Clupeidae spp	1.5×10^{-5}	2.2×10^{-5}	4.5×10^{-5}	2.1×10^{-3}	4×10^{-5}	5.6×10^{-5}	1.6×10^{-5}
Terapon theraps	1.8×10^{-5}	5.5×10^{-5}	2.1×10^{-5}	5×10^{-3}	1.5×10^{-5}	3.4×10^{-5}	$9. \times 10^{-6}$
Mystus gulio	1.2×10^{-5}	4.5×10^{-5}	3.1×10^{-5}	2.1×10^{-3}	1×10^{-5}	4.8×10^{-5}	7×10^{-5}

In the present study the concentration of chromium was 0.06 ppm (Table 2) which is approximately near to the natural amounts present in the fishes. Therefore, it could be said that chromium concentrations did not indicate elevated exposure and uptake in fish.

Iron makes up about five percent of the earth's crust. It can be a soluble or relatively insoluble form found in water. Iron (Fe) is an indispensable element for the functioning of organs and tissues of higher animals, including fish, because of its vital role in oxygen transport and cellular respiration. Iron is also one of the most important micronutrients in terms of its effect on functioning of immune system and defense against various infections (Beisel, 1982; Bhaskaram, 1988). Fish can absorb soluble Iron from the water across the gill membrane and intestinal mucosa (Roedar and Roedar, 1968; Sealey *et al*., 1997). Iron plays a key physiological role in all aspects of animal's life; however, it causes deleterious effects on living organisms at supra-optimal concentrations (Davies, 1991; Misra and Mani, 1992). The present study reveals that the concentration of Iron is within supraoptimal levels (Table 2).

Most mercury contamination in human beings comes from eating contaminated fish. Mercury from the atmosphere deposits in water and a portion this is transformed into methylmercury which enters the aquatic food chain. Mercury is bioaccumulative and persistent in living organisms. It takes long time to decline. Methylmercury is highly toxic to mammals, including human and causes a number of adverse effects. Research and health studies claiming neurotoxicity of mercury; particularly in developing organisms are most abunbant. The mercury found in fish tissues during present study was very insignificant (Table 2) and fishes could be considered safe for consumption.

Lead is found in all parts of environment. However, excess amounts are released by human activities. The principal source of Lead in the marine environment appears to be the exhaust of vehicles run with leaded fuels that reaches the sea water by a way of rain and wind blown dust (Castro and Huber, 1997). When accumulates in the human body, it replaces calcium in bones. Lead exposure has been mainly related to retardation of neurobehavioral development (Lidsky and Schneider,2003; Castoldi *et al.* 2003). The European maximum residue limits permitted in fish is 0.3 µg/g for Lead, 0.1 to 0.3 µg/g for Cd (Herreros, 2008). From the present data, it is apparent that the Lead concentration in fish is also lower than permissible limits (Table 3) and safe for consumption.

Cadmium is rarely found in natural water (Hem, 1989). It is considered to be toxic if its concentration exceeds 0.01 mg/ L both in drinking and irrigation water (Taha, 2004). They are potentially toxic even at trace concentrations (Robert, 1991) and causes are high blood pressure, kidney damage, destruction of testicular tissue as well as destruction of red blood cells (Gupta and Mathur, 1983). The cadmium found in the fish tissue (Table 2) is still in a permissible value of Cadmium; 0.5 mg/ kg that was proposed by the Food and Agricultural Organizations (FAO, 1983) to be safe for human consumption.

Overall study indicates that though Vashi Creek is exposed to various sources of pollution from industries as well as road ways, the accumulation of metals in fishes is low. The reason could be the size of the fishes which indicates that they were young and smaller. As the samples were collected immediately after the monsoon, because of the dilution by the rain, the accumulation might have not been significant.

The nutrient analysis showed that *Clupidae* spp. has high protein content followed by *Mugil* spp. (Table 3). However, only 0.75 % was seen in *Harpadon neherius*. The proteins were also low in *Terapon theraps* and *Macrobrachium idae*. However, the reason for this could be the smaller size of fishes. The lipid content was very high in *Therapan theraps* and minimum lipids were found in *Macrobrachium idae*. The fishes like *Mugil*, *Tilapia*, *Clupeidae*, *Terapon theraps* are good in the calorific values.

Table 3: Proximate composition of fishes

Name of Fish	Length (cm)	Weight (gm)	Moisture %	Protein %	Lipid %	Calorie %
Mugil spp.	15.5	50	70	10	6.6	460.71
Harpadon nehereus	21.9	50	87	0.75	3	41.73
Tilapia mossambica	11.9	15	75	6.8	2.7	150.57
Macrobrachium idae	23.9	17.5	80	2.7	1	59.12
Clupeidae spp.	15	45	74	11	1.1	213.18
Terapon theraps	9.5	22.5	81	2.2	9.4	128.01
Mystus gulio	9.5	22.5	78	3.2	1.3	76.67

Socioeconomic Status

Generally the fishermen are characterized by low living standard and hence belong to the weaker sections of the society. They are mostly illiterate and unaware of the government policies regarding fisheries. The daily income they get is spent on liquor which has adverse effect on their livelihood. A preliminary survey was conducted on fishermen residing in around Vashi creek indicated that about 15% of the fishermen were involved only in fishing as their only source of income. 60% of them were less than SSC qualified with 33% earning less than rupees 5000 per month and 67% with more than rupees 5000 per month. 41% were found to be the only earning member in family. Going through such hardship with no government help the fishermen were also found to suffer with swelling, wounds and skin disease.

Conclusion

The results of this study revealed that consuming fish from the Vashi creek is still safe to consumers because observed values of heavy metals were within the permissible limits issued by FAO/WHO for human consumption. However, as the present study was for a limited period with small sample size, it cannot give exact scenario and hence more intensive study is needed in order to determine the bioaccumulation of heavy metals in fishes from the study area.

The fishermen are hard working but need special attention for the up-liftment of their socio-economic status. Some mitigation strategies must be made for the fishermen from such potential area as well as NGOs should take initiative to support them.

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