Environment Conservation Journal 12(1&2) 17-22, 2011
(ISSN 0972-3099) Abstracted and Indexed

Heavy metal contamination in seafood of two suburban areas of Mumbai (West Coast) of India

G.V. Zodape

Received: 15.12.2010 **Accepted: 05.03.2011**

Abstract

Seafood is a major source of food for large number of people residing in the coastal areas of Maharashtra. Fish samples namely *Escuolosa thoracata, Carcharhinus limbatus, Ilisha filigera, Johnius sina* and *Sardinella longiceps* (Goregaon market) and *Megalaspis cordyla, Ilisha filigera, Harpadon nehereus, Coilia dussumieri* and *Lepturacanthus lepturus* (Borovali market) were collected directly from the two suburban markets (Goregaon and Borivali markets) of Mumbai coast. In the present study, the level of Zn in fishes from Goregaon and Borivali market was found above the tolerable limits, while the concentration of Fe in different species of fishes was found quite high as also reported in earlier literature. Iron was found tobe the dominant metal measured during the study period.The level of Pb was found within the tolerable limits. The concentration of Cd in marketed fishes was far lower than the consumption safety tolerance in fishes. Hg level in the samples of the fishes was found below the tolerable limits. The study concludes that the value of Fe represents severe contamination in the seafood and necessary steps are required to minimize heavy metal contamination.

Keywords: *Heavy metals, Fish, Contamination, Spectroscopy, Tolerance limit*

Introduction

Increased industrialization, urbanization, population growth and overall man's greed to overexploit mother nature has created a serious threat to all kind of life in the form of pollution which has now become a global problem. Massive amounts of domestic wastewater and industrial effluents are transported by rivers and finally discharge to the sea, containing rivers and coastal waters. Such anthropogenic pollutants are the main sources of heavy metal contaminants in the ocean. These contaminants entering the aquatic ecosystem may not directly damage organisms; however, that can be deposited into aquatic organisms through the effects of bio-concentration, bio-accumulation and passes into the food chain process and eventually threaten the health of humans by seafood consumption. Metals may occur in the environment as hydrated ionic species or they may form a variety of complexes with inorganic and organic ligands (VanLoon, 1977).

Author's Address

Department of Zoology, S.S and L.S Patkar College of Arts and Science and V.P. Varde College of Commerce and Economics, S.V. Road, Goregaon (West) Mumbai, India
E-mail: gautamvz5@yahoo.com

The global heavy metal pollution of water is a major environmental problem with the advent of agricultural and industrial revolution by which most of the water resources are becoming contaminated (Khare and Singh, 2002). Industrial discharges containing toxic and hazardous substances, including heavy metals (Gbem *et al*., 2001; Woodling *et al.*, 2001) contribute tremendously to the pollution of aquatic ecosystem causing cytotoxic, mutagenic and carcinogenic effects in animals (More *et al*., 2003). Fish are often at the top of aquatic food chain and may concentrate large amounts of metals from the water (Mansour and Sidky, 2002). Metal bioaccumulation is largely attributed to different fish species (Tiwari-Fufeyn and Ekaye, 2007). Multiple factors including season, physiological and chemical properties of water (Kirgin, 1996) can play a significant role in metal accumulation in different fish tissues. The natural concentrations of these metals in sea water are very low and hence the risk of contamination in living tissues is high. Industrial effluent is one of the prime sources of metal contamination in coastal waters and the Bay of Bengal and Arabian Sea is no exception (Mitra and Choudhury, 1993).

The contaminants contributed in water, sediments and tissues of several marine organisms have also been reported along with toxicity tests. 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 (MacFarlane and Burchett, 2000). Among environmental pollutants, metals are of particular concern due to their potential toxic effect and availability of bioaccumulation in aquatic ecosystems (Censi *et al*., 2006).

At present the population of Mumbai is severely suffering from lots of disorder particularly respiratory and digestive, due to air and drinking waters. Most of these causes have been identified and remedial measures have been taken up. However, toxic effect due to contamination of sea food, which is a main diet of majority of the population of Mumbai is not primarily addressed and completely neglected. In fact the relevant toxic effect may be already prevalent in the society and most probably they may become severe in due course of time. Hence, the stage has already reached to address the problem in detail and to dig the thought under the problem.

However, in India, the contamination of sea food studies have not been seriously attended so far.The present study has been undertaken with an aim to determine the current status of heavy metal contamination in seafood and to highlight the information regarding sources of pollution and measures to mitigate it.

Materials and Method

a) Collection of fish Samples

Fish samples namely *Escuolosa thoracata*; *Carcharhinus limbatus*, *Ilisha filigera*, *Johnius sina* and *Sardinella longiceps* (Goregaon market) and *Megalaspis cordyla*, *Ilisha filigera*, *Harpadon nehereus*, *Coilia dussumieri* and *Lepturacanthus lepturus* (Borivali market) were collected directly from suburban markets of Goregaon and Borivali respectively. The samples were identified in the Department of Zoology S.S & L.S. Patkar College Goregaon (West), Mumbai. These samples were brought to the laboratory and washed in sea and dried in oven at 80 ^{0}C. The dried fishes were crushed into a fine powder by mortal and pestle and pass through a 2 mm sieve and stored in amber colored bottles in vacuum dessicators.The samples were then analysed following the standards methods of APHA (1998).

Results and Discussion

The range of heavy metals in seafood collected from Goregaon and Borivalli markets are given in Table-1.

Zinc (Zn)

The mean concentration of zinc was found to be highest in *Harpadon nehereus* (55.358 ppm) collected from Borivali market, whereas the lowest mean concentration of Zn was found in *Carcharhinus limbatus* (2.45 ppm) collected from Goregaon market. It was found that Zn is above the tolerable limits in *Escuolosa thoracata* (10.04 ppm), *Ilisha filigera* (10.321 ppm) and *Sardinella longiceps* (10.449 ppm) collected from Goregaon market and *Megalaspis cordyla* (9.357 ppm), *Ilisha filigera* (16.969 ppm) and *Lepturacanthus lepturus* (12.111 ppm) collected from Borivali market. The level of zinc was found below the tolerable limit in *Johnius sina* (6.346 ppm) collected from Goregaon market and in *Coilia dussumieri* (6.128 ppm) collected from Borivali market. Denton and Burdon (1986) have reported higher mean value of Zn (1.9 to 35.0 ppm) in *Thalassorna* sp., in *A. saxatils* the highest concentration was found in the liver of these fishes (30.0 ppm- 44.9 ppm). Similar range of concentration (4.3 ppm-41.8 ppm) was found by them in the muscles of fish species from the Great Barrier Reef. They have also reported relatively high concentrations of Zn in the liver of these fishes. In comparison to this Hanna (1989) found much higher and wider concentrations of Zn in the muscles (8.4-195.0 μg g^{-1}), livers (43-620 μg g^{-1}), and gonads (72-259 μg g^{-1}) of fishes from the Red Sea. The present study shows that Zn levels in the fishes collected from Goregaon and Borivali markets are within the levels reported from the Red Sea and other regions of the world. During the study the level of Zn was found above the tolerable limits.

Manganese (Mn)

Manganese is an essential element and is subject to some internal regulation in human body. Although this element is of low toxicity, it has a considerable biological significance and seems to accumulate in certain fish species (Eustace, 1974; Uthe and Bligh, 1971). The highest mean concentration of Mn was recorded in the fish *Escuolosa thoracata* (0.849 ppm) collected from Goregaon market, while the lowest mean concentration was recorded in the fish *Lepturacanthus lepturus* (0.216 ppm) collected from Borivali market. It is evident that the level of Mn was found above the tolerable limits in *Ilisha filigera* (0.783ppm), *Johnius sina* (0.523 ppm) *Harpadon nehereus* (0.282 ppm), *Ilisha filigera* (0.249 ppm), *Megalaspis cordyla* (0.28 ppm), *Sardinella longiceps* (0.299 ppm) and *Carcharhinus limbatus* (0.315 ppm) collected from Goregaon and Borivali markets respectively. Cross *et al*. (1973) reported lower Mn concentrations (0.20-0.28 µg g-1 wet weight) in the muscle of the blue fish *P. saltatrix*. Eustace (1974) found that 39 species of marine fish from Derwent Estuary, Tasmania contained up to 0.6- 4.4 µg g^{-1} wet weight Mn when homogenized whole. By comparison, Wahbeh and Mahasneh (1987) reported higher mean concentration (5.6-26.8 ppm) in various organs of fish they examined from the same study area within the Gulf of Aqaba. Our data is generally within the tolerable limits and does not indicate any particular contamination issue as reported in abovesaid literature.

Table-1: Range of heavy metals in seafood collected from Goregaon and Borivali markets

GOREGAON MARKET							
SAMPLE		**Zn (ppm)**	**Mn (ppm)**	**Fe (ppm)**	**Pb (ppm)**	**Cd (ppm)**	**Hg (ppm)**
1	*Escuolosa thoracata*	10.04	0.849	16.82	0.085	0.015	0.08
2	*Carcharhinus limbatus*	2.45	0.315	8.46	0.331	0.078	0.038
3	*Ilisha filigera*	10.321	0.783	26.167	0.861	0.037	0.164
4	*Johnius sina*	6.346	0.523	58.425	0.22	0.036	0.074
5	*Sardinella longiceps*	10.499	0.299	11.365	0.21	ND	0.042
BORIVALI MARKET							
SAMPLE		**Zn (ppm)**	**Mn (ppm)**	**Fe (ppm)**	**Pb (ppm)**	**Cd (ppm)**	**Hg (ppm)**
1	*Megalaspis cordyla*	9.357	0.280	13.254	0.204	0.011	0.084
2	*Ilisha filigera*	16.969	0.249	12.197	0.198	0.011	0.037
3	*Harpadon nehereus*	55.358	0.282	67.279	0.113	0.006	0.029
4	*Coilia dussumieri*	6.128	0.301	7.394	0.100	0.008	0.037
5	*Lepturacanthus lepturus*	12.111	0.216	11.067	0.441	0.017	0.02

N = 3 (Average of three readings) ND = Not detected or less than 0.0001ppm

Iron (Fe)

In the present study, it was found that Fe was dominantly present in the samples collected from Goregaon and Borivali markets. Our observations are similar to the observations of other workers (Okoye *et al*., 2002; Asuquo *et al*, 1999). It has also been observed that iron is the dominant metal in the muscle of *C. gariepinus* (Adeyeye *et al*., 1996). There is wide variation in mean concentrations of Fe among different species of fishes. The mean concentration of Fe was recorded highest in the fish *Johnius sina* (58.425 ppm) and *Harpadon nehereus*(67.279 ppm) collected from Goregaon and Borivali market whereas the concentration of Fe was found lowest in *Coilia dussumieri* (7.394 ppm) and *Carcharhinus limbatus* (8.46 ppm) from Borivali and Goregaon markets respectively. The mean concentration of Fe was recorded above the tolerable limits in *Escuolosa thoracata* (16.82 ppm), *Ilisha filigera* (26.167 ppm) and *Sardinella longiceps* (11.365 ppm) collected from Goregaon and *Megalaspis cordyla* (13.254 ppm) and *Lepturacanthus lepturus* (11.067 ppm) collected from Borivali market. The mean concentration of Fe was recorded below the tolerable limits in *Carcharhinus limbatus* (8.46 ppm) collected from Goregaon market and *Coilia dussumieri* (7.394 ppm) collected from Borivali market. Similar variations were also found by Wahbeh and Mahasneh (1987) for fish species from the Gulf of Aqaba. Cross *et al*. (1973) reported lower mean levels of Fe in the muscles of the blue fish, *Pomatomus saltatrix* (4.5-5.0 $\mu g\ g^{-1}$ wet weight). During our study it was found that the concentration of Fe in different species of fishes collected from Goregaon and Borivali markets correlate with the earlier data.

Lead (Pb)

Lead is known to induce reduced cognitive development and intellectual performance in children and increased blood pressure and cardiovascular disease in adults (Commission of the European Communities, 2001). FAO (1983) of the United Nations and WHO (1990) have established a provisional tolerable weekly intake (PTWI) of lead as 25 µg/kg body weight for humans, equaling 1,500 µg/g lead/week for a 60-kg person.

The maximum lead level permitted for canned fishes is 0.2 ppm according to the European communities (Commission of the European Communities, 2001). In the present study, the mean lowest and highest levels of lead in fish samples ranged from 0.085 ppm to 0.861 ppm collected from Goregaon market, whereas the level of Pb in fishes ranged from 0.1ppm to 0.441ppm collected from Borivali market. The fact that toxic metals are present in high concentrations in fishes is of particular importance in relation to the FAO/WHO (1972) standards for lead as a toxic metal. The maximum permissible dose for an adult is 3 mg lead per week, but the recommended sources are only one-fifth of those quantity. Lead is a neurotoxin that causes behavioural deficits in vertebrates (Weber and Dingel, 1997) and can cause decreases in survival, growth rates, learning, and metabolism (Eisler, 1988; Burger and Gochfeld, 2000). Levels of 50 ppm of lead in the diet can cause reproductive effects in some predators, and dietary levels as low as 0.1–0.5 ppm are associated with learning deficits in some vertebrates (Eisler, 1988). In our study, the levels of lead are within the tolerable limits.

Cadmium (Cd)

In the present study the concentrations of cadmium in market fishes were found to be far lower than the consumption safety tolerance in fishes set by countries worldwide. The contamination of Cd in fishes ranged from 0.015ppm to 0.078 ppm in fishes collected from Goregaon market and from 0.006 ppm to 0.017 ppm in fishes collected from Borivali market. These values are below the range reported by (Hanna, 1989). Cadmium is accumulated primarily in major organ tissues of fish rather than in muscles (Moore and Ramamurthy, 1984). In contrast, Cd levels in muscles of fish *Mullus barbatus* and *Sardinella aurita* from the Great Barrier Reef were consistently lower than 0.1ppm (Denton and Burdon Jones, 1986), while in liver of *Mullus barbatus and Sardinella aurita*, Cd concentrations varied from less than (0.6 ppm to 0.7 ppm) Roth and Hornung (1977). In general, it can be stated that the concentrations of Cd found in the present study was below the tolerable level as compared to those of uncontaminated fish (< 1.5) reported by Moore and Ramamurthy (1984).

Mercury (Hg)

According to the results obtained, the mercury levels in the samples of the fishes collected from the Goregaon and Borivali markets were found below the tolerable limits than the permissible level, *i.e*., 1 ppm. (WHO, 1994). The Food and Drug Administration (FDA) has set a maximum permissible level of one part of methylmercury in a million parts of seafood (1 ppm). The higher level of mercury can be attributed to the sewage–sludge outfall present along this western coast. This sewage outfall consists of treated industrial effluents from industries and other biochemical manufacturing units situated in that part of Mumbai. It is possible that though the sewage–sludge was treated, traces of heavy metals might have leached into the sea. Fish analyzed from Goregaon and Borivali markets showed normal mean levels of Hg which were in the range of 0.02 ppm to 0.164 ppm. In the case of Goregaon market, mercury levels range from 0.038 ppm to 0.164ppm and in Borivali market, the mercury levels were found to be in the range of 0.02 to 0.084 ppm which suggests that the fish brought to the market was relatively less contaminated with mercury. The PTWI (permissible tolerable weekly intake) of mercury has been set at 5 µg/kg body weight (FAO-WHO 1972), equaling 300 µg mercury/week for a 60-kg person. Mercury is known to be a latent neurotoxin compared to other metals like lead, cadmium, copper and arsenic. A high dietary intake of mercury (organic) from consumption of fish has been hypothesized to increase the risk of coronary heart disease (Salonen *et al*., 1995). When deposited in biota, mercury undergoes biotransformation, in which inorganic mercury may convert to organic mercury (methyl mercury). Microbes subsequently concentrate mercury through the food chain in the tissue of fish and marine animals (Altindag and Yigit, 2005).

Conclusion

From the above results, Zn, Fe, and Pb was found to be high in fish samples collected from Goregaon and Borivali markets. It can be assumed that the sea from where the fishes were collected might be receiving outfalls from industrial waste and sewage from the city as it faces the open Arabian Sea. The levels of heavy metals such as Mn, Cd, and Hg in fish samples collected from Goregaon and Borivali markets were within permissible limits. These elemental toxicants may be transferred to man on consumption of fish obtained from the market. These heavy metals transferred to man through the consumption of fish pose health hazards because of their cumulative effect in the body. Therefore, it was concluded that the fishes are not heavily burdened with metals, but a danger must be considered depending on the agricultural and industrial developments in this region. The fish from Arabian Sea should be monitored periodically to avoid excessive intake of trace metals by human and to monitor the pollution of aquatic environment. In view of these findings strict method of waste disposal control should be adopted to ensure the safety of the environment and safeguard our aquatic life.

Acknowledgement

Author is thankful to the “University Grant Commission” for sanctioning the grant for pursuing the research project. Author is also thankful to the Director, Sophisticated Analytical Instrument Facility (RSIC), Indian Institute of Technology (IIT) Powai, Mumbai for providing facilities of Atomic Absorption Spectrophotometer (AAS) for the analysis of samples.

References

Adeyeye, E.I., Akinyugha, N .J, Fesobi, M.E.and Tenabe, O., 1996. Determination of some Metals in *Clarias gariepinus*, *Cyprinus carpio* (L) and *Oreochromis niloticus* (L) fishes in a polyculture fresh water pond and their Environments. ***Aquaculture***147(3-4) pp 205- 214. Elsevier Science.

Altindag, A., and Yigit, S., 2005. Assessment of heavy metal concentrations in the food web of lake Beysehir, Turkey. Chemosphere, 60,552–556.doi:10.1016/j. ***Chemosphere***. 2005.01.009.

APHA, 1992. *Standard methods for examination of water and waste wate treatment*, American Public Health Association.

Asuquo, F.E., Ogri, O.R.and Bassey, E.S., 1999. Distribution of Heavy Metals and Hydrocarbons in Coastal Waters and Sediments of Cross River State, South Eastern Nigeria. ***International Journal of Tropical Environment***, 1(2) pp 229-242

Burger, J. and Gochfeld, M., 2000. Effects of lead on birds (Laridae): a review oflaboratory and field studies. ***J. Toxicol. Environ. Health*** 3, 59–78.

Censi. P., Spoto, S.E., Saiano, F., Sprovieri, M. and Mazzola, S., 2006. Heavy metals in coastal water system. A case study from the North Western Gulf of Thailand, ***Chemosphere***, 64: 1167-1176

Commission of the European Communities, 2001. Commission Regulation (EC) No. 221/2002 of 6 Feb 2002 amending regulation (EC) NO. 466/2002 setting maximum levels for certain contaminants in foodstuffs. ***Official Journal of the European Commucities***, Brussels, 6 Feb. 2002.

Cross, F.A., Hardy, L.H., Jones, N.Y. and Barber, R.T., 1973. Relation between total body weight and concentrations of manganese, iron, copper, zinc, and mercury in white muscle of bluefish (*Pomatomus saltatrix*) and a bathy-demersal fish Antimora rostrata. J***. Fish. Res. Board Can***. 30:1287-1291.

Denton, G.R.W., and Burdon-Jones, C., 1986. Trace metals in fish from the Great Barrier Reef. ***Mar. Pollut. Bull***. 17: 201-209.

Eisler, R., 1988. *Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*. US Fish and Wildlife Service, Washington, DC.

Eustace I. J., 1974. Zinc, cadmium, copper and manganese in species of finfish and shellfish caught in the Derwent Estuary, Tasmania. ***Aust. J. mar. Freshwat. Res***. 25: 209-220.

FAO , 1983. *Manual of methods of aquatic environment*.

FAO-WHO, 1972. *Evaluation of mercury, lead, cadmium and the amaranth, diethylpyrocarbonate and octyl gallate*. In 16th Meeting of the Joint FAO/WHO Expert Committee on Food Additives. WHO Food Additive Series no. 4, Geneva.

Food and Agriculture Organization, 1976. *List of maximum levels recommended for contaminants by the Joint FAO/WHO Codex Alimentarius Commission*. (Vol. 3). Second series. CAC/FAL, Rome, Italy. pp. 1-8.

Gbem, T. T., Balogun, J.K., Lawaland, F.A. and Annune, P.A., 2001. Trace metal accumulation in *Claris gariepinus.* Teugules exposed to sublethal levels of tannery effluent. ***Sci. Total Environ*** 271: 1-9.

Hanna, R.G.M., 1989. Levels of heavy metals in some Red Sea fish before Hot Brine pools' mining. ***Mar. Pollut. Bull***. 20: 631-635.

Khare, S. and Singh, S., 2002. Histopathological lessons induced by copper sulphate and lead nitrate in the gill of freshwater fish Nundus. ***J. Ecotoxicol. Environ. Mar. Poll. Bull***., 6; 57-60

Kirgin, F., 1996. Seasonal changes in heavy metals in tissues of Mullus barbatus and *Sparus aurata* collected from Iskenderum Gulf (Turkey). ***Water, Air,Soil Pollut***., 90; 557-562

Macfarlane, G.B. and Burchettt, M.D., 2000. Cellular distribution of Cu, Pb and Zn in the Grey Mangrove Avicemnia marina (Forsk). ***Vierh Aquat. Bot***. 68: 45-49.

Mansour, S. A. and M.M. Sidky., 2002. Ecotoxicological studies. 3: Heavy metals contaminating water and fish from Fayoum Govemorate, Egypt. ***Food Chem***., 78; 15-22

Mitra, A. and Choudhury, A., 1993. Trace metals in the macrobenthic molluscs of the Hooghly estuary. India. ***Mar. Pollut. Bull. UK***, 26(9): 521-522.

Moore, J.W. and Ramamoorthy, S., 1984. *Heavy Metals in Natural waters Applied Monitoring and Impact Assessment*. Springer-Verlag, New York, 268 pp.

More, T.G., Rajput, R.A. and Bendela, N.N, 2003. Impact of heavy metals on DNA content in the whole body of freshwater bivalve. *Lamelleiden marginalis*. ***Environ. Sci. Pollut. Res***., 22: 605 – 616

Okoye, P.A.C., Enemuoh, R.E. and Ogunjiofor, J.C., 2002. Traces of heavy metals in marine crabs. ***J. Chem. Soc. Nig***., 27: 76-77.

Roth, I. and Hornung, H. 1977. Heavy metal concentrations in water, sediments, and fish from Mediterranean coastal area, Israel. ***Environm. Sci. Tech***. 11: 265-269.

Salonen, J. T., Seppanen, K., Nyyssonen, K., Korpela, H., Kauhanen, J., Kantola, M., 1995. Intake of mercury from fish, lipid peroxidation, and the risk of myocardial infarction and coronary, cardiovascular, and any death in eastern Finnishmen. ***Circulation***, 91: 645– 655.

Tawari- Fufeyin, P. and Kkaye, S.A., 2007. Fish species diversity as indicator of pollution in Ikpoba river, benincity, Nigeria. Rev. ***Fish. Biol. Fisheries***, 17: 21-30

Uthe, J.F. and Bligh, E.G., 1971. Preliminary survey of heavy metal concentrations of Canadian freshwater fish. ***J. Fish. Res. Board Can***. 28: 786-788.

Vanloon, J.C., 1977. *Chemical Analysis of Inorganic Constituents of W ater*. CRC Press, Inc., Florida.

Wahbeh, M.I. and Mahasneh, D.M., 1987. Concentrations of metals in the tissues of six species of fish from Aqaba, Jordan. ***Dirasat*** 14: 119-129.

Weber, D.N., Dingel, W.M., 1997. Alterations in neurobehavioral responses in fishes exposed to lead and lead-chelating agents. ***Am. Zool***. 37, 354–362.

WHO, 1994. *Guidelines for drinking water quality recommendation*. World Health Organization, Geneva.

WHO, Methyl mercury, 1990. *World Health Organization Environmental Health Criteria* 101, Geneva.

Woodling, J. D., Brinkman, S. F. and Horn, B. J., 2001 Nonuniform accumulation of cadmium and copper in kidney's of wild brown trout *Salmo trutta* populations. ***Arch. Environ. Contam. Toxicol***. 40: 318-385