Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 11	No. 1	pp. 147-151	2012

Original Research Paper

Contamination of Heavy Metals in Seafood Marketed from Virar and Bhayender Markets of Suburban Areas of Mumbai

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com
Received: 22/10/2011
Accepted: 14/11/2011

Key Words:
Seafood
Heavy metals
Fish
Mumbai suburban markets

ABSTRACT

Seafood is the major source of food of large number of people residing in the coastal areas of Maharashtra. Fish samples namely *Arius dussumieri, Parastromateus niger, Harpadon nehereus, Dasyatis uranak* and *Carcharhinus limbatus* from Virar Market, and *Nemipterus japonicus, Harpadon nehereus, Coilia dussumieri, Johnius sina* and *Megalaspis cordyla* from Bhayender Market were collected directly from the two suburban markets of Mumbai coast. The fish samples were dried in the laboratory and the dried fishes were crushed into a fine powder by mortar and pestle and stored in amber coloured bottles in vacuum desiccators. These samples were later used for determination of the six heavy metals namely zinc, manganese, iron, lead, cadmium and mercury by Atomic Absorption Spectrophotometer. It is reported in the literature that the level of Zn in fishes is generally above the tolerable limits. In the present study it was found that the level of Zn in fishes from Virar and Bhayender markets was also above the tolerable limits. The data for Mn are comparable with the similar data reported by other workers. Iron was the dominant metal measured during the study. From this study, it was found that the concentration of Fe in different species of fishes was quite high as also reported in the earlier literature. Thus, the values of Fe in present study suggest severe contamination in seafood in recent years. The level of Pb, in this study is within tolerance limits. The concentration of Cd in the fishes was far lower than the consumption safety tolerance in fishes set by countries worldwide. According to the results obtained, the Hg level in the fishes was found to be below the tolerance limits. It was also found that the metal ion concentration was having a trend of increasing in winter season as compared to the pre monsoon and monsoon seasons.

INTRODUCTION

Seafood, consisting mainly of fats and proteins, serves as a vital diet for the population of over 14 million people of Mumbai and satellite areas. It is well known that numerous industries around Mumbai discharge their effluents containing toxic substances in the Ullhas estuary, Vasai creek, Thane creek, Mumbai bay and several minor creeks like Manori, Malad and Mahim. The untreated domestic effluents containing high nutrients also enter the sea through eight main outfalls and several non-point sources. Consequently, these areas are reported to be highly polluted.

National Institute of Oceanography has reported high levels of heavy metals in inshore sediments of the creeks. Aniruddha Ram et al. (2003) has reported high levels of mercury up to 1.13 to 6.43 µg/g dry weight in Ullhas estuary. Thane creek was also found to be highly polluted by metals.

The contaminants entering in the sea through constant land based discharge can influence biota by accumulating these contaminants. Chousky (2002) reported the accumulation of PHCs in the range of 1.8 to 8.1 µg/g in the tissues of several species of fishes landed in Mumbai.

Excessive amount of toxic heavy metals intake leads to several diseases (Train 1979). For example, manganese causes tremor and gait disorder; iron causes damage to heart and brain; copper causes sporadic fever, jaundice and anaemia; nickel causes carcinoma of respiratory tract; chromium causes nephritis and anuria; lead causes damage of chromosomes; cadmium causes cerebral damage; and zinc causes retardation of growth and anaemia. These toxic effects may also be introduced to a large Mumbai population after consumption of heavy metal contaminated sea food. Hence, it is necessary to monitor the concentration of these heavy metals in the sea food so that warning signals can be given to the society in case the concentration levels cross the threshold limits.

Earlier studies reveal that the inshore water of the creeks around Mumbai possesses elevated levels of heavy metals, and their consistent input has resulted in high build-up of heavy metals in marine organisms particularly fish. Hence, it is expected that the seafood available around Mumbai may have elevated levels of heavy metals.

At present the population of Mumbai is severely suffering from a number of disorders particularly respiratory and digestive due to contamination of air and drinking water. However, most of these causes have been attended, but toxic effects due to contamination of sea food are not primarily addressed, and completely neglected.

Internationally, several Organizations like Food and Agriculture Organization, FAO (1983)), APHA (1992), US Environmental Protection Agency (U.S.EPA), US Public Health Services (U.S.PHS), U.S. National Academy of Sciences (NAS), etc. have worked on toxicity levels that can influence the human beings on short and long term basis and correlated corresponding symptoms, chronic effects and diseases observed.

Environmental pollution by heavy metals as a result of rapid industrialization has been reported by researchers in different parts of India and other countries (Adrienne & Resmissan 1998, Ansari et al. 1999, Lang et al. 1999, Lottermoser 1998, Govil et al.1999). However, in India, the contamination of sea food has not been seriously studied so far. Only few reports are available on this aspect. The toxicity levels in sea food, the contamination in diet and other relations with various symptoms have not been studied in India. It is, therefore, necessary to determine the extent of contamination in sea food so that the warning can be given to the society in case the threshold limits have reached. The study can also provide the information on possible causes of pollution so that mitigation measures to minimize the pollution can be taken in time.

MATERIALS AND METHODS

Collection of fish samples: Fish samples namely *Arius dussumieri, Parastromateus niger, Harpadon nehereus, Dasyatis uranak, Carcharhinus limbatus* (Virar Market) and *Nemipterus japonicus, Harpadon nehereus, Coilia dussumieri, Johnius sina and Megalaspis cordyla* (Bhayender Market) were collected directly from the two suburban markets in pre monsoon (April-June), monsoon (July-September) and winter (December- March) in year 2009-2010. These samples were brought to the laboratory and washed in distilled water and dried in oven at 80°C. The dried fishes were crushed into a fine powder by glass mortar and pestle and passed through a 2 mm sieve and stored in amber coloured bottles in vacuum desiccators.

Processing of powdered samples: Five grammes of each powdered sample was taken in 250 mL Kjeldahl flask separately. The samples were moist with few mL of distilled water and 15 mL of concentrated HNO_3 and heated on a burner till brown fumes were evolved. Few drops of H_2O_2 were then added to clear the solution to pale yellow. 1-2 mL concentrated HNO_3 was added again and the process was repeated to get a clear solution. It was then filtered through Whatman filter paper No. 40 and washed with distilled water and collected in a 50 mL volumetric flask. A reagent blank was also run simultaneously.

Preparation of standard metal ion solutions: Stock solutions (1µg/mL) of each of the metal ions were prepared using appropriate metal salt of AR grade quality in dilute HCL or nitric acid. The working standards of these solutions were prepared by appropriate dilutions in distilled water.

Metal analysis: The samples were analysed for metals at the Sophisticated Analytical Instrument Facility (RSIC), Indian Institute of Technology (IIT), Mumbai. Atomic Absorption Spectrophotometer was used with appropriate hollow cathode lamps. Air-acetylene gas was employed as per the instructions of the manufacturer.

RESULTS AND DISCUSSION

Zinc: Table 1 shows the range of heavy metals in seafood collected in pre monsoon (April), post monsoon (August) and winter (December) from Virar and Bhayender market. There was wide variation in Zn concentration among species. The mean concentration of zinc was found to be highest in winter season in *Harpadon nehereus* (116.081 ppm) collected from Virar market, whereas lowest mean concentration of Zn was in *Johnius sina* (1.112 ppm) in post monsoon season collected from Bhayender market. It was found that Zn is above the tolerable limits in *Megalaspis cordyla* (21.772ppm), *Nemipterus japonicus* (22.637ppm) from Bhayender market, and Arius *dussumieri* (12.538ppm) and *Carcharhinus limbatus* (8.615ppm) collected from Virar market. The level of zinc was found below the tolerable limit in *Parastromateus niger* (4.911 ppm) and *Dasyatis uranak* (5.710 ppm) collected from Virar market, whereas it was below the tolerable limit in *Harpadon nehereus* (3.096ppm) and *Coilia dussumieri* (6.126ppm) collected from Bhayender market. Denton and Burdon-Jones (1986) reported higher Zn from the livers of these fishes (30.0-44.9 ppm). Similar range of concentration (4.3-41.8ppm) of Zn in the muscles of fish species from the Great Barrier Reef. Hanna (1989) found much higher and wider concentrations of Zn in the muscles (8.4-195.0 µg/g), livers (43-620 µg/g), and gonads (72-259 µg/g) of fishes from the Red Sea. Our data show that Zn levels in the fishes collected from Virar and Bhayender markets from the study area are within the levels reported from the Red Sea and other regions of the world. From the literature and our study it was found that the level of Zn is above the tolerable limits.

Manganese: Manganese is an essential element and survey shows that tolerable limits for Mn in fishes have not been reported since and is subject to some internal regulation in human body. Although Mn is of low toxicity, it has a con-

Table 1: Range of heavy metals in seafood contamination collected in pre monsoon (April-June), monsoon (July-September) and winter (December-March) from Virar and Bhaynder markets in year 2009-2010.

Virar Market																		
	Zn (ppm) n = 3			Mn (ppm) n = 3			Fe (ppm) n = 3			Pb (ppm) n = 3			Cd (ppm) n = 3			Hg (ppm) n = 3		
Sample	Pre M	Mon	Winter	Pre M	Mon	Winter	Pre M	Mon	Winter	Pre M	Mon	Winter	Pre M	Mon	Winter	Pre M	Mon	Winter
Arius dussumieri	12.538	12.232	11.943	0.436	0.211	0.465	14.094	13.987	16.033	0.192	0.071	1.122	0.01	0.01	0.11	0.028	0.011	0.126
Parastro-mateus niger	5.936	4.911	6.138	0.309	0.101	0.421	8.174	7.871	8.914	0.179	0.912	1.064	0.001	0.001	0.009	0.027	0.003	0.131
Harpadon nehereus	112.124	111.989	116.081	0.418	0.115	0.449	20.497	21.011	22.091	0.237	0.711	1.140	0.02	0.01	0.08	0.033	0.012	0.112
Dasyatis uranak	6.793	5.710	7.022	0.223	0.329	0.318	6.391	5.161	6.967	0.12	0.158	0.527	0.03	0.01	0.04	0.018	0.009	0.112
Carcharhinus limbatus	8.615	7.229	8.611	0.259	0.251	0.227	9.155	7.926	10.027	0.22	0.45	0.79	0.016	0.011	0.112	0.022	0.101	0.411
Bhayender Market																		
	Zn (ppm) n = 3			Mn (ppm) n= 3			Fe (ppm) n = 3			Pb (ppm) n = 3			Cd (ppm) n = 3			Hg (ppm) n = 3		
Sample	Pre M	Mon	Winter	Pre M	Mon	Winter	Pre M	Mon	Winter	Pre M	Mon	Winter	Pre M	Mon	Winter	Pre M	Mon	Winter
Nemipterus japonicus	19.533	18.212	22.637	0.224	0.110	0.224	8.112	7.112	9.416	0.122	0.097	0.498	0.004	0.002	0.109	0.025	0.022	0.110
Harpadon nehereus	3.096	4.401	4.772	0.226	0.353	0.226	9.638	8.632	9.121	0.119	0.122	0.643	0.007	0.006	0.104	0.025	0.012	0.096
Coilia dussumieri	6.223	6.126	7.102	0.311	0.289	0.311	10.711	10.986	11.928	0.054	0.096	0.123	0.007	0.003	0.110	0.04	0.09	0.08
Johnius sina	1.971	1.112	1.880	0.233	0.441	0.233	8.817	9.125	10.193	0.064	0.019	0.098	0.01	0.04	0.92	0.04	0.07	0.09
Megalaspis cordyla	21.772	20.259	19.978	0.261	0.262	0.085	23.97	26.011	27.874	0.238	0.429	0.962	0.017	0.011	0.121	0.03	0.01	0.08

n = 3 (Average of three readings); Pre M = Pre Monsoon; Mon = Monsoon

siderable biological significance and seems to accumulate in certain fish species (Eustace 1974, Uthe & Bligh 1971). The highest mean concentration of Mn was recorded in the fish *Arius dussumieri* (0.465 ppm) collected from Virar market, while the lowest mean concentration was recorded in the fish *Dasyatis uranak* (0.223ppm) and *Johnius sina* (0.233ppm) collected from Virar and Bhayender markets respectively. It is evident that the level of Mn was above the tolerable limits as reported by Cross et al. (1973). Cross reported lower Mn concentration (0.20-0.28 µg/g wet weight) in the muscle of the blue fish *P. saltatrix*. Eustace (1974) found that 39 species of marine fish from Derwent estuary in Tasmania, contained up to 0.6- 4.4 µg/g wet weight of Mn when homogenized whole. Wahbeh & Mahasneh (1987) reported higher mean concentrations (5.6-26.8 ppm) in various organs of fish they examined from the same study area within the Gulf of Aqaba. Our data are within the range as reported in literature and do not indicate any particular contamination issue.

Iron: Iron is the dominant metal observed during this study. 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 a wide variation in mean concentrations of Fe among different species of fishes. The mean concentration of Fe was recorded highest in the fish *Megalaspis cordyla* (27.874 ppm) collected from Bhayender market whereas the concentration of Fe waslowest in *Dasyatis uranak* (5.161ppm) collected from Virar market. The mean concentration of Fe was recorded above the tolerable limits in *Arius dussumieri* (16.033ppm) and *Harpadon nehereus* (22.091ppm) collected from Virar market, and *Coilia dussumieri* (11.928ppm) from Bhayender market. The mean concentration of Fe was below the tolerable limits in *Parastromateus niger* (7.871ppm) and *Carcharhinus limbatus* (7.926ppm) collected from virar market, and *Nemipterus japonicus* (7.112ppm), *Harpadon nehereus* (8.622ppm) and *Johnius sina* (8.817ppm) collected from Bhayender market. Similar variations were also found by Wahbeh & Mahasneh (1987) in fish species from the Gulf of Aqaba. On the other hand, Cross et al. (1973) reported lower mean levels of Fe in the muscles of the blue fish, *Pomatomus saltatrix* (4.5-5.0 µg/g wet weight). From our study, it is found that the concentration of Fe in different species of fishes correlate with the earlier data reported in the literature. Thus, the values of Fe in the present study are high in seafood and suggest long term contamination in recent years.

Lead: 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 (1990) has established a provisional tolerable weekly intake (PTWI) of lead as 25 μg/kg body weight for humans, equalling 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 were from 0.12 ppm to 1.140 ppm collected from Virar market, and 0.054ppm to 0.643 ppm collected from Bhayender market. The fact that toxic metals are present in high concentrations in fishes is of particular importance in relation to the FAO/WHO (1976) standards for lead as toxic metal. The maximum permissible doses for an adult are 3 mg lead per week, but the recommended sources are only one-fifth of those quantities. Lead is a neurotoxin that causes behavioural defects in vertebrates (Weber & Dingel 1997) and can cause decrease in survival, growth rates, learning and metabolism (Eisler 1988, Burger & Gochfeld 2000). Levels of 50 ppm 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 level of lead is within the prescribed tolerable limits.

Cadmium: The concentration of cadmium in marketed fishes in the present study was found to be far lower than the consumption safety tolerance in fishes set by countries wordwide. The mean concentration of Cd in fishes ranged from 0.001ppm to 0.112ppm in fishes from Virar market, and from 0.004ppm to 0.110ppm in fishes from Bhayender market. These values are below the range reported by Hanna (1989). Cadmium is accumulated primarily in major organ tissues of fishes rather than in muscles (Moore & Ramamurthy 1984). In contrast, Cd levels in muscles of fish from the Great Barrier Reef were consistently lower than 0.1ppm (Denton & Burdon Jones 1986), while in liver of *Mullus barbatus* and *Sardinella aurita*, Cd concentrations were 0.6 ppm to 0.7 ppm (Roth & Hornung 1977). In general, it can be stated that the concentrations of Cd, found in the present study, are below the tolerable level as those of uncontaminated fish (< 1.5) reported by Moore & Ramamurthy (1984).

Mercury: According to the results obtained, the mercury levels in the samples of the fishes were found to be below the tolerable limits than the permissible level, i.e., 1 ppm (WHO, FDA Consumer, September 1994). The Food and Drug Administration (FDA) has set a maximum permissible level of 1 ppm. The higher level of mercury can be attributed to the sewage-sludge outfall present along this western coast, which also includes treated industrial effluents. It is possible that though the sewage-sludge was treated, traces of heavy metals might have leached into the sea. Fish analysed from Virar and Bhayendar markets showed normal mean levels which were in the range of 0.018 to 0.411 ppm. In case of Virar market, mercury levels range from 0.018 ppm to 0.411ppm and in Bhayendar market, the mercury levels were found to be in the range of 0.025 to 0.110 ppm. The PTWI (permissible tolerable weekly intake) of mercury has been set at 5 μg/kg body weight (FAO-WHO 1972), equalling 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 be converted into organic mercury. Microbes subsequently concentrate mercury through food chains in the tissue of fish and marine animals (Altindag & Yigit 2005).

CONCLUSION

It can be concluded from the study that the metal contamination in fish brought from the two selected markets was within the permissible level except Zn, Fe and Pb in few cases. It can be assumed that the sea around that part is receiving industrial outfalls and sewage from the city. It was also found that there is an increasing trend in metal concentration in winter season as compared to the pre monsoon and monsoon seasons. These elemental toxicants may be transferred to man on consumption of fish obtained from the market posing health hazards. Though the fish 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 the Arabian Sea and pollution of water should be monitored periodically to avoid excessive intake of trace metals by humans. In view of these findings, strict method of waste disposal should be adopted to ensure safety of the environment and to safeguard the 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-400076, for providing facilities of Atomic Absorption Spectrophotometer (AAS) for the analysis of samples.

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