Seasonal pattern of heavy metals levels in vegetable and fish species collected from East Kolkata Wetlands (EKW)

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Abstract: *Seasonal monitoring of commonly edible vegetable and fish specimens are carried out for toxic heavy metals during the scope of present research. The samples were collected from East Kolkata Wetlands, a designated Ramsar Site of West Bengal, India. It is also a food basket in the peri-urban space of metropolitan city of Kolkata. The samples were analyzed for pre-monsoon and monsoon seasons of 2017. The toxic heavy metals analyzed for this study were lead, cadmium, chromium and mercury. Our results conclusively reveal that the accumulation of toxic heavy metals in fish samples is well below global standards. Hence, the consumption of fishes is safe. However, for vegetables the levels are alarmingly higher and require immediate season wise monitoring and assessment. The consumption of vegetables also requires proper guidelines as recommended by FAO/WHO.*

Key Words: *heavy metals, vegetables, fishes, East Kolkata Wetlands, seasonal monitoring.*

1. INTRODUCTION:

Exposure to environmental pollutants is an important problem of environmental toxicology (Zukowska et al., 2008). Terrestrial and aquatic ecosystems are most vulnerable to pollution due to series of factors including toxic heavy metals that leads to bioaccumulation at different trophic levels (Boran and Altınok, 2010). The term ‘heavy metal’ refers to any metallic element that has relatively high density and is toxic even at low concentration. Natural and anthropogenic activities, for example, solid-waste disposal, atmospheric deposition, and the application of sewage sludge and waste water irrigation on land are the main sources of heavy metal contamination in the environment (Cui, et al., 2005; Komarnicki, et al., 2005). The contamination of aquatic and terrestrial ecosystems with a wide range of pollutants and especially heavy metals has become a matter of concern over the last few decades (Vutukuru, 2005; Dirilgen, 2001; Voegborlo, et al., 1999; Canli, et al., 1998; Janssen, et al., 1993). Heavy metal contamination may have devastating effects on the ecological balance of the recipient environment and a diversity of aquatic organisms (Farombi, et al., 2007; Vosyliene and Jankaite, 2006; Ashraj, 2005). The natural aquatic systems may extensively be contaminated with heavy metals released from domestic, industrial and other man-made activities (Velez and Montoro, 1998; Conacher, et al., 1993). Heavy metals are both extremely toxic and ubiquitous in natural environments and they occur in soil, surface water and plants, and it is readily mobilized by human activities such as mining and dumping industrial waste in natural habitats such as forests, rivers, lakes, and ocean (Larison et al., 2000). Similarly, heavy metal accumulation in soil interrupts the normal functioning of soil ecosystems and plant growth. (Khan et al., 2008; Khan et al., 2008). Heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg) and chromium (Cr) generally refer to metals having densities greater than 5 g/cm^3 (Oves et al., 2012). These heavy metals have toxic effects on human health. Generally, heavy metals create toxic effect by forming complexes with organic compounds (Akbulut et al., 2011). Lead can adversely influence the intelligence development of children, cause excessive lead in blood, and induce hypertension, nephropathy and cardiovascular disease (Goyer, et al., 1993; Ekong, et al., 2006; Navas, et al., 2007). Cadmium is considered as phytotoxic as it inhibits plant growth parameters including respiration, photosynthesis and water and nutrient uptake (Kuo, et al., 2006). Chronic Cd exposure can cause acute toxicity to the liver and lungs, induce nephrotoxicity and osteotoxicity, and impair function of the immune system (Klaassen, et al., 1999; Klaassen, et al., 2009; Patrick, 2003). The cumulative deleterious effects of chromium (Cr) at various *vital* functional sites like metabolic rate, hematological indices and biochemical profiles are observed (Vutukuru, 2005). The toxic effects of mercury on edible crops and vegetables are humongous leading to far reaching consequences. Hg and Pb are associated with the development of abnormalities in children (Gibbes and Chen, 1989). Among organic Hg species, methylmercury (MeHg) is the most abundant, and is bioaccumulated by aquatic organisms and biomagnified through the food chain (Kojadinovic, et al., 2006). Some other heavy metals such as copper (Cu), zinc (Zn), chromium (Cr), manganese (Mn) lie in the narrow ‘window’ between their essentiality and toxicity, *i.e*., they are nutritionally essential at lower levels but can also be toxic when certain limits are exceeded (Loutfy et al., 2012). Vutukuru (2005) studied the toxic effects of hexavalent chromium and the metal induced cumulative deleterious effects at various functional levels in the widely consumed freshwater fish, *Labeo rohita*. When heavy metals are dispersed into water, soil and air, they could be bioaccumulated by the crops (Fu, et al., 2008; Xiu, et al., 2009) as well as in the fishes *via* aquatic medium (Lorenzon, et al., 2001; Akan, et al., 2012; Mitra, et al., 2014; Arantes, et al., 2016; Dutta et al., 2017). The current paper attempts to study the toxic heavy metal levels such as lead (Pb), chromium (Cd), cadmium (Cr) and mercury (Hg) in commonly edible fishes and vegetables found in East Kolkata Wetlands (EKW)- a designated Ramsar site in Kolkata, West Bengal India.

Vegetables play important roles in human nutrition and health, particularly as sources of vitamin C, thiamine, niacin, pyridoxine, folic acid, minerals, and dietary fibres (Siegel, et al., 2014). Heavy metal in vegetables is of growing concern since some soils and irrigation waters are demonstrated to be polluted (Sipter, et al., 2008). Vegetables easily take up heavy metals and accumulate them in their edible parts (Sipter, et al., 2008). Once vegetables containing high levels of heavy metals are consumed by human, such metals can cause several clinical and physiological problems (Khan, et al., 2008; Kumar, et al., 2007). Fishes mostly have a tendency to bioaccumulate heavy metals and humans can be at great risk sometimes even lethal, through contamination of the food chain (Ui, 1972). The changes in the metal concentration in the different tissues of aquatic fauna are associated with metal concentration in eco system, time of exposure, ecological needs, metabolic processes, feeding habits, salinity, temperature and interacting agents (Mathana, et al., 2012). Heavy metals such as Cd and Pb have been shown to have carcinogenic effects (Trichopoulos, 1997). High concentrations of heavy metals (Cu, Cd and Pb) in fruits and vegetables were related to high prevalence of upper gastrointestinal cancer (Turkdogan et al., 2002).

Simple correlation analysis by (Ye, et al., 2015) revealed that there were significantly positive correlations between the metal concentrations in vegetables and the corresponding soils, especially for the leafy and stem vegetables such as pakchoi, cabbage, and celery. This study by (Ye, et al., 2015) further reveals that Bio-Concentration Factor (BCF) values for Cd are higher than those for Pb and Cr, which indicates that Cd is more readily absorbed by vegetables than Pb and Cr. Therefore, more attention should be paid to the possible pollution of heavy metals in vegetables; especially Cd. Knowledge of acute toxicity of a xenobiotic often can be very helpful in predicting and preventing acute damage to aquatic life in receiving waters as well as in regulating toxic waste discharges (APHA, 1998). The edible vegetables grown in wastewater-irrigated soil shows significant accumulation of heavy metals in their edible parts (Gupta, et al., 2010; Gupta, et al., 2008).

The present paper is an attempt in this direction to evaluate the seasonal variation of four common toxic heavy metals Pb, Cd, Cr and Hg in three species of finfishes such as *Catla catla, Labeo rohita* and *Oreochromis niloticus* as well as in three species of commonly consumed vegetables such as *Ipomoea aquatica*, *Brassica oleracea* and *Raphanus sativus*.

2. METHODOLOGY:

2.1 Description of study area

East Kolkata Wetlands (EKW) is situated at the eastern outskirts of the mega city of Kolkata, India (22°27′00″N and 88°27′00″E). It is the designated Ramsar Site of West Bengal and is of utmost ecological significance. It has a geographical area of 12, 500 ha and has an elevation of approximately 2 m (G.T.S.). The wetlands to the east of Kolkata are well known over the world for their multiple uses. The resource recovery systems developed by the local people through ages using wastewater from the city is the largest in the world. It is a natural wastewater treatment plant and largest stretch of aquaculture belt in the world. As identified by Ramsar Secretariat, the East Calcutta Wetlands basically consists of three components:

- The core area which includes the fish pond systems, where waste water treatment (domestic sewage of the city) and fishing activities take place.
- The garbage farming land where different types of seasonal vegetables are cultivated during wastewater irrigation from intermittent ponds where wastewater is settled for purification.
- Paddy cultivation area where paddy cultivation is practiced in regular course.

The metropolitan city of Kolkata lies on the fringes of this vast wetlands and the wastewater from the city naturally drains through the innumerable fish ponds in the wetland covering an area of about 4000 hectares. These ponds act basically as solar reactors and form a natural reservoir of solar energy. The East Kolkata Wetlands is thus one of the rare examples of ecologically dynamic and socio-economically significant ecosystem. The huge peri-urban population is economically dependent on this ecosystem by mastering the resource recovery activities. The humongous proportions of vegetables grown in dumping lands turned agricultural fields and rich variety of fishes grown in the innumerable fish ponds locally termed as *bheries* are nourished by water and soils historically rich in toxic heavy metals and hazardous chemicals. The food security challenges and issues associated with ever burgeoning populations of Kolkata and outskirts are fulfilled by the farm productivity of the wetlands. Bioaccumulation studies on

East Kolkata Wetlands are carried out on previous occasions. (Chattopadhyay et al., 2002; Bhattacharyya, et al., 2015; Dutta, et al., 2016; Dutta, et al., 2017).
The present sampling site was selected at *Natur Bheri* (22^0 32′ 49.9″ N to 88^0 25′ 30.1″ E) which is one of the innumerable bheries located in East Kolkata wetlands- the designated Ramsar site of Kolkata, West Bengal.

2.2 Sample collection and analysis

The sample collection was carried during premonsoon and monsoon season of 2017 from the study site. Vegetable samples were collected from the agricultural plots in East Kolkata Wetlands. About nine to ten vegetables samples were stored in polyethylene bags in the field and the samples were transferred to the laboratory as early as possible. The edible portions of the vegetables were removed separately and oven dried overnight at 105^0C. After complete drying, the remaining portions were powdered and stored separately by labeling the samples. 1 gm of dried portion (in three replicates) was mixed in 10ml solution of HNO_3 and HCl in the ratio 1:3 to form Aqua-regia solution. The solution was stirred for few minutes and kept for overnight. The flasks were then placed on a hot plate with tightly corked and allowed to digest until a transparent and clear solution was obtained. This solution was separately aspirated in Atomic Absorption Spectrophotometer with Hydride module (NOVA 350 Model) and the readings were recorded considering the blank correction.

Fish specimens were collected from *Natur bheri* (one of the innumerable bheries of East Kolkata Wetlands). About five to eight fishes of each species were collected and brought in ice freezed condition (temperature -200 c) in the laboratory. Five to eight samples are basically the merging of ten sub-samples and hence n=50-80. The muscle tissues of each species were removed separately and oven dried overnight at 105^0C. After complete drying, the fish muscles were powdered and stored separately by labeling the samples. 1 gm of dried tissues (in three replicates) was mixed in 10ml solution of HNO_3 and $HClO_4$ in the ratio 5:1. The solution was stirred for few minutes and kept for overnight. The flasks were then placed on a hot plate with tightly corked and allowed to digest until a transparent and clear solution was obtained. The use of microwave-assisted digestion appears to be very relevant for sample dissolution, especially because it is very fast (Nadkarni, 1984; Matusiewicz, et al., 1989; Guardia, 1990). This solution was separately aspirated in Atomic Absorption Spectrophotometer with Hydride module (NOVA 350 Model) and the readings were recorded considering the blank correction. All the values are expressed in ppm (parts per million) of dry weight of the samples.

3. RESULTS:

The current study reveals that bioaccumulation values of heavy metals in both vegetables as well as fish samples is much higher in monsoon season than in premonsoon (Table 1- 6). Among the vegetable samples, the values show the trend in descending order *Ipomoea aquatica*> *Raphanus sativus*>*Brassica oleracea* for both monsoon and premonsoon. Among the fish samples, the values show the descending trend *Oreochromis niloticus*> *Labeo rohita*> *Catla catla.* The bioaccumulation trend of toxic heavy metals show the order lead (Pb) > cadmium (Cd) > chromium (Cr) > mercury (Hg) irrespective of all species.

Table 1: Accumulation of Pb, Cd, Cr and Hg in *Ipomoea aquatica* during premonsoon (PM) and monsoon (M)

Name of Species	Season during 2017	Pb (ppm dry wt.)	Cd (ppm dry wt.)	Cr (ppm dry wt.)	Hg (ppm dry wt.)	WHO levels in (ppm)
Ipomoea aquatica	PM	17.2	5.23	1.35	1.07	Pb: 0.001 Cd: 0.002 Cr: 0.001 Hg:0.0003
	M	29.61	9.67	4.16	1.33	

Table 2: Accumulation of Pb, Cd, Cr and Hg in *Brassica oleracea* during premonsoon (PM) and monsoon (M)

Name of Species	Season during 2017	Pb (ppm dry wt.)	Cd (ppm dry wt.)	Cr (ppm dry wt.)	Hg (ppm dry wt.)	WHO levels In (ppm)
Brassica oleracea	PM	3.19	1.92	0.98	0.81	Pb: 0.001 Cd: 0.002 Cr: 0.001 Hg:0.0003
	M	4.61	3.02	1.35	0.99	

Table 3: Accumulation of Pb, Cd, Cr and Hg in *Raphanus sativus* during premonsoon (PM) and monsoon (M)

Name of Species	Season during 2017	Pb (ppm dry wt.)	Cd (ppm dry wt.)	Cr (ppm dry wt.)	Hg (ppm dry wt.)	WHO levels in(ppm)
Raphanus sativus	PM	9.34	2.17	1.33	0.94	Pb: 0.2 Cd: 0.1 Cr: 0.001 Hg:0.03
	M	13.69	3.65	1.66	1.16	

Table 4: Accumulation of Pb, Cd, Cr and Hg in *Labeo rohita* during premonsoon (PM) and monsoon (M)

Name of species	Season during 2017	Pb (ppm dry wt.)	Cd (ppm dry wt.)	Cr (ppm dry wt.)	Hg (ppm dry wt.)	Choi (2011) recommendations (ppm dry wt.)
Catla catla	PM	1.05	0.99	0.71	0.37	Pb: 6 Cd: 2 Cr: 1 Hg: 0.5
	M	1.66	1.37	0.89	0.73	

Table 5: Accumulation of Pb, Cd, Cr and Hg in *Catla catla* during premonsoon (PM) and monsoon (M)

Name of species	Season during 2017	Pb (ppm dry wt.)	Cd (ppm dry wt.)	Cr (ppm dry wt.)	Hg (ppm dry wt.)	Choi (2011) recommendations (ppm dry wt.)
Labeo rohita	PM	1.98	1.05	0.89	0.68	Pb: 6 Cd: 2 Cr: 1 Hg: 0.5
	M	4.38	1.66	1.02	0.77	

Table 6: Accumulation of Pb, Cd, Cr and Hg in *Oreochromis niloticus* during premonsoon (PM) and monsoon (M)

Name of species	Season during 2017	Pb (ppm dry wt.)	Cd (ppm dry wt.)	Cr (ppm dry wt.)	Hg (ppm dry wt.)	Choi (2011) recommendations (ppm dry wt.)
Oreochromis niloticus	PM	2.02	1.14	0.94	0.71	Pb: 6 Cd: 2 Cr: 1 Hg: 0.5
	M	4.49	2.05	1.11	0.94	

4. DISCUSSION:

Vegetables and fishes form the most important sources of essential nutrients, minerals and vitamins essential for human body. They form the staple diet for millions of people worldwide due to their nutritional benefits, easy availability and mass production across almost all agro-climatic zones of the world. Fishes are an important source of food and animal protein. It is majorly consumed as a staple diet by population living in the lower Gangetic belt of West Bengal, our study area. Therefore, the levels of contaminants in fishes are of particular interest as well as on their consumers present in the trophic level (Burger and Gochfeld, 2005). Continuous use of inorganic fertilizers and pesticides although increased the global food production by many folds, have degraded the ecological functioning of agricultural lands, lowered the quality and taste of agricultural produce and have increased the health and environmental risks to human being (Tilman et al. 2001). The samples chosen for our current research are commonly grown and consumed in the study site. The study stations form one of the major sources of the vegetables and fishes largely consumed by people across Kolkata and outskirts. A major portion is also exported across the country and abroad. Hence, it is extremely essential to monitor and assess the levels of toxic substances, particularly heavy metals that bioaccumulate across the trophic levels of the dynamic ecosystem. The present data of toxic heavy metals such as Lead (Pb), Cadmium (Cd), Chromium (Cr), Mercury (Hg) as revealed during study of seasonal variations in 2017 is much less than permissible limits in fish species as suggested by (Choi, 2011). Hence, the fish species are safe for human consumption. In case of vegetables, the current data shows the levels of toxic heavy metals are higher in the samples when compared with WHO/FAO recommended levels (1999). Immediate monitoring of all point sources is to be carried out in and around our study site to keep a track on the bioaccumulation pattern and trend in edible vegetables and fishes to avoid any adverse effect on human health. More such seasonal studies are to be carried out in East Kolkata Wetlands on a temporal scale to assess and monitor the environmental health (particularly with respect to conservative pollutants) across different trophic levels in this unique ecosystem.

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