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Mercury contamination in urban ecosystem – a case study in and around Kolkata metropolis, West Bengal, India

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Abstract

Mercury has a unique place in the field of pollution and toxicity. The mercury contamination increased day by day in urban environment through anthropogenic activities. The mercury accumulated in the urban environmental components and its toxicity has adverse effect on the urban ecosystem health. A study was carried out to estimate the mercury contamination in water, soil, road dust, plant, vegetable and fishes in Kolkata metropolis. The studied samples have found mercury residue in considerable amount which may affect to ecosystem tropic level and human health in and around the Kolkata metropolitan city.

Keywords: Kolkata, mercury, neurotoxic, toxicity.

Introduction

Mercury has recognized a well known environmental toxic elements and popular in pollution history of world due to the Minamata incident in Japan. The mercury is found in nature in five main forms, i.e. divalent mercury, metallic mercury, phenyl mercury, alkoxy alkyl mercury and methyl mercury. The methyl mercury is the most toxic form available in environment and readily accumulates in biological organisms. Mercury is a highly neurotoxic compound and one of the six most dangerous chemicals in the world's environment (Chang, 1977; Clarkson, 1987; Louria, 1992; IRIS, 1993). In recent years the use of mercury and its associated compounds has been increased in industrial, medical and agricultural sectors. The wide use of mercury has been resulted its accumulation in different environmental components and translocated through food chain in different tropic levels and risk to human and ecosystem (Samal et al., 2002; Shastri and Diwekar, 2008). The accumulation of mercury and other heavy metals in plants, vegetables, fishes, meat of urban areas has been reported by various workers. (Wang and Wai, 1996; Sadhukhan, et al., 1997; Deb and Santra, 1997; Ribeiro et al., 2000; Kar et al., 2006; Driscoll et al., 2007; Bhattacharyya et al., 2010; Kar et al., 2010; Monteiro et al., 2010; Jha et al., 2016). The plants and vegetables are capable to absorbing mercury from the contaminated environment and translocation it through the tissue (Bhattacharya, 2015).

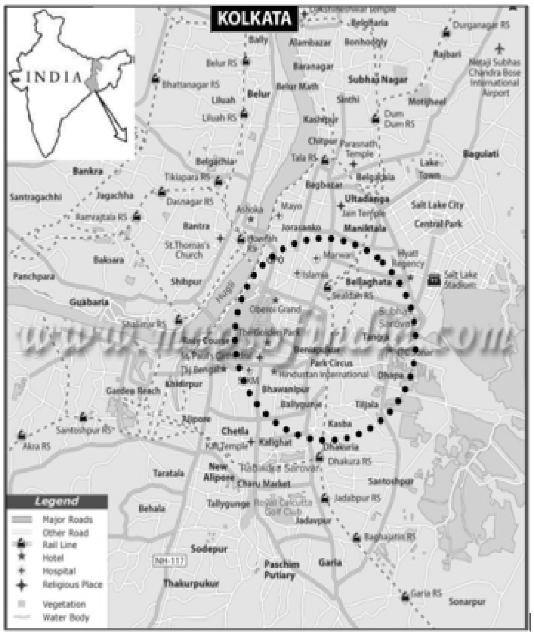
The common features of methyl mercury poisoning include parenthesis (number and tingling), progressive in coordination, loss of vision, hearing and intellectual deterioration. The symptoms are irreversible when exposure is server. Acute exposure to inorganic mercury compounds is rare and symptoms (acute gastroenteritis and severe kidney damage) are different from those of methyl mercury poisoning. The inhalation of inorganic mercury vapour may cause injuries in the respiratory tract and oral cavity, characterized by sore mouth, ulcerated gums, coughing, bronchial inflammation, chest pains, vomiting, excitement, tremors, irritability, diarrhea and respiratory arrest. Longer exposures may lead to death. In 2001 US-EPA revised the reference dose for methyl mercury of 0.1 µg/kg/day. The chronic mercury poisoning, mostly caused by occupational exposure involves injury of the central nervous system, followed by tremor of the hands and other parts of the body, physic disturbance, decreased productivity, increased fatigue, loss of memory and self confidence and injury to the kidney(Fergusson, 1990; Ghosh, 2016).

The present investigation was planned with the aim to estimate the residual mercury in urban environment of Kolkata metropolis and its risk to the ecosystem.

Materials and Methods

Study area

The central part of the Kolkata metropolitan city selected for the present study. Samples are collected from different locations of central Kolkata i.e., Dharmatala, Park-street and Maidan and for aquatic sampling the East Kolkata wetland has chosen (map 1). There is huge anthropogenic activity with industrial and heavy vehicular pressure occurred in these areas.



(Map downloaded from: www.mapsofindia.com)

Map 1. Sampling location indicated by dotted circle (not to scale).

Sample collection and preservation

The samples like, soil, road dust and the biological samples like, grass, plant leaves are collected from the central Kolkata locations.

The water, soil, vegetables, fish and meat samples were collected from East Calcutta wetland areas near to the eastern metropolitan bypass. Samples were collected from two different seasons, the Pre Monsoon and Post Monsoon with three replicates.

The road dust samples are collected by sweep the road with brush and collected the sample in zipper polythene packet. The soil samples were collected from the road side and cultivated field in zipper polythene packet form the depth of 10-20 cm. In a particular sampling site, 3 to 4 samples were collected and then thoroughly mixed to get the homogeneity and kept with air tight packet with proper leveling.

The grass samples were collected by uprooting and transported to laboratory in polythene pack for further analysis. The leaves of different road side plant were collected in polythene pack from the sampling location for lead analysis in laboratory. The water samples from the wetland are collected in polythene bottle and add nitric acid to maintain pH-2 for further analysis in laboratory. The edible parts of the vegetable samples were collected from the agricultural fields in polythene pack and transported to laboratory. The fish samples were collected from the fishery pond and transport to laboratory in Ice box. The goat meat samples are collected from the local meat shop and transport to laboratory in Ice box.

Sample preparation and analysis

The soil and dust samples were dried, crushed and sieved for further analysis total mercury. The biological samples like, leaves, grass, vegetables were thoroughly and repeatedly washed, dried at 60°C for two days to achieve constant weight and then grounded to a fine powder by using motor and pastel and kept in desiccators. The muscle tissues of fish and meat were removed and washed with deionized water, dried at 60°C in hot air oven, homogenized to a fine powder, and kept in desiccators for further analysis of total mercury.

About 0.5 - 1g of sample was taken in a round bottom flask added 10–12 ml of concentrated nitric acid and 1–2 ml of sulfuric acid and digested through a Bethge's apparatus. The mercury was determined by a cold-vapour atomic absorption spectrophotometer (Mercury Analyzer-5840, ECIL, detection limit 0.1 μg/l) at 253.6 nm using 20% $SnCl_2$ and 10% HNO_3 (APHA, 1995).

Results and Discussion

The mean concentrations of the total residual mercury in the water, soil, plant, vegetables, fish and meat samples of the study area are showed in the Table 1 and Fig. 1. The water sample contains the mercury concentration 0.06ppm. The U.S. EPA set the maximum contaminant level goals (MCLG) for drinking water is 0.002 mg/L or 2 ppb. The mercury content in soil was found to be 1.44ppm. Among the plants Debdaru leaves found very high residual mercury (1.22ppm). These roadside plants are continuous exposed to the polluted environment at low height. The other roadside plants Banian and Katbadam accumulated significant amount of mercury and these plant leaves are situated more height than Debdaru plant. All the vegetable samples found significant concentration of residual mercury in the range of 0.16 to 0.74ppm. Samal et al., (2002) found the similar results from analyzed mercury residue in marketable vegetables from West Bengal. The residual mercury content of Tilapia fish and goat meat was found 0.94 and 0.90 ppm respectively. Mercury concentration in collected fish ranged from to 0.073 to 0.94

Table 1. Mercury residue in different samples (Mean ± SD).

Sample type	Mercury residue (ppm)
Water	0.06± 0.002
Soil	1.44±0.070
Road Dust	0.54±0.023
Grass	0.70±0.030
Banyan (*Ficus bengalensis*)	1.08±0.050
Debdaru (*Polylthia longifolia*)	1.22±0.060
Katbadam (*Terminalia catappa*)	0.96±0.040
Lettuce (*Lactuca sativa*)	0.16±0.007
Raddish (*Raphanus sativus*)	0.64±0.028
Cucurbita (*Cucurbita maxima*)	0.74±0.037
Basella (*Basella alba*)	0.50±0.022
Brinjal (*Solanum melongena*)	0.44±0.022
Cauliflower (*Brassica oleracea* var. *botrytis*)	0.56±0.028
Tilapia fish (*Oreochromis* sp.)	0.94±0.041
Goat meat	0.90±0.040

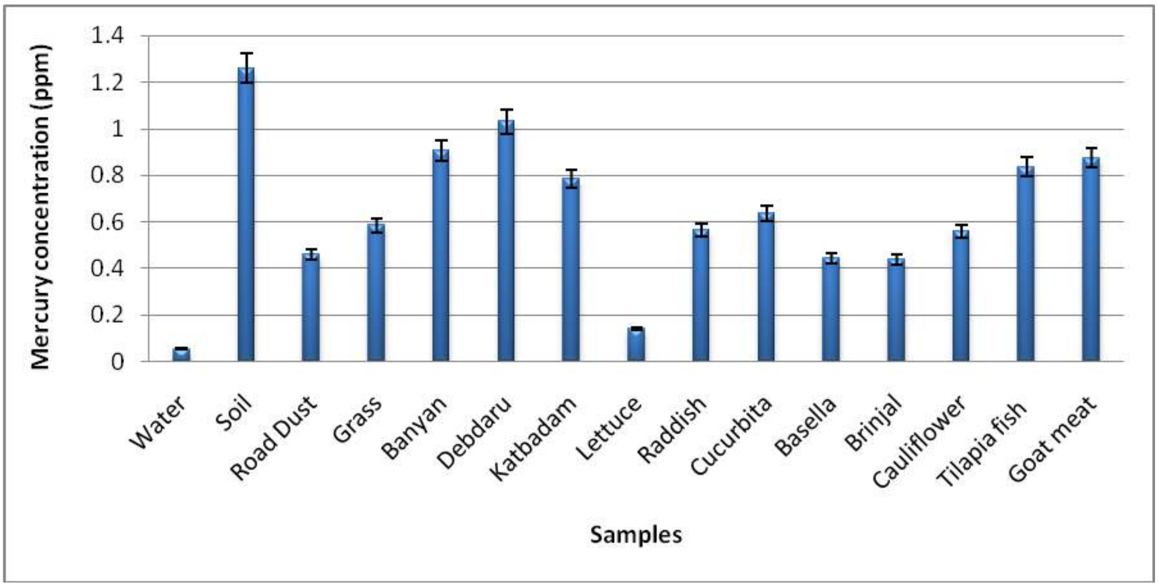


Fig. 1. Mercury residue in environmental components in the studied area.

µg/g was reported by Bhattacharya et al., (2010) from East Calcutta Wetlands and Titagarh Sewage fed Aquaculture in West Bengal. In our previous study from Dhapa area near East Calcutta Wetlands found the mercury concentration in Tilapia, Mrigel and Rohu was 0.90, 0.75 and 0.875ppm respectively (Samal et al., 2002). The mercury enters water, biological process transform it to a highly toxic form that builds up in fish and animals that eat fish. Methyl mercury accumulates in fish, with larger fish generally accumulating higher levels of methyl mercury. Fish appear to find methyl mercury strongly and is biological half life in fish is on the order of two years.

Conclusion

Mercury is a naturally occurring element that is present throughout the environment. Anthropogenic activity can release some of that mercury into the environment. Accumulation and bio-magnification of mercury in environmental components cause great hazard for the human beings and non human targets. Proper identification, monitoring and management of threats and sources the hazardous contaminants are very much essential in the urban environment. The present study revealed that there is significant concentration of residual mercury present in different environmental components like, soil, water, plant, vegetables, fishes and meat in Kolkata metropolis area. The sources of contamination like automobile and industrial emission should be taken care off. The human exposure and risk assessment of this toxic contaminant should be detail studied. The control and remediation process through research and development programmes should be encouraged to minimize the hazardous toxic pollutants for a sustainable better environment.

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