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An investigation of lead in urban environment of Kolkata city, India

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Abstract

The lead heavy metal is an important environmental pollutant particularly in the urban areas with high anthropogenic pressure like vehicular and industrial. Its presence in the atmosphere, soil, water and biological systems even in traces can cause serious problems to all living organisms and its bio accumulation in the food chain especially can be dangerous to the human and animal health. The lead accumulation and exposure by human populations through contaminant environment and food chain has been reported widely all over the world. The lead is the well known environmental contaminants which may be deposited on the surfaces and then adsorbed into the tissues of crops and vegetables. Plants can uptake lead by absorbing them from deposits on the parts of the plants exposed to the polluted environment as well as from contaminated soil. In this study we have analyzed the lead contamination in different environmental components like water, soil, road dust, plants, vegetables and fishes in and around Kolkata metropolitan city. There are considerable amount of lead found in every environmental component and its management and remedial measures should be urgently needed for better environmental health in urban environment.

Keywords: Environmental pollutant, heavy metal, Kolkata city, lead accumulation.

Introduction

Lead (Pb) has been recognized as toxic metal having health hazard for centuries. One of the most studied metals; much information has been accumulation on its toxicity which is caused by acute or chronic environmental exposure. Lead toxicity causing adverse effects to human health includes: neurological, reproductive, renal, and hematological. Children are more sensitive than adults to the effects of lead (Juberg, 2000).

Lead moves into and throughout ecosystems and contaminated the vegetation, air, water and soil. The chemical and physical properties of lead and the biogeochemical processes within ecosystems will influence the movement of lead through ecosystems. Lead accumulates in the environment, but in certain chemical environments it will be transformed in such a way as to increase its solubility (e.g., the formations of lead sulfate in soils), its bioavailability or its toxicity. The effects of lead at the ecosystem level are usually seen as a form of stress (US EPA, 1986). The major source of lead contamination in air includes burning of fossil fuels, gasoline burning, cement manufacture metallurgical additives, iron and steel and foundries. Lead enters the aquatic environment through sedimentation and rainfall containing atmospheric lead, urban storm water runoff (specially from industries and highway sectors), industrial effluents arising from planting units, and from paper, rayon, dye, pigment, chemical, fertilizer, ghee and battery industries and mine drainage.

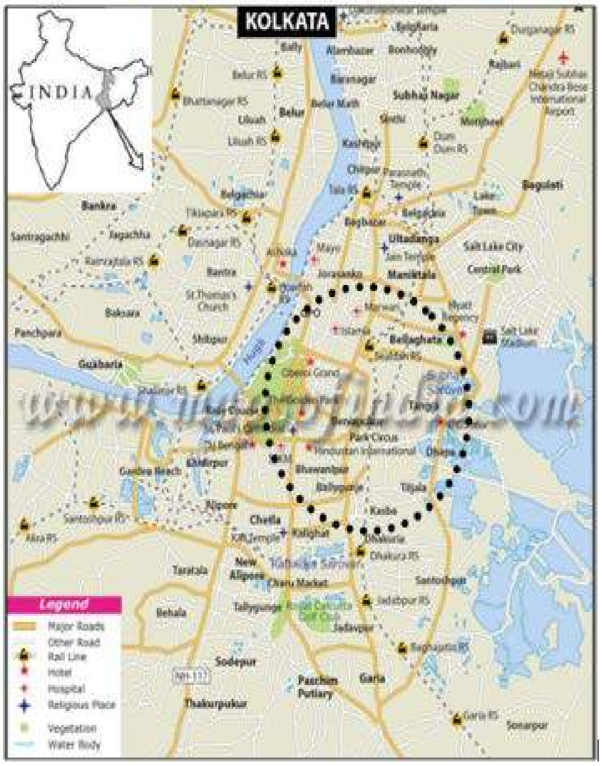
There are various types of human exposure has been possible such as, paints, cooking and storage vessels containing lead (tinned polish), cans, ceramic pottery with painted lead glaze, country liquor, beverages, food adulterant in ice-cream, drinking water, contaminated food etc. Lead in the food chain comes mostly from direct deposit from the air to plants and from livestock eating soil laced with Pb as they eat the plants. The average rate of absorption of dietary lead is about 8%, but about 40% of the fine particulate lead retained in the lungs is absorbed. Lead intake is increased by about 5% for every 20 cigarettes smoke per day. The absorbed lead enters the bloodstream, where over 90% is bound to the red-blood cells with a mean residence time of one month. Lead binds strongly to a large number of molecules, such as amino acids, hemoglobin many enzymes, RNA and DNA, it thus disrupts many metabolic pathways (O'neill, 1998). Heavy metal pollution of the environment, even at low levels, and their resulting long-term cumulative health effects are among the leading health concerns all over the world (Oluyemi et al., 2008).

The rapid and unorganized urbanization have led to the high accumulation of heavy metals and organic pollutants in soil, water, sediment, street dust, as well as organisms in urban areas (El-Hasan et al., 2002; Wei and Yang, 2010; El Nemr, 2010; Chaudhari et al., 2012; Hou et al., 2013; Hu et al., 2013; Li et al., 2013; Sedky et al., 2013). Due to their toxicity, bioaccumulation, persistence, and biomagnifications through food chains, heavy metals posed a potential threat to ecological system and human health, and gradually drew a wide concern (El-Sikaily et al., 2004, 2005; Luo et al., 2012; Pan et al., 2016). Urban area open dumps are a source of various environmental and health hazards. There is a recent challenge to determine how specific features of the urban environment influence the well-being of city dwelling organisms, including humans (Pataki, 2015). The present study was planned with the aim to investigate the ecosystem risk to lead in urban environment of Kolkata city.

Materials and Methods

Study area

The centre of the Kolkata city selected for the sampling. For the sampling site of terrestrial sampling the area of central Kolkata i.e. Dharmatala, Park-street, Maidan has been chosen and for aquatic sampling the East Kolkata wetland has chosen (map 1). Lots of anthropogenic activity with heavy vehicular pressure occurred in this area.



Map 1. Sampling location indicated by dotted circle (not to scale).
(Map downloaded from: www.mapsofindia.com)

Sample collection and preservation

The abiotic samples like, soil and road dust and the biotic samples like, grass, plant leaves are collected from the central Kolkata sites. The water, soil, vegetable and fish 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.

Sample preparation and analysis:

The soil and dust samples were dried, crushed and sieved and 0.5gm of sample was digested with HNO_3: H_2SO_4 (2:1) mixture by the heating block digestion procedure (Rahman et al*.,* 2007) and analysis the lead content in Atomic absorption spectrometer (AAS).

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. Suitable sample was digested with HNO_3 and $HClO_4$ (AR Grade) for lead analysis in AAS (Elmer, 1996).

The fish muscle samples were oven dried, powdered and digested with HNO_3 and H_2SO_4 following the method 'Perkin Elmer Analytical Methods for Atomic Absorption Spectroscopy (Agemian et al., 1980; Elmer, 1996) for the analysis of lead.

The total lead content of the digested samples (soil, plant and animal tissue) were analyzed by atomic absorption spectrophotometer (FI-HG-AAS, Perkin Elmer Analyst 400) using external calibration.

Result and Discussion

The mean concentrations of the total lead in the water, soil, plant, vegetables and fish samples of the study area in pre-monsoon and post-monsoon seasons are presented in the Table-1 and Fig. 1. The water sample contains the lead concentration 0.010 and 0.076 mg/L in post-monsoon and pre-monsoon season respectively. The U.S. EPA set the maximum allowable concentration of lead in public drinking water was 0.015 mg/L (US EPA, 1999). The lead content in soil found 144.65 and 265.95 mg/kg in pre monsoon and post monsoon season respectively and road dust also have significant concentration of lead. Lead concentrations in urban soils are not evenly distributed (Mielke et al., 1983). Lead-contaminated soil and dust have been identified as important sources of exposure for children especially in an urban setting (Duggan and Williams, 1977). An acceptable level of 600ppm of lead in soil suggested as a "safe" level would contribute no more than 5 µg/dl to total blood lead of children less than 12 years of age (Madhavan et al., 1989).

The maximum concentration of lead found in the Debdaru leaves among the road side plants in the post monsoon season. Among the vegetable samples Cucurbita and Basella found considerable

Table 1. Lead concentration in different samples in different seasons (Mean ± SD).

Sample type	Mean of post monsoon (mg/kg)	Mean of pre-monsoon (mg/kg)
Water	0.010± 0.003 (mg/L)	0.076± 0.005 (mg/L)
Soil	265.95± 14.30	144.65±7.23
Road Dust	111.35± 5.60	82.75± 4. 31
Grass	62.70± 3.13	41.80± 2.10
Banyan (*Ficus bengalensis*)	108.70± 5.43	56.75± 2.83
Debdaru (*Polylthia longifolia*)	150.10± 7.15	48.90± 2.40
Katbadam (*Terminalia catappa*)	122.85± 6.14	82.75± 4.13
Lettuce (*Lactuca sativa*)	78.85±4.24	49.15± 2.50
Raddish (*Raphanus sativus*)	89.95±4.50	44.65± 2.23
Cucurbita (*Cucurbita maxima*)	167.25±8.36	33.30± 2.66
Basella (*Basella alba*)	173.60±6.68	95.50± 7.40
Brinjal (*Solanum melongena*)	-	83.30± 4.16
Cauliflower (*Brassica oleracea* var. *botrytis*)	132.70±6.63	-
Tilapia fish (*Oreochromis* sp.)	97.25±4.72	74.60±3.70

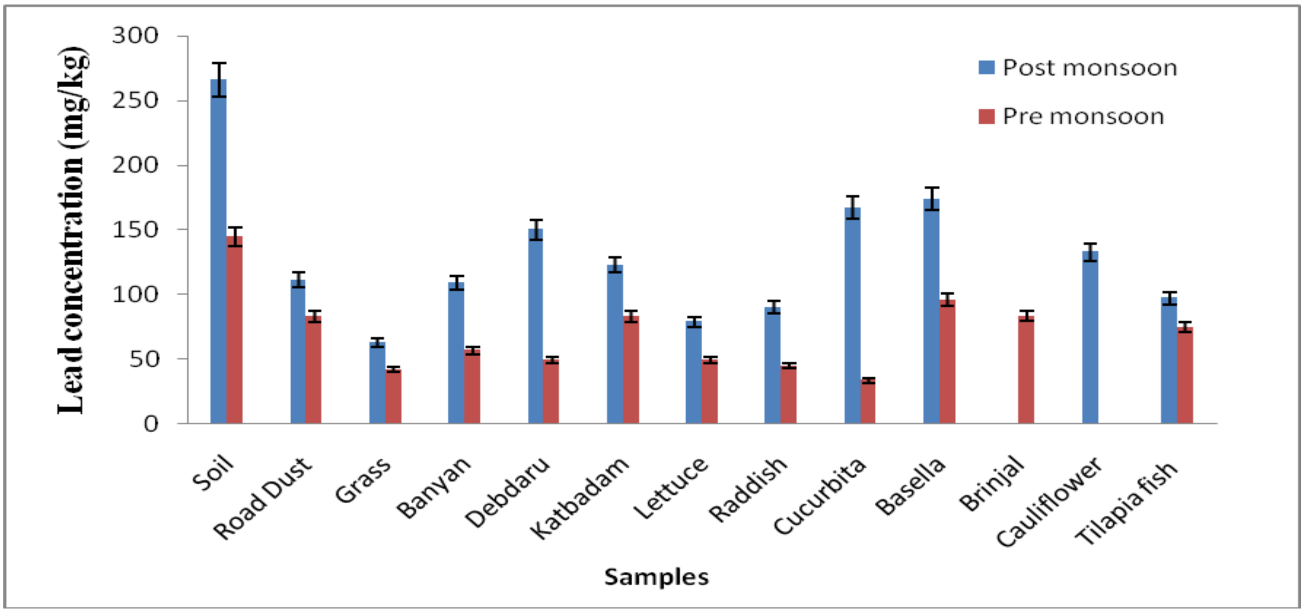


Fig. 1. Seasonal comparison of lead concentration in studied samples.

higher concentration of lead in post monsoon season. All vegetable samples found significant concentration of lead which is very high compared to the threshold value of 2.5mg/kg specified by Food Safety and Standards Regulation (2011). The lead content in Tilapia fish was found 74.6 and 97.25 mg/kg in pre-monsoon and post-monsoon season respectively. Lead concentrations of tilapia fish from rivers of Nigeria were found to be 310-650 mg/kg (Bolawa and Gbenle, 2010). Rashed (2001) studied the lead levels in Tilapia fish tissues as biological indicator for lake water pollution. Some works has been studied by different researchers in different areas like lead in atmosphere, aquatic organism, leaves of trees, Lichen, dust, etc. in India (Khandekar et al., 1984; Sadasivan et al., 1987; Datta et al., 1990; Mitra, 1990; Singh et al., 1997; Singh et al., 2005; Patel et al., 2010; Vishwanath et al., 2012)

Conclusion

Accumulation and magnification of heavy metals like lead 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 an alarming condition of lead accumulation in different environmental components like, soil, water, plant, vegetables and fish in and around Kolkata city area. The contaminant sources of lead like automobile and industrial emission should be taken care off. The human exposure to this contaminants should be studied in detail. Precautions should be taken to limit childhood exposure and keep blood lead levels (BLL) below the CDC-recommended level of 10 µg/dL. International and national regulations on the maximum permissible levels of toxic metals in the environmental components and food items should be strictly followed and increased the awareness of the risk of the metals for save the future generation. Abatement and remediation process through research and development programmes should be encouraged to minimize the hazardous pollutants for a sustainable better environment.

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