LEAD AND OTHER ELEMENTS STATUS IN CALCUTTA'S ENVIRONMENT: A FIVE-YEAR STUDY

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ABSTRACT
The lead and other 20 elements were determined in soil, road-dusts, dusts on leaves, leaves samples those were collected in eight different crucial points of the Calcutta City. Concentrated nitric acid (5 ml) and 30 % hydrogen peroxide (1 ml) mineralized the samples (250 mg) in Teflon vessels in a closed pressurized microwave digestion system with using a developed microwave digestion program. The digests were diluted and analyzed by inductively coupled plasma mass spectrometry using In as internal standard. The elevated level of lead: 1354 mg/kg (average) in the road dusts; 205 mg/kg in the restaurant dust; 765 mg/kg in the leaves dust were found. The other elements such as Cr, Mn, Cd, Hg, Tl, Bi and others were also high in the samples. A comparison between our previous finding exhibited a decreasing trend of the lead in the atmosphere. The decrease in lead concentration in the atmosphere was due to the unleaded gasoline used now days in the Calcutta City. The other elements level were till higher and major concern as some of the elements are very toxic and caused a health hazard to the residents. The elevated level of the elements in the Calcutta's atmosphere might be due to the different types of industries situated within the city area and these factories were polluting the environment through toxic emission and are till the major concern of the pollution.

INTRODUCTION
Exposure of lead is hazardous to humans, particularly to children with their immature neurological system (Howden et al., 1996). Reduced cognitive development and impaired intellectual performance of children (Oskarson et al., 1995) has been linked to lead exposure. Lead is readily transported across the placenta to the fetus and with human milk to infants (Chatterjeee and Banerjee, 1999). Lead has been identified as one of the most commonly occurring contaminants (Hafen and Brinkmann, 1996). Mercury, arsenic, cadmium, silver and zinc are also well known potential toxic elements (Chatterjeee and Banerjee, 1999). These elements contaminated the environment during lead smelting and by other human activities (Carvalho et al., 1989; Rieuwerts and Farago, 1996). It has been established that populations exposed to these elements developed alterations in their nervous system functions, neurophysiological consequences with severe health hazard (Chatterjee et al., 1993; Olivero and Solano, 1998). According to the United Nations (UN) reports the Calcutta historic well-known city, is one of the most polluted cities in the world. However, the systematic data on major pollutants present in the Calcutta City's atmosphere are lagging. The present study is centered on Calcutta; lies on the eastern bank of the river Hoogly and situated in the Gangetic delta about 100 km from the sea (Fig. 1). Within the 104 km^2 of city area 11,500 small and large factories are situated. Out of them about 42 factories produce lead alloys, lead ingots, and are located in populated areas.
To assess the degree of pollution with metals, especially with lead, and the source (s) of contamination in a Calcutta city, soils, dusts from the roads and from leaves on trees and leaves were collected. The lead and other 19 elements were quantified in

these samples by ICP-MS after microwave digestion. Finally, a five years comparison study is carried out.

METHODS

A microwave digestion system (MLS 1200 Mega) from Milestone, Leutkirch, Germany was used. Inductively coupled plasma mass spectrometric measurements were performed with a VG PlasmaQuad Turbo Plus (VG Elemental Ltd., Winford, UK) equipped with a Meinhard concentric glass nebulizer type TR-30-A3, a double-pass, Scott-type spray chamber (water cooled, 0° C), and a Gilson Minipuls-3 peristaltic pump. The operating conditions for the ICP-MS are: rf power forward 1.35 kW, reflected < 5 W; argon flows for cooling 13.5 L min^{-1}, for auxiliary 0.9 L min^{-1}, for nebulizer 0.92 L min^{-1}; nebulizer uptake ~1.0 mL min^{-1}; sample cone - nickel, orifice 1.0 mm diameter, skimmer cone - nickel, orifice 0.7 mm diameter.

Montana Soil SRM-2710, San Joaquin Soil, SRM-2709 from the National Institute of Standards and Technology (Gaithersburg, Maryland, USA), Sewage Sludge BCR No. 144 and Olive Leaves BCR No. 062 from the Commission of European Communities served as standard reference materials.

Sample Collection

Soils, leaves, road dust and dusts from leaves were collected during 1992-1996 in the eight different areas of Calcutta city (BBD Bag, Jadavpur, Taratola, Shyambazar, Moulali, Gariahat, Park-Street and Tollygange Phari) Fig. 1. Soils were collected with a Teflon knife after scraping away the top 0.5-cm. The samples were placed in plastic bags. Soils were dried at 80^0C for 24 h, manually ground to a fine powder with a mortar and passed through a 30-mesh sieve (Chatterjee et al., 1993). The road dust (~20 g) was collected by gently sweeping the road with a soft plastic brush. Dust from leaves (~1 g) was brushed from the top of the leaves into a plastic bag. The dusts were dried at 60^0C for 24 h and passed through a 30-mesh sieve.

Digestion

An aliquot (~ 0.20 g) of the dry, finely powdered solid was weighed into a dry, clean Teflon digestion vessel. Conc. nitric acid (5.00 ml) and hydrogen peroxide (1.00 ml) were added. The vessel was closed, placed into the rotor, and tightened. The loaded rotor was placed into the microwave oven. The digestion was carried out with the following program (power in W/time in min.): 250/2, 0/0.5, 300/5, 0/0.5, 400/10, 0/0.5, 500/5, 600/4. The vessels were cooled and carefully opened. Each digest was transferred quantitatively to a 100-mL volumetric flask. Before the volumetric flasks were filled to the mark, an aliquot of the standard In solution was added to achieve a final concentration of 100 µg In /L. These solutions were analyzed by ICP-MS. The Standard Reference Materials were digested under the same conditions.

RESULTS AND DISCUSSION

Air, water soil are the direct paths for heavy metals contamination. Soil is one of the foremost components of the dust. The dust also contains automobile aerosol, industrial aerosols, and weathering of building materials and other artificial sources. The concentration of heavy metals especially the Pb in soils, road dust (RD), leaves dust (LD), leave (L) collected from eight different sites of Calcutta over five years are decreased. There is a positive correlation between the Pb concentrations in soil and the Pb concentration in the DR, and LD. The heavy metals concentrations' in the dust are higher than the heavy metal concentrations found in the soils. Table 1 shows the heavy metals trend over the five years. To check whether our analytical results agree

with standard reference materials, the standard reference samples (Soils SRM-2709, 2710, Sediment BCR-144, Leave BCR-062), were analyzed after utilizing the same digestion and analytical procedure as that of samples. Obtained values are in good agreement with certified value.

However, all the eight locations throughout the city show significant correlation between air borne lead and the vehicular traffic density, which was counted at the time of sampling. The enrichment factor (EF) was calculated taking the Fe as reference element. It illustrates that for the maximum elements, the enrichment occur in the soils, DR, DL and L and the enrichment of these elements are from man-made sources. Still now, in Calcutta City the most of the city people use the coal as energy source for household cooking. So the contribution of heavy metals from the coal burning is not ruled out. A positive correlation between the Pb, Fe and Zn indicates that the Zn and Pb smelters are the one of the dominant sources for Pb and other elements contamination in the city's atmosphere. The high concentration of Pb in densely traffic areas (BBD Bag, Taratola, Shyambazar, Moulali, Gariahat and Park-Street) is normally due to automobiles' exhaust that contains burnt leaded gasoline. The concentration of Pb decreases over years suggested that the Pb content in the atmosphere has decreased. That is due to the unleaded gasoline using presently for the automobile as a fuel. The tetraalkyllead compounds are highly toxic to living organisms. The introduction of tetraalkyllead (TAL) compounds as antiknock agents in the gasoline, have played a detrimental role in the environment. It has been claimed that automobile traffic accounts for 90 % of the total Pb disseminated into atmosphere. The TAL concentration in ambient air varied between 0.5-0.2 $\mu g\ m^3$. The TAL concentration decreases with years and lowest at 1996. The mean concentration of TAL in the years 1992, 1993, 1994 and 1996 are 0.47, 0.4, 0.3 and 0.2 $\mu g\ m^3$. The decreasing trend is due to the unleaded gasoline used in the automobiles nowadays. The high concentrations' elements in the samples are likely the contamination from the automobile tyres. Due to poor and inferior road conditions the decomposition of the automobile tyres is occurred very frequently that increase the some of the elements concentration in the Calcutta City's environment.

Although the soil, road dust, dust on leaves, and sediments have elevated level of lead and other elements, but the tubewell waters (groundwater) are still free from Pb. The foremost reason, the groundwater water is free from lead is that the upper aquifers for yielding groundwater is overlain by a thick non-permeable clay rich layer. So the contaminated water is incapable to penetrate through the clay layer to the underground aquifers. The penetrating study of soil quality reconfirmed the low permeability. The additional reason is the soil pH (range) of the study area is alkaline 7.5-8.5, which decreases the solubility of lead in water as the Pb has limited solubility in soils due to complexation with organic matter.

Analysis of associations between metals at each sampling site suggests that multiple sources, the smelter stack from different industries, fossil fuel burning, automobile exhaust and coal burning, contaminated the whole study area. From the clinical investigation it also found that the children of the study area are more affected because part of their normal behavior includes hand to mouth through thumb and finger sucking activities (Chatterjee and Banerjee, 1999). Lead does not dissipate, biodegrade or decay. Hence high concentrations of lead and other metals in soil causes a great risk for the people particularly for the children of the city. The stability of lead and other metals in samples with such elevated concentrations can persist for many years, even after closure of the source of contamination (Chatterjee et al., 1993). So to save the people of the city the appropriate plans should be taken to

decrease the pollution load of the city's environment with dispersing the city, with decreasing the traffic load and clean up the contaminated soil.

Table 1. Variation of elements concentration (mg/kg) with time.

Year	Sample	Element						
		Pb	Cr	Ni	Mn	Cd	As	Hg
1992	DL	765	74	35	708	0.93	8.32	1.16
1993	DL	636	56	32	656	1.8	15.5	1.5
1994	DL	540	50	30	595	4.18	11.3	1.0
1996	DL	515	67	42	646	17.5	6.56	11
1992	DR	1350	64	34	778	2.34	.0	0.7
1993	DR	640	35	31	643	2.43	14.3	1.86
1994	DR	707	68	29	668	3.9	4.7	0.62
1996	DR	518	175	65	850	2.4	58	0.82
1992	Soil	350	53	31	551	1.3	4.7	0.22
1993	Soil	794	33	40	500	0.5	8.3	0.31
1994	Soil	440	44	39	538	2.2	7.1	0.81
1996	Soil	572	46	52	552	0.15	8.5	0.21
1996	Leaves	164	11	4.9	100	0.26	2.3	0.1

DL- Dust on Leaves; RD- Road Dust;

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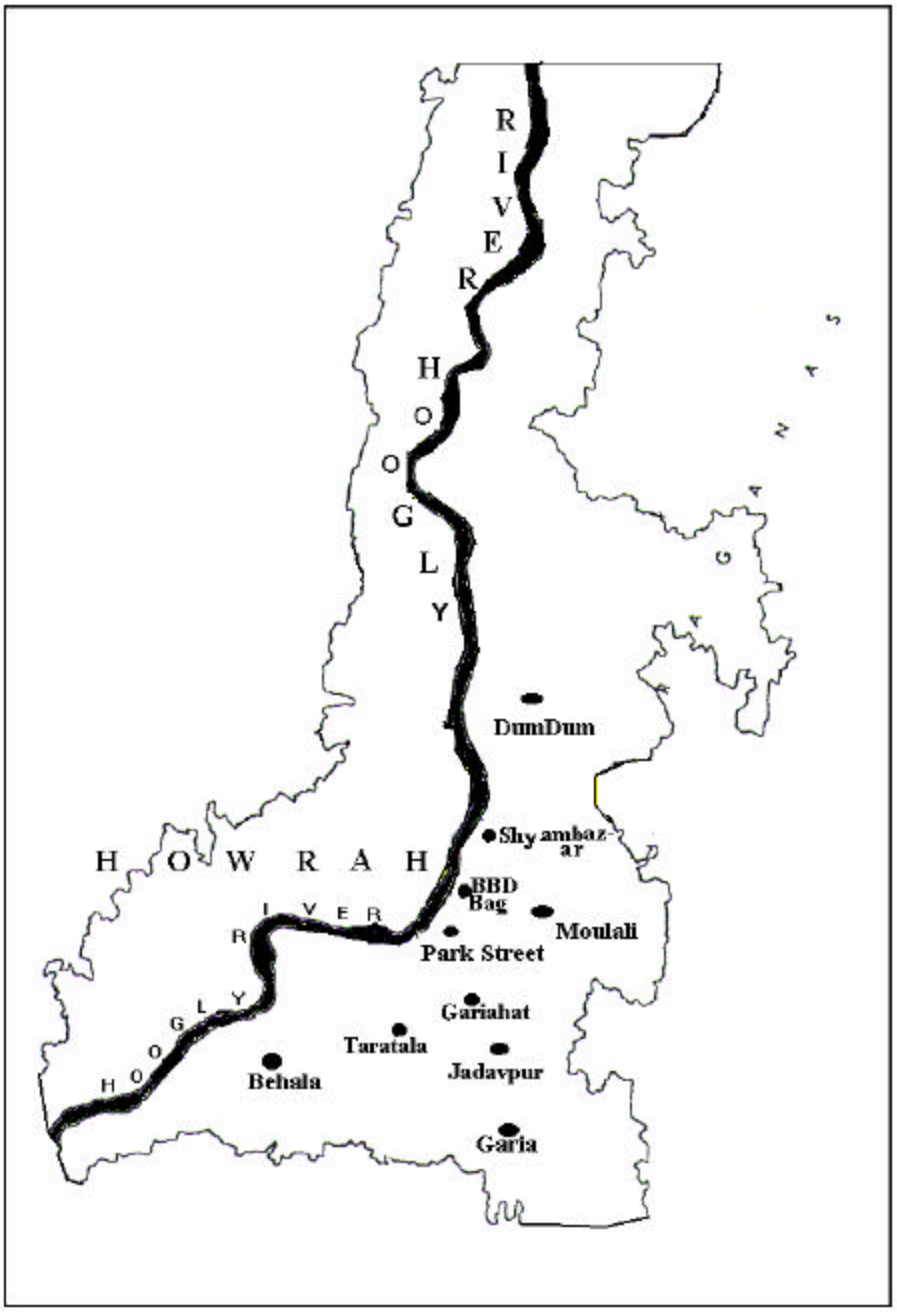

Fig. 1 Sampling sites in Calcutta City