Levels and sources of heavy metals in house dust

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The concentration and the sources of heavy metals (Pb, Cd, Zn and Cu) in house dust samples of nine selected houses of Jalil Town, Gujranwala, Pakistan are determined and a comparison with the concentration of these metals in respective street dust samples is given. Sources, exterior as well as interior are identified. The extent of contribution of lead in house dust from exterior sources and interior sources is calculated by determining the isotopic ratios in house dust, street dust and paint used in the houses. It is noticed in the case of well ventilated houses, that most of the heavy metal contribution is from the exterior sources. However, in less ventilated houses, contribution from the interior sources is also significant.

Introduction

Heavy metals like Pb, Cd, As, Hg, Cr, Cu, Au, Zn etc. are the most polluting metals in the urban environment and have several toxic effects for human beings, especially for children. Chronic exposure to Pb has been found to adversely affect the renal, hematopoietic and neurological systems as well as the growth of children. It has been shown by STARK et al. that lead level in blood of children is directly related to Pb level in the dust. It has been estimated that a Pb concentration of 1000 μg g⁻¹ in dust may contribute 5 μg dl⁻¹ of Pb in blood. Cadmium is nephrologically toxic, carcinogenic and has the ability to damage the blood vessels system. The presence of Cu irritates the mucous membranes and disturb the digestive system. Sources of trace elements in house dust are mainly paint used in the house and petrol used in automobile activity around the location. Lead is derived from atmospheric fall out of petrol and lead-based paints, whereas other elements, like Zn, Cu and Cd are associated with the tyre wear, corrosion of metallic parts of automobiles and with the condition of the carpets used in the house. Study made by FERGUSSON et al. 3,4 shows that metal loading for Cu, Pb, Zn and Cd in house dust correlates strongly with the dustiness of the house and this in turn relates strongly to the amount of carpet wear. Few other factors associated with the dustiness are house materials (wood 2.4 times more than brick) and roof type (tiled roof 2 times more than other roofs). A ten fold increase in dustiness from new to thread bare carpets corresponds to a seven fold increase in the amount of Cd, Cu and Pb and a two fold increase in the amount of Zn. 4

Lead have four stable isotopes, i.e., 204Pb, 206Pb, 207Pb and 208Pb. Amongst these, only 204Pb is non-radiogenic whereas rest three isotopes are radiogenic in nature, resulting from the decay of radioactive parents. Consequently, the abundance of three radiogenic stable isotopes in all environmental Pb samples depends upon the age and primordial concentration of the U and Th of the source. Furthermore, the variation in composition of stable Pb isotopes remains the same during the refining and processing of Pb ores into different consumer products like tetra ethyl lead used in gasoline and Pb compounds used as the paint pigments. So by the knowledge of the isotopic composition of Pb in domestic and environmental materials, potential sources contributing to Pb as contaminant can be determined with fairly good accuracy.

Heavy metals concentration in environmental sample can be determined with good precision by atomic absorption spectrometry and X-ray fluorescence spectrometry, whereas for Pb source identification, isotopic ratio analysis can be performed by thermal ionization mass spectrometry (TIMS) and by inductively coupled mass spectrometry.

In this study, Pb, Cd, Zn and Cu concentrations in different samples of houses in Jalil Town, Gujranwala, Pakistan have been determined by using atomic absorption spectrometry. Whereas, the relative contribution to Pb from different sources have been estimated by isotopic analysis performed by TIMS. The area under study has been selected because Grand Truck Road (G. T. Road) is passing through this city having heavy intercity traffic. Also the city has a large industrial zone, producing large amount of industrial wastes.

Experimental

Chemicals

Nitric acid (AnalaR, BDH Laboratory Supplies), hydrochloric acid (extra pure, Merck), phosphoric acid (extra pure, Merck), silica gel (extra pure, Merck) were used during sample preparation and mass spectrometric analysis. Already prepared 1000 ppm AAS standard solutions of PROLABO of European Union and Merck
of Germany were used to prepare working standard solutions of Pb, Cd, Zn and Cu for concentration determination of the respective metals. NBS/981 – Pb standard was used for isotopic ratio analysis. During the experimental work distilled hydrochloric acid and nitric acid were used, while all dilutions were made in double distilled water.

**Instruments**

Isotopic measurements were carried out by a thermal ion source mass spectrometer VG-354 (V.G. Isomass, U.K.) equipped with a Daly and two Faraday cups as detector system. The resolution of the instrument is better than 500, measured at mass numbers 235 and 238. Abundance sensitivity is less than 5 ppm, peak to peak noise of electrometry is in the range of 10^-14 A, while the overall stability of the instrument is in the order of 50 ppm. Single rhenium filament assemblies of Cathodeon Ltd., England, having ribbon thickness of 25 µm, were used for samples loading.

Concentration determinations of Pb, Cd, Zn and Cu were performed on 932 AB atomic absorption spectrometer (GBC Scientific Pty. Ltd. Australia), equipped with GF 3000 graphite furnace. Working range for above mentioned metals was 0.1 to 12 ppm, 0.004 to 1.8 ppm, 0.005 to 1.6 ppm and 0.01 to 4.0 ppm, respectively. However, by using graphite furnace the sensitivity can be enhanced to working range 2.5 to 26 ppb, 0.15 to 2.6 ppb, 0.05 to 2.0 ppb and 1.0 to 26 ppb, accordingly.

**Sample collection**

Dust samples from nine selected houses were collected during the routine cleanliness of the areas commonly used by the residents of the house, i.e., lounge and bed rooms. Dust samples of the streets were collected from the areas in front of main gates and boundary walls of the respective houses. Paint samples were collected by scratching paint from the walls of the areas under study as described by Adgate et al.8

**Sample treatment**

Dust samples containing carpet fur and paper pieces etc. were sieved through sieve of mesh size (63±45) µm on “FRITSCH” sieving machine.

**Sample dissolution**

Paint samples: Scratched paint samples were dissolved by the method as described by M. Viggan et al.7

Dust samples: Dissolution was carried out by adding 15 ml of distilled nitric acid to weighed dust sample and refluxing it for two hours. Dissolved sample was filtered. Heated to dryness in order to eliminate excess nitric acid. Dry mass was dissolved in 0.2N distilled nitric acid. Filtered through Whatman filter paper No. 42 into 50 ml measuring flask and final volume was made up to the mark with 0.2N nitric acid. The concentration of the sample was measured by atomic absorption spectrometer.

**Sample preparation for mass spectrometry**

5 ml of sample solution (either dust or paint) was mixed with 2 ml of 3N distilled hydrochloric acid. Evaporated to dryness and dissolved in 5 µl of 0.75M phosphoric acid.

**Sample deposition on filament**

One drop of silica gel solution was added to the centre of the filament. Heated to dryness in order to obtain a white, visible silica gel deposition. On the deposition, 2–3 µl of sample was added drop wise. After loading the sample, filament current was raised to smoke the sample for a short time.

**Results and discussion**

Concentrations of Pb, Cd, Zn and Cu in house dust along with respective street dust samples for nine selected houses are given in Tables 1 and 2, which indicate the higher concentration of the metals in house dust as compared to street dust.

Loading of Pb, Cd, Zn and Cu in house dust depends upon the dustiness and ventilation of the house. Similarly, 7 times increase in the amount of Cd, Cu and Pb, and 2 times increase in Zn is observed in the case of thread bare carpets as compared to new carpets. Whereas Arizona et al.9 obtained an outdoor/indoor ratio (R<sub>SIH</sub>) of 0.42 for lead. However, covering the windows with clean plastic sheets this ratio decreased to 0.17, whereas, by widely opened windows, the ratio increased to 1.2. In this study, the ratio varies from 0.97 to 0.35 in the case of Pb (Table 1). This value is directly related to the source of contamination. Value equal to 1 indicates that the contaminants are coming from exterior sources whereas value of less than 1 indicates that the contaminants are also being generated from interior sources, along with exterior sources. The value of R<sub>SIH</sub> of Pb in house dust samples of well ventilated houses (DJG, EJG, FJG and JJG) is near to 1 which shows that major part of the dust in the house is originated from the street, whereas in houses with a little ventilation (BJG, GJG, HJG and IJG) this value is less than 1, indicating the loading of Pb in house dust from interior sources as well. Similar trend is also observed in the case of Cd, Zn and Cu.