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Heavy metal determination in household dusts from Ilorin City, Nigeria

F. A. Adekola and O. O. Dosumu

Department of Chemistry, University of Ilorin, Ilorin, Nigeria

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ABSTRACT: Levels of lead, cadmium, nickel, copper and iron were determined in the indoor dusts from 18 different and geographically spread locations in Ilorin, capital of Kwara State of Nigeria. The highest mean level was obtained for Fe and it ranged from 28.60 – 45.40 mg kg^{-1}, while the lowest mean level was obtained for Cd with the range of 0.001 – 0.38 mg kg^{-1}. Some locations exhibited higher levels than the Dutch standard values for uncontaminated soil, but they were all below indicative values required for further investigation or cleaning up.

Higher average levels were generally observed for residential houses or public buildings located along heavily travelled municipal roads such as Post Office, Ibrahim Taiwo, Amilegbe and Emir's Palace Market. Statistical analysis also indicated positive correlation between all the possible pairs of heavy metals except copper and cadmium. The most important correlation coefficients were observed between Cd/Fe (r = 0.4520) and Pb/Ni (r = 0.4450). Low correlations were obtained for Pb/Cu (r = 0.0895), Cu/Ni (r = 0.0962) and Cu/Fe (r = 0.0983). This suggested a likely common source, which could most probably be traced to vehicular emissions and other related activities.

Key Words: Environmental pollution; Heavy metals; Lead; Cadmium; Nickel; Copper; Iron.

Introduction

Dust can be defined as matter or particulate in the form of fine powder, lying on the ground or on the surface of objects or blown about by the wind.

Most of the air pollution studies have revealed a strong association between urban aerosol concentrations and deaths from respiratory diseases (Byrne, 1998; Hammer et al., 1992).

In a recent study conducted by the U.K. Department of Environment Expert Panel on Air Quality Standard, it was concluded that particulate pollution hazards are most likely to exert their effect on mortality by accelerating death in people who are already ill. The elderly and babies are also susceptible to high risk as aerosol particles readily penetrate buildings through doors and windows, and cracks in building structures (Byrne, 1998). Toxic house dust is a particular menace to small children who play on floors, crawl on carpets and regularly put their fingers in their mouths. Some authors (Thornton, 1991; Tong and Lang, 1998) have established that the major mechanism by which children staying indoors are exposed to lead (Pb) and other heavy metals arise from infiltrated vehicle and industrial emissions and also from eroding painted surfaces.

Furhetmore, Tong and Lang (1998) also found from their investigation that indoor dust is one of the major pathways of childhood exposure to heavy metals. In Nigeria, Akeredolu (1990) investigated the deposition rates of indoor particulate matter at various points in Ile-Ife town. The most toxic elements such as lead and cadmium were, however, not analyzed in the dusts.

The assessment of the level of heavy metals in indoor dusts is important as small children, especially those in the crawling stage, are highly exposed to indoor dusts. The high risk of exposure of small children as well as adults even though to a small extent, to indoor dusts or fine particles has prompted this investigation.

Materials and Methods

Sample Collection

Sampling was carried out between the months of June and September, 1998. All the sampling points are shown in Fig. 1. The indoor dust samples were all taken by early morning sweeping of the houses using new brooms. Samples were collected in the central floor area away from the walls. Samples collected daily during each month were pooled together to form a composite sample. At least three composite samples were collected for each location.

Sample Preparation

About 10g each of dried samples were pulverized to uniform size and the fraction with particles of diameter 0 – 0.2 mm was retained for analysis.

Analysis

About 1.5g of pulverized sample was digested in a mixture of hot concentrated perchloric acid (4 ml), nitric acid (25 ml) and sulphuric acid (2 ml) (IITA, 1979). The reproducibility of the digestion procedure was checked by analyzing the samples in duplicate. Duplicate results did not usually differ by more than 5% of the mean.

Concentrations of metals were determined using an atomic absorption spectrophotometer (Pye Unicam Model 2900). All results are presented as milligram of metal per kg of dry matter of sample. The data were then subjected to statistical analysis using SAS statistical package.

Results and Discussion

The mean concentrations of heavy metals in the indoor dust samples are summarized in Table 1. The mean concentration of lead ranges between 2.34 mg kg^{-1} and 10.17 mg kg^{-1}. The lowest mean value of 2.34 mg kg^{-1} was obtained at Sabo-Oke area (D13) while the highest value of 10.17 mg kg^{-1} was obtained around Garin-Alimi Area (D10).

Most of the well travelled/busiest roads such as Post Office, Unity Road, Emir's Road, Garin Alimi exhibited high levels of lead, while the indoor dusts collected from less travelled areas such as University/Tanke Road, Sabo-Oke, Asa Dam Road and University Staff Quarters (Permanent Site) had relatively low levels of lead.

The mean concentration of copper varies between 0.19 mg kg^{-1} at site D4 and 1.99 mg kg^{-1} at site D9. While the levels of cadmium were generally low and less than 0.5 mg kg^{-1} in all cases, its level ranges from less than 0.001 to 0.38 mg kg^{-1}, the highest value at 0.38 mg kg^{-1} was obtained at Amilegbe area.

The mean concentration of nickel ranges between 0.006 mg kg^{-1} and 2.191 mg kg^{-1}. The highest value of 2.191 mg kg^{-1} was obtained at site D7, the Post Office area, while the lowest value of 0.006 mg kg^{-1} was obtained at site D13, Sabo-Oke area. Finally, the highest mean concentration was obtained for iron, among all the heavy metals investigated. Iron level ranges from 28.60 to 45.40 mg kg^{-1}. The lowest level was obtained at the University Quarters while the highest level was obtained at Post Office area.

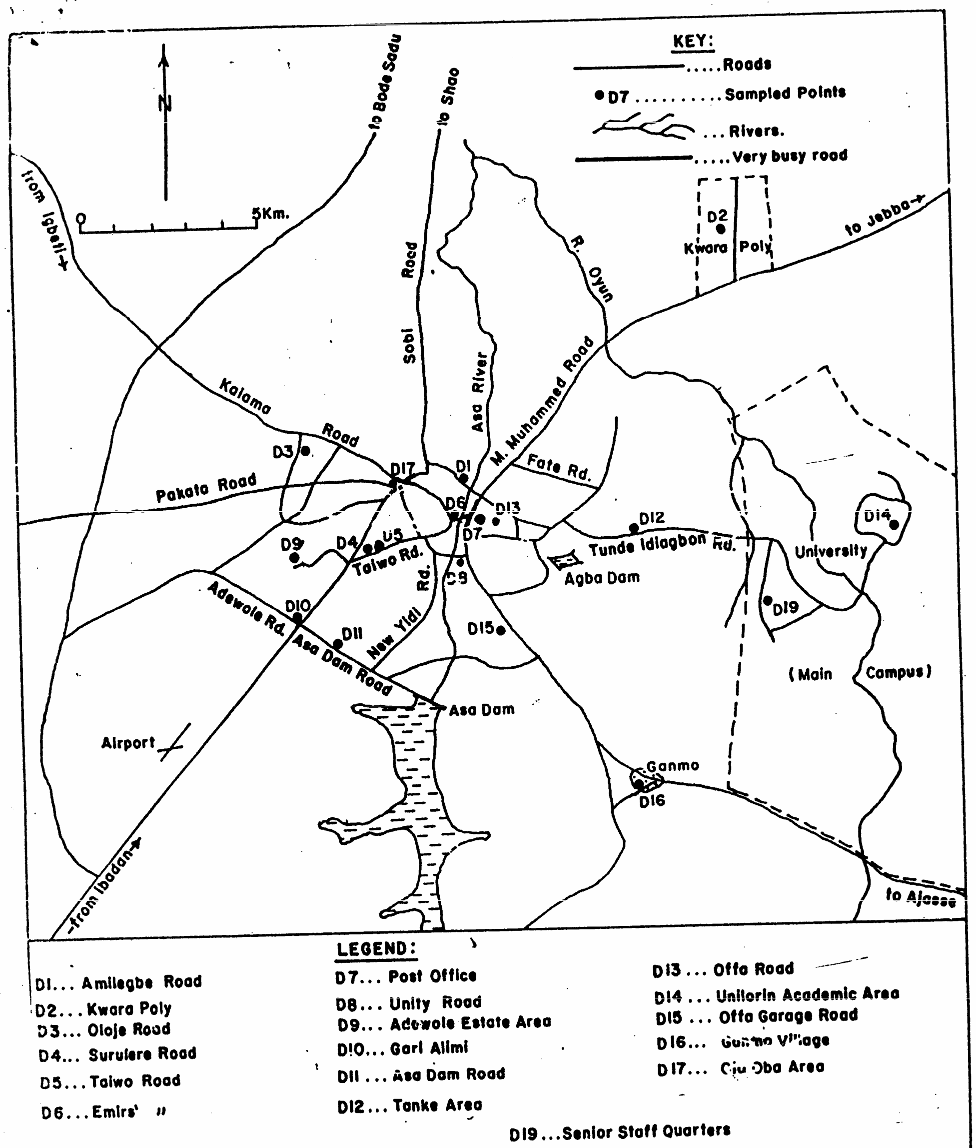

Fig. 1 : Major road network in Ilorin Metropolis.
Source : Author's Fieldwork, 1999.

Table 1: Heavy metal mean concentration (mg kg^{-1} of dry dust) in indoor dust samples from various locations in Ilorin, Nigeria.

Sample No.	Pb	Cu	Cd	Ni	Fe
D1	4.670	0.290	0.380	1.619	43.180
D2	6.500	0.390	0.017	0.952	40.800
D3	6.830	0.430	0.000	1.619	31.800
D4	5.000	0.190	0.050	1.048	37.130
D5	6.170	0.750	0.008	0.952	40.060
D6	8.000	0.530	0.103	1.714	43.200
D7	8.170	0.580	0.129	2.191	45.400
D8	9.830	0.530	0.008	1.619	41.930
D9	5.170	1.990	0.052	1.143	37.000
D10	10.170	0.470	0.026	1.238	39.600
D11	5.330	0.470	0.069	1.714	31.800
D12	3.340	0.510	0.001	0.476	36.300
D13	2.340	0.210	0.100	0.006	40.800
D14	8.000	0.510	0.216	1.619	40.600
D15	3.500	0.240	0.060	1.524	33.590
D16	7.670	0.580	0.147	0.381	44.400
D17	6.170	0.240	0.060	0.476	30.670
D19	5.670	0.360	0.026	0.476	28.600

Table 2: Regression equation and correlation coefficients for the various pairs of the heavy metals.

S/No	Metal Pairs	Regression Equation	Correlation Coefficient	P-Value
1.	Pb/Cu	Pb = 0.41117 + 0.01661 Cu	0.0895	0.724
2.	Pb/Cd	Pb = 0.1039 + 0.0047 Cd	0.1070	0.670
3.	Pb/Ni	Pb = 0.37875 + 0.12399 Ni	0.4450	0.064
4.	Pb/Fe	Pb = 32.8826 + 0.8442 Fe	0.3573	0.146
5.	Cu/Cd	Cu = 0.09789 – 0.03043 Cd	– 0.1280	0.613
6.	Cu/Ni	Cu = 0.4410 + 0.0641 Ni	0.0962	0.704
7.	Cu/Fe	Cu = 0.2205 + 0.0077 Fe	0.0983	0.698
8.	Cd/Ni	Cd = 0.03697 + 0.03874 Ni	0.2450	0.327
9.	Cd/Fe	Cd = – 0.2397 + 0.00842 Fe	0.4520	0.060
10.	Ni/Fe	Ni = 35.9501 + 1.9133 Fe	0.2254	0.369

The analytical results clearly indicate important levels of Pb, usually greater than 1.0 mg kg^{-1} in all cases. The levels of copper and cadmium were generally low. The level of nickel was also greater than 1.0 mg kg^{-1} in most of the sites, except at sites D2, D5, D12, D13, D16, D17 and D19. It is important to note that the indoor dust collected from the three public buildings: a primary school classroom (site D5), the General Post Office (site D7) and Unilorin Lecture Room (site D14) all have high levels of lead, nickel and iron.

The suburb or well-planned areas such as Sabo-Oke (site D13) and University Road (site D12), Offa Garage area (site D15), Oloje Estate (site D3) and University Quarters (site D19) all have relatively lower levels of heavy metals.

The results of the statistical analysis obtained with SAS software, summarized in Table 2, show that all the possible metal pairs, except copper and cadmium, are positively correlated. All other metal pairs involving copper also have correlation coefficient values of less than 0.10. This indicates that Pb, Cd, Fe and Ni would most likely originate from sources such as emission from automobiles and fall out from wall paints.

It is evident from these results that the level of heavy metals in the household dusts depend on factors such as site location and the intensity of human activities within the localities. There are presently no national regulatory guidelines on the permissible levels of heavy metals in indoor dusts. However, the levels observed in public buildings such as Post Office (site D7), a primary school (site D5), Unilorin Lecture Room (site D14) and in most of the houses located within the town indicate that the floor dusts pose a serious health risk to younger children, especially those in the crawling age.

The studies also revealed that the levels of Pb and Cd in floor dust in Ilorin are however lower than those reported for some towns/cities in the developed countries (Solomon and Hartford, 1976; Tong and Lang, 1998).

The present study tends to confirm an automotive origin of lead, cadmium and nickel in urban dusts as these metals occur in important proportion in the iron-rich fraction of the indoor dusts. The higher concentration coefficient between Pb and Fe, Cd and Fe, Pb and Ni in the dusts also lend support to this. Olson and Skogerboe (1975) had earlier associated airborne lead derived from auto exhaust with iron. The important levels of Fe observed in all the locations could also be a function of the nature of the local soil and the intensity of human activities in the various localities.

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