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Roadside Topsoil Concentrations of Lead and Other Heavy Metals in Ibadan, Nigeria

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Concentrations of Pb, Zn, Cd, Cu, Cr, Co, and Ni were determined in roadside topsoil collected from locations of varied vehicular traffic densities in the city of Ibadan, Nigeria, with a view to determining the level of contamination and the contribution of traffic density. Levels of Pb, Zn, Cd, and Cu were elevated above background concentrations measured in control areas. Average values (ppm) for all sample locations were Pb — 81 ± 140; Zn — 48 ± 37; Cd — 0.55 ± 0.49; Cu — 17 ± 17; Cr — 22.1 ± 9.6; Co — 7.9 ± 3.8; Ni — 10.5 ± 9.7. Factors of accumulation of metals in roadsides relative to control sites were highest for Pb. Vehicular traffic was not an important source of chromium, cobalt and nickel, for which roadside concentrations were about those of the control sites. Metal concentrations were poorly correlated with traffic volumes. An average of about 60% of total soil concentration of the metals were determined to be held in bioavailable geochemical phases, of which the highest concentrations were mostly held in either the reducible or oxidizable phase. Levels of the metals in the topsoil were generally lower than the soil quality criteria of some developed countries.

Key Words: *topsoil, lead, zinc, heavy metals, speciation.*

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Introduction

Topsoil around main roads in urban areas have been found to be significantly contaminated with lead derived mostly from automobile exhausts (Stone and Marsalek, 1996; Charlesworth and Lees, 1999; Koeleman *et al.*, 1999; Mellor and Bevan, 1999; Al-Chalabi and Hawker, 2000). Earlier studies have positively correlated the degree of contamination with traffic volume, and estimated that up to 100-m-wide strip around the center of roads is usually contaminated (Ward *et al.*, 1977; Wheeler and Rolfe, 1979; Wrobel *et al.*, 2000). Lead in topsoil poses a significant health hazard, particularly to children who have been found to be the most susceptible group to lead poisoning (Xintaras, 1992; Jin *et al.*, 1997; Peramaki and Decker, 2000). Blood lead level in children has been found to significantly correlate with soil levels. Growing concerns on the health implications of automobile-derived lead pollution has led to the phasing out of leaded gasoline in many developed countries.

Some amount of roadside topsoil lead burden is also derived from other anthropogenic sources, including industrial emissions from smelter works, incineration of wastes, land disposal of wastes containing paints, and scrap batteries and solder. The fractional contribution from these sources is becoming more significant with the gradual introduction of nonleaded fuels.

Other metals such as aluminium, barium, cadmium, chromium, copper, iron, magnesium, manganese, nickel, silicon, silver, tin, titanium, and zinc have been reported to be associated in trace amounts with automobile-related pollution of topsoil (Lagerweff and Specht, 1970; Hopke *et al.*, 1980; Monaci and Bargagli, 1997; Monaci *et al.*, 2000). These are derived from varied sources such as exhaust emissions, tyre abrasion, lubricating oil spills, and engine wear. They are also derivable from the other aforementioned pollution sources.

The monitoring of heavy metals in roadside topsoil has provided useful data on the exposure risk from pollution in urban areas. Speciation studies have also been used to describe the distribution of metals in the various geochemical phases of the soil and hence evaluate the relative bioavailability and mobility of the metal burden of the soil (Asami *et al.*, 1995; Stone and Marsalek, 1996; Serrano-Belles, 1997; Cabral and Lefebvre, 1998; Wang *et al.*, 1998; Ge *et al.*, 2000; Maiz et al, 2000).

Whereas the use of leaded gasoline has been completely phased out in many developed countries, the same cannot be said for less-developed ones. In Nigeria, for example, the market share of leaded gasoline is still 100%, and this is known to have a very high lead content of 0.66 g per liter (World Resources Institute, 2000). About 4200 million liters (1995 estimates) of gasoline is consumed annually in the country, giving a leaded gas emission of 2770 metric tonnes. On a scale of 1-59 for potential exposure to air pollution from gasoline for urban centres in developing countries, Nigeria is scored 57, which is one of the highest degrees of exposure (World Resources Institute, 2000). Therefore, there is the need to be concerned about the levels of Pb and other metals in the environment in Nigeria.

Ibadan city, the second largest in Nigeria, with current population estimated at about 4 million inhabitants, is one of the urban settlements that is more susceptible to lead pollution. Previous studies of various environmental media in this city have highlighted the growing potential for heavy metal-related pollution problems (Oluwande, 1977; Mombeshora *et al.*, 1983; Onianwa and Ajayi, 1987; Onianwa, 1993; Onianwa and Fakayode, 2000). However, there has been no major study reported in the literature that has detailed the extent of heavy metal pollution of roadside topsoil in this city. Therefore, the aim of this study was to determine roadside topsoil concentrations and speciation of lead and other heavy metals (zinc, cadmium, chromium, copper, cobalt, and nickel), in Ibadan, and the extent to which vehicular traffic density contributes to the level of contamination.

Materials and Methods

Sampling of topsoil for this study was conducted during the period June to July 1998. The selection of roads for the study was based on a foreknowledge of the relative densities of traffic on each road, and the desire to have each category of traffic density in different sections of the city. Samples were obtained from 45 roadside locations all over the city (Figure 1) with traffic densities ranging from very low to very high. These were mainly located in residential and commercial districts of the city. Control topsoil samples were obtained from two botanical garden reserve sites within the city which are remote from traffic. At each sampling location, the top 0 to 5 cm soil was collected with a stainless steel shovel from about five spots (usually about 2 to 5 m from the edge of the road) and pooled to form a composite for a given road. Samples were placed in polythene bags and air-dried in the laboratory for about 3 days. They were then ground in a porcelain mortar and passed through a 150-µm sieve.

Samples were digested and extracted for heavy metals analysis using the method of Andersson (1976), which estimates the ecologically significant fraction of soil metal burden. 50 ml 2 *M* nitric acid was added to 5 g soil in a stoppered flask and placed in a boiling water bath for 2 h with intermittent shaking. Extracts were filtered and analyzed for lead, zinc, cadmium, copper, chromium cobalt, and nickel using a flame atomic absorption spectrophotometer. Each sample was analysed in duplicate, and variation in analytical results between duplicates were generally within 5 to 10%. Results reported are averages for the duplicates.

A blank was included for every 15 samples. All glassware and polythene sample vials used in the analyses were precleaned by soaking overnight in 1 *M* nitric acid and then rising thoroughly with distilled–deionized water. Reagents used were of analytical reagent (analaR) grade, and the instrument working calibration standards were made by diluting the commercial BDH stock (1000 ppm) standard with distilled-deionized water using Class A calibrated volumetric flasks and pipettes. A recovery study of the extraction procedure was carried out by spiking portions

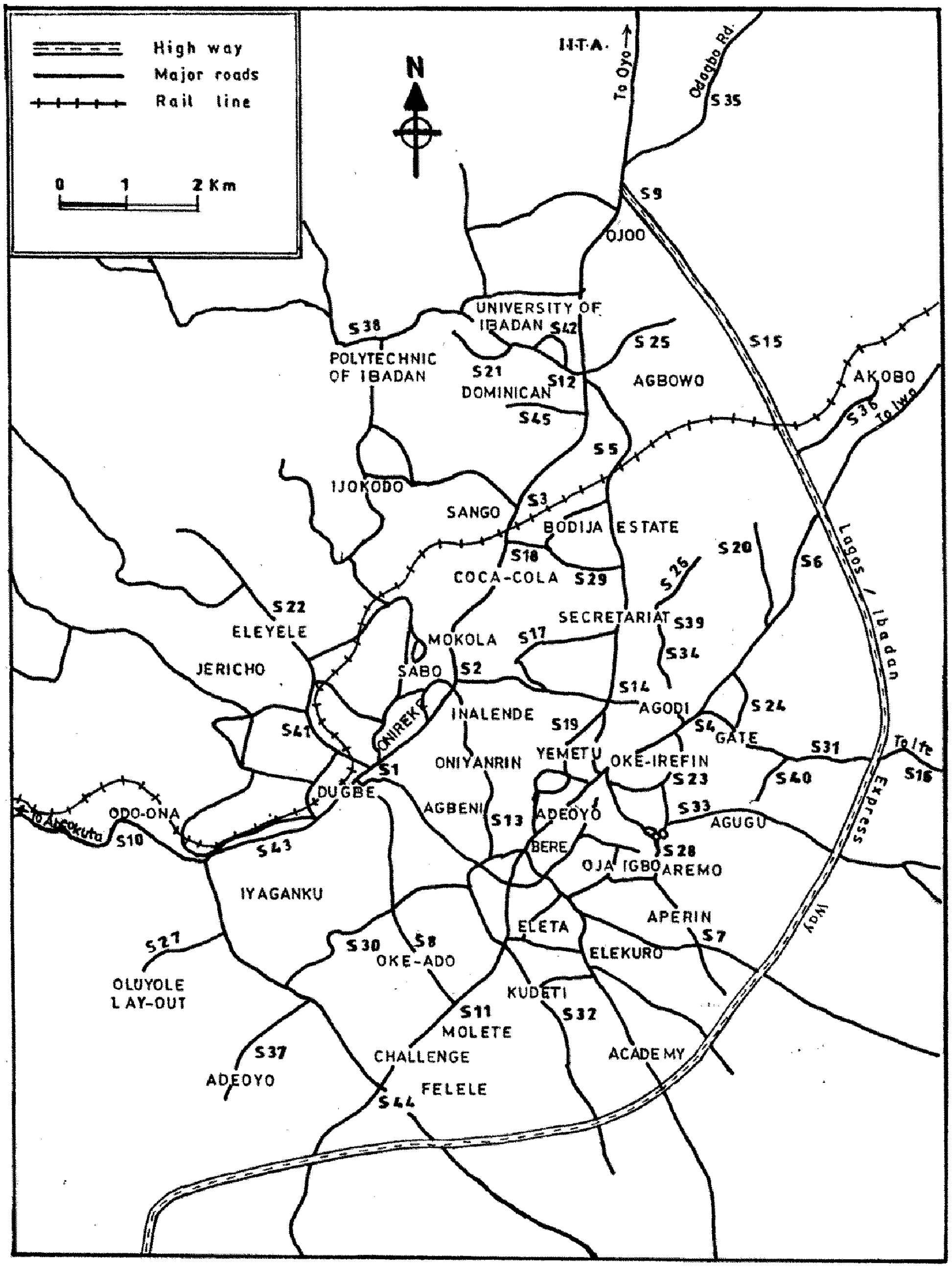

FIGURE 1. Map of Ibadan showing locations of samples indicated in Table 1.

of five previously analyzed samples with mixed standards of lead, zinc, and cadmium. These were then dried, homogenized, and passed through the extraction and analytical steps. Recoveries obtained were: lead — 94 ± 2%, zinc — 89 ± 3%, and cadmium — 91 ± 4%. Detection limits for the procedure were estimated as 0.20 ppm for Cd and Zn, and 0.50 ppm for the other elements.

For the determination of the speciation of the metals in soils, the sequential extraction scheme of Tessier *et al.* (1979) was applied to ten randomly selected samples. Using detailed procedures as described in the scheme, the exchangeable fraction was extracted with $MgCl_2$ solution at pH 7, and the carbonate-bound fraction by leaching with 1 *M* CH_3COONa, adjusted to pH 5.0 with CH_3COOH. The reducible fraction was extracted with 0.04 *M* $NH_2OH.HCl$, in 25% (v/v) CH_3COOH, while the oxidizable fraction was determined by treatment with 30% H_2O_2 adjusted to pH 2 with HNO_3. The residual fraction was digested with a 2:1 mixture of concentrated HF-$HClO_4$. Appropriate reagent blanks were prepared and analyzed for each extraction type. All extracts were analysed for the metals by atomic absorption spectrophotometry.

Traffic volume at each sampling sites was estimated during the usual peak traffic period of 7.30 a.m. — 8.30 a.m. by directly observing and counting the traffic for several days. Data analysis were carried out with the aid of the Jandel SigmaStat 2.0 statistical package.

Results and discussion

Heavy metals concentrations in the soils, as well as the peak period traffic volumes are shown in Table 1. The average abundance of metals in the topsoil was of the order Pb>Zn>Cr>Cu>Ni>Co>Cd. The bedrock geology of the area is primarily banded gneiss of granitic, migmatitic quartzite. Thus, soil weathering is slow and mineralisation of lead from the rock material is not significant (Alloway, 1990). The high concentrations of lead in the soils is indicative of the importance of lead as the primary anthropogenically derived pollutant heavy metal. The dependence of metal concentrations on traffic density was evaluated by calculation of the Spearman rank correlation coefficients (Table 2), which is the appropriate test for nonparametric data. The correlations were found to be generally very poor and insignificant, and this may be due to the fact that other sources of heavy metals contribute significant fractions to the soil burden. The topsoil is also regularly eroded by precipitation runoff into public drains and water bodies, so that some amount of accumulated metals is removed with the rains. Also, correlation with traffic may only become more evident when very high traffic volumes and very high degrees of contamination are obtained, far above background concentrations of the metals. In Table 3, sampling locations are grouped into three classes according to traffic densities, and geometric average values of metal concentrations calculated for each. Locations with traffic densities lower than 250 vehicles

TABLE 1
Concentrations (ppm) of Metals in Topsoil of Ibadan City Roadsides

Location Code	Traffic Volume / hr	Pb	Zn	Cd	Cu	Cr	Co	Ni
S1	3520	97.0	85.2	1.09	25.9	39.7	6.6	15.2
S2	3024	96.0	70.4	0.80	19.2	19.0	7.1	10.4
S3	3012	147	52.8	1.00	29.9	32.6	7.2	12.8
S4	3000	101	67.7	2.71	32.7	15.1	5.0	67.7
S5	3000	69.0	56.8	0.71	10.6	20.8	11.7	6.8
S6	2880	121	72.0	0.42	22.0	37.1	8.2	12.0
S7	2800	231	62.0	0.36	28.8	30.0	5.9	12.0
S8	2400	580	60.9	0.72	28.6	47.2	10.3	20.9
S9	2040	146	42.9	0.81	21.9	24.2	7.5	2.9
S10	2020	107	65.3	0.85	19.8	12.8	18.2	15.3
S11	1960	112	62.7	0.44	17.1	26.4	9.8	12.7
S12	1812	42.0	43.3	0.21	13.8	19.8	12.3	13.3
S13	1800	260	50.5	0.83	73.6	21.6	4.6	10.5
S14	1620	126	40.2	1.42	30.8	25.5	6.9	10.2
S15	1440	128	50.0	0.26	11.8	3.7	9.0	8.9
S16	960	48.0	24.5	0.15	16.6	6.3	5.1	5.2
S17	960	96.0	106	1.25	5.5	29.3	8.7	9.1
S18	600	33.0	20.0	0.40	8.9	18.2	13.0	7.8
S19	450	21.5	137	0.46	11.9	18.7	6.7	13.6
S20	440	62.0	40.0	0.81	8.6	23.9	4.9	8.2
S21	430	30.0	40.6	0.44	8.0	9.4	11.9	12.5
S22	428	92.0	42.3	0.77	16.3	22.7	8.7	11.0
S23	420	650	97.0	0.89	92.5	33.9	5.0	20.2
S24	400	15.1	42.3	0.73	16.1	25.4	5.4	8.5
S25	360	39.0	20.0	0.48	14.2	50.1	13.3	10.6
S26	350	48.2	78.2	1.77	14.9	22.9	7.3	13.4
S27	338	36.2	58.0	0.96	10.9	35.5	22.2	13.2
S28	332	253	64.0	0.02	25.6	29.7	10.9	11.2
S29	328	71.1	30.4	1.49	14.5	19.3	6.0	8.4
S30	320	153	42.2	0.64	21.5	17.6	12.0	32.9
S31	310	146	86.2	1.41	26.4	21.6	4.0	7.1
S32	300	43.4	46.1	0.21	35.3	32.5	6.4	11.6
S33	160	340	57.1	0.82	33.5	28.3	6.8	14.3
S34	150	156	26.3	0.30	11.5	20.4	10.3	9.0
S35	150	21.2	122	0.59	17.8	34.6	4.3	6.6
S36	148	54.3	21.3	0.29	9.5	29.4	10.0	9.1
S37	144	450	10.7	0.63	51.7	31.2	8.6	15.2
S38	140	33.3	12.1	0.84	10.7	15.3	12.0	9.5
S39	136	86.0	25.6	0.89	10.1	15.2	10.3	8.2
S40	132	39.0	106	0.45	20.3	32.8	4.1	6.5
S41	130	64.2	214	0.34	9.5	18.0	7.0	6.9
S42	120	40.3	22.4	0.33	11.7	15.6	14.2	8.7
S43	120	21.2	16.0	0.20	6.7	14.1	4.9	4.6
S44	81	87.4	25.5	0.24	7.6	29.3	5.0	7.8
S45	36	21.0	70.0	0.38	2.7	18.9	7.5	7.7

TABLE 2
Correlation of Traffic Volume with Element Concentrations

Element	Spearman coefficient (r)	P value	Significant (at P = 0.05)?
Pb	0.139	0.362	No
Zn	0.076	0.619	No
Cd	0.271	0.071	No
Cu	0.181	0.235	No
Cr	0.130	0.393	No
Co	0.029	0.850	No
Ni	0.302	0.044	Yes

per hour are classed as low traffic density sites; those between 250 and 1000 vehicles per hour as medium traffic density sites, and those above 1000 vehicles per hour as high traffic density sites. Average metal concentrations in the roadside topsoil were elevated above the background levels in the control sites. The trends of results in Table 3 are further amplified in Table 4, which gives the factors of accumulation of the metals in the soils, compared with the levels in the control sites. The highest degree of contamination was obtained for lead, but there was no clear difference in the levels of contamination between the low and medium traffic density zones. Zinc, cadmium, and copper concentrations were only slightly enhanced above background levels. Average concentrations of chromium, cobalt, and nickel at all the locations were only about the levels in the control sites, indicating an insignificant level of pollution of the roadside soils with these metals.

Interelement association was evaluated by calculating the correlation coefficients (Table 5). Significant correlations ($P < 0.05$) were only obtained for the pairs of lead and copper ($r = 0.758$), lead and chromium ($r = 0.366$), and cadmium and nickel ($r = 0.580$). The correlations were generally poor, possibly due to the varied nature of the sources of the contamination. Open burning of municipal solid waste, which can contribute to soil metal levels, is a common feature on many street corners of Ibadan. The city also hosts two major automotive battery manufacturing companies as well as a paint manufacturing plant, among other miscellaneous sources from which random metal pollution could occur. Studies in the vicinity of one of the battery factories showed highly elevated lead levels, and some degree of correlation between lead and cadmium levels, in soil and vegetation (Onianwa and Fakayode, 2000).

Results of the speciation studies are shown in Table 6. The bioavailable (nonresidual) fraction constituted about 60% of the total. The value for chromium was lower, being about 25%. The most mobile of the bioavailable phases, the exchangeable phase, was only a very small proportion (generally less than 5%) of the metal levels, except for cadmium (7.6%). Similarly, low proportions of exchangeable phase metals have been found in other soil speciation studies (Stones and Marsalek, 1996; Sauve *et al.*, 1997). The proportions held in the pH-affected

TABLE 3
Summary of Metal Concentrations (ppm) in the Various Traffic Density Areas

Sample Location[a]	Parameter	Pb	Zn	Cd	Cu	Cr	Co	Ni
High Traffic Density	*Mean* (n =15)	129 ± 130	58 ± 12	0.69 ± 0.59	23 ± 14	22 ± 11	8.2 ± 3.4	12 ± 15
	Median	121	60.9	0.80	22.0	24.2	7.50	12.0
Medium Traffic Density	*Mean* (n =17)	65 ± 150	49 ± 32	0.54 ± 0.48	16 ± 19	22 ± 10	8.0 ± 4.5	11.0 ± 6.2
	Median	48.0	42	0.73	14.9	22.9	7.3	11.0
Low Traffic Density	*Mean* (n =13)	64 ± 130	36 ± 57	0.43 ± 0.23	12 ± 13	22.0 ± 7.4	7.5 ± 3.0	8.4 ± 2.9
	Median	54.0	25.6	0.38	10.7	20.4	7.5	8.2
All Roadside Locations	*Mean* (n =45)	81 ± 140	48 ± 37	0.55 ± 0.49	17 ± 17	22.1 ± 9.6	7.9 ± 3.8	10.5 ± 9.7
	Median	87	50.5	0.64	16.3	22.9	7.5	10.4
Control Sites	*Mean* (n =2)	6.0	21.2	0.31	7.25	27.2	14.3	20.4

[a] High Traffic Density (>1000 vehicles per hour); Medium Traffic Density (250 – 1000 vehicles per hour); Low Traffic Density (<250 vehicles per hour)

TABLE 4
Average Factors of Accumulation[a] of Heavy Metals in Topsoil of the Different Zones

Traffic Density of Zone[b]	Pb	Zn	Cd	Cu	Cr	Co	Ni
High	21.5	2.74	2.23	3.17	0.81	0.57	0.59
Medium	10.8	2.31	1.74	2.21	0.81	0.56	0.54
Low	10.7	1.70	1.26	1.66	0.81	0.52	0.41

[a] Ratio of average concentration at given location to concentration at control site
[b] High Traffic Density (>1000 vehicles per hour); Medium Traffic Density (250 – 1000 vehicles per hour); Low Traffic Density (<250 vehicles per hour).

TABLE 5
Interelement Association (Spearman Correlation) for All Sampling Points

	Pb	Cd	Cu	Cr	Ni	Co
Cd	0.0647					
Cu	0.758[a]	0.204				
Cr	0.366[a]	0.0055	0.28			
Ni	0.229	0.580[a]	0.285	–0.0064		
Co	–0.120	–0.154	–0.296	–0.198	0.0088	
Zn	0.025	0.102	0.0674	0.120	0.0483	-0.249

[a] Significant at P <0.05

TABLE 6
Average Speciation (% in Geochemical Phases) of the Metals

Phase	Pb	Zn	Cd	Cu	Cr	Co	Ni
Exchangeable	4.4	1.1	7.6	0.8	3.2	3.4	3.1
Carbonate-bound	7.8	8.9	11.3	4.1	1.7	3.6	4.0
Reducible	39.4	39.6	7.4	14.7	7.8	41.4	10.8
Oxidisable	10.9	6.4	15.6	37.7	12.3	2.8	30.1
Residual	37.6	44.0	58.0	42.7	75.0	48.7	52.0

carbonate-bound phase were generally only slightly higher than in the exchangeable phase. Environmental factors that tend to reduce soil pH will readily mobilize this fraction. Lead, zinc, and cobalt were enriched in the reducible phase (bound to oxides of iron and manganese), while copper, chromium, cadmium, and nickel were enriched in the organic matter-bound oxidisable phase. Stones and Marsalek (1996) also observed an enrichment of lead and zinc in the reducible phase, as well as copper in the oxidizable phase. Changes in soil electrode potentials and soil redox reactions will influence the release and retention of elements in these two phases (Chuan *et al.*, 1996; Charlatchka and Cambier, 2000).

Table 7 shows the levels of roadside metal concentrations obtained in a number of studies elsewhere, compared with levels obtained in this study. Average lead level of 81 ± 140 ppm in this study is higher than have been recently obtained in Warsaw (52.9 ppm), Weinfelden, Switzerland (23.3 ppm), and some catchments in the Arctic (9 to 26 ppm). The Ibadan value compares closely with those of Abakaliki, Nigeria (78 ± 180 ppm) and Hong Kong (90 ± 53 ppm), but is lower than those obtained from Tyneside, UK (167 ± 330 ppm), Brisbane, Australia (2910±660 ppm), and N.W. London (261 to 2296 ppm). Average zinc level (48 ± 37 ppm) of this study is close to those of urban soils of Hong Kong and Weinfelden, Switzerland. Average topsoil zinc levels in Warsaw, Marie-Ontario, and London, are higher than the levels in Ibadan soils. Similarly, the average levels of the other metals are intermediate between extremes of low and high values that have been obtained from other studies.

Nigeria has no soil quality criteria against which to assess the metal levels obtained from this study. The levels are therefore compared with the criteria for Norway, Netherlands, Switzerland and Canada (Table 8). The average lead level in this study exceeds the 50 ppm Norwegian and Swiss guide values. Two-thirds of all the sample locations had lead levels exceeding these guide levels. Twelve of the 45 locations had levels that exceeded the 140 ppm Canadian soil lead limit for residential areas, while two locations exceeded the Dutch criteria for action (530 ppm). The overall average lead concentration is, however, lower than the Dutch and Canadian criteria. The USEPA has defined a soil lead value of 1000 ppm as the level that correlates with the critical blood lead level of 7 $\mu g\ dl^{-1}$ in children (USEPA, 1994; Tsuji and Serl, 1996). None of the sampling points in this study contained soil lead level that exceed 1000 ppm, but the prevailing levels call for closer monitoring and preventive actions. Average levels of all the other metals were also generally lower than the quality criteria listed in Table 8.

In conclusion, the results show that there is a significant elevation of the levels of lead, cadmium, copper, and zinc above the background levels in topsoil of this urban city, particularly in high traffic density areas. However, the concentrations do not correlate well with traffic volume as have been obtained in some other studies. The current average levels do not exceed the quality criteria set by several developed countries for these metals in soil.

TABLE 7
Roadside Topsoil Metal Levels (ppm) Obtained from Other Cities, Compared with This Study

Place		Pb	Zn	Cd	Cu	Cr	Co	Ni	Reference
Ibadan, Nigeria (this study, all sites)	Mean	81 ± 140	48 ± 37	0.55 ± 0.49	17 ± 17	22.1 ± 9.6	7.9 ± 3.8	10.5 ± 9.7	This study
	Range	15.0–650	2.9–278	0.02—2.7	2.7–92.5	3.7–50.1	4.0–22.2	2.9–67.7	This study
Warsaw, Poland	Range	18.4–163	70	0–5.5	7.0–65	4.8	—	—	Pichtel *et al.*, 1997
	Mean	52.9	140	1.0	24.8	12./9	—	—	Pichtel *et al.*, 1997
Hong Kong	Mean	90 ± 53	59 ± 5	0.9 ± 0.3	16 ± 5	—	—	—	Chen *et al.*, 1997
Arctic Catchments, N. Europe	Range	9–26	17–60	0.24–0.35	4–2270	0.6–42	0.6–98	2.5–2520	Reimann *et al.*, 1997
Weinfelden, Switzerland	Mean	23.3	53.8	0.24	25.6	—	—	—	von Steiger *et al.*, 1996
Brisbane, Australia	Mean	2910 ± 660	—	—	—	—	—	—	Al—Chalabi and Hawker, 2000
Tyneside, UK	Mean	167 ± 330	—	—	—	—	—	—	Mellor and Bevan, 1999
Marie, Ontario	Mean	64 ± 53	193 ± 530	0.78 ± 0.65	81 ± 137	11 ± 10	2.4 ± 7.9	2.4 ± 1.6	Stone and Marsalek, 1996
Abakaliki, Nigeria	Mean	78 ± 180	111 ± 88	0.21 ± 0.21	28 ± 14	—	—	53 ± 24	Chukwuma, 1996
	Range	12–882	27–319	0—1.0	11–61	—	—	14–97	Chukwuma, 1996
N.W. London, UK	range	261–2296	245–2133	1.7–6.3	35–640	—	—	—	Ellis and Revitt, 1982

TABLE 8
Soil Quality Criteria for Some Countries Compared with Levels (ppm) Obtained in This Study

Country / Definition	Pb	Zn	Cd	Cu	Cr	Co	Ni	Reference
Norway	50	150	1.0	100	100	—	30	Reimann *et al.*, 1997
Netherlands (action level)	530	720	12	190	380	240	210	Reimann *et al.*, 1997
Netherlands (further investigation)	310	380	6	110	240	130	120	Reimann *et al.*, 1997
Switzerland (Guide values)	50	200	0.8	50	—	—	—	FOEFL, 1987
Canada (residential)	140	200	10	63	64	—	50	CCME, 1999
Canada (agricultural)	70	200	1.4	63	64	—	50	CCME, 1999
Canada (commercial)	260	360	22	91	87	—	50	CCME, 1999
Canada (industrial)	600	360	22	91	87	—	50	CCME, 1999
Ibadan, Nigeria (this study, all sites, Mean[a])	81 ± 140	48 ± 37	0.55 ± 0.49	17 ± 17	22.1 ± 9.6	7.9 ± 3.8	10.5 ± 9.7	This study
Ibadan, Nigeria (this study, all sites, Range)	15.0–650	2.9–278	0.02–2.7	2.7–92.5	3.7–50.1	4.0–22.2	2.9–67.7	This study

[a] geometric mean

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