

Metal Pollution of Plants and Soil in Ibadan and its Environs in Southwestern Nigeria

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Abstract

Plant samples of *Eupatorium odoratum* and the soil samples on which it was grown were collected from thirty – eight points in Ibadan and its environs and were grouped into five zones. The samples were prepared and digested. The metal analysis was done by atomic absorption spectrometer (AAS). The ionic impulsion was calculated and pollution indexes were proposed for both the plant and soil. Automobiles exhaust and tire abrasion, burning of refuse and indiscriminate disposal of industrial wastes are the major causes of pollution. Urban high traffic zones has the highest index, 106.18% for plant and 135.46% for soil. The rural zones is the least polluted with plant and soil pollution indexes of 25.02% and 10.95% respectively.

Introduction

Environment is man's immediate surrounding which can be grouped into air, water, and land, with associated living and non-living things. Pollution has been defined as an introduction into the environment substances or energy liable to cause hazards to human health, harm to living organisms and ecological system, damage to structure or amenity of interference with legitimate uses of the environment by man (Hoigate, 1979). Environmental pollutants on the other hand are defined as chemicals of natural or synthetic origin that are released by man's activity into the environment where they have undesirable effect on the environment or on man through the environment and most people are unaware of the danger (Hutzinger and Vercicamp, 1991). Several authors have shown that lead and related metals are discharged from automobile exhausts into roadside soils, vegetation and nearby surfaces (Oniawa and Adoghe, 1997). The wear and tear of car tires due to abrasion on road surface and burning of tires will also lead to production of cadmium, nickel and some oils along the motorway (Lagerwesff and Specht, 1970). Heavy metals though essential to living organisms at low concentration are potentially toxic to human life at high concentration. (Azpiazu et al. 1986). This study was aimed at determining and monitoring heavy metal pollution of soil and plants in Ibadan metropolis and its suburb areas. The need for this study can not be over emphasized considering the metropolitan nature of Ibadan with high volume of traffic plying the roads, the large deposit of domestic waste generated by the large population and of cause the increase in the number of industries.

Materials and Methods

Site selection

The sites (Table 1) were divided into 5 zones for effective sampling and these zones include (a) Rural zone, with a total of 6 sampling sites (b) Urban-industrial zone, with 11 sampling site (c) Urban-high traffic, with 13 sampling sites (d) Urban-low traffic with 4 sampling sites and (e) The special zone, including sites around scientific laboratory, refuse dump site and unpolluted botanical garden, with 4 sampling sites. The choice of the number of sampling sites was due to the fact that much of the interest was in the urban industrial and high traffic while others was used as comparison.

Sampling and sample preparation

Areas that grow healthy matured *Eupatorium odoratum* were selected as sampling sites. Soil samples were taken from the soil top (0 – 5cm) where the plant has been removed. Composite samples were collected in each site from three locations (50x50x50cm) apart, mixed and stored in clean polyethylene bags. The plant samples were collected at each sampling site by carefully collecting the leaves at the base position of the *E. odoratum* by hand picking. All samples were collected within two weeks in November 2002.

Treatment of sample and preservation

Soil sample: The soil samples were air dried at room temperature in the laboratory for 5 days. It was then crushed using crushed using porcelain mortar and pestle. The sample was then sieved through a 100 mesh nylon screen and homogenous particle size (<0.150mm) was obtained. A 25g sub-sample was drawn from the bulk by randomly transferring five 5 scoops of the soil to a plastic container and air-dried. Kneading and rotating of the within the polythene containers was done until the time for digestion.

Plant samples: The plant leaves were sun dried for 6 days. These dried samples were hand crushed and ground to powder in porcelain mortar and pestle. The powdered samples were passed through 0.5mm sieve. It was stored in a new polythene bags until the time digestion.

Table 1: Sampling zones and site description

Sampling points/zones	Sample site Description
Rural	
Q1	Elebu village, approx. 3.0km from Moniya
2	Elebu village
3	Temidire – Alaja Village
4	Lalupon village, along Ibadan – Iwo Road
5	Ajibade village (near UI)
6	Akanran village, Onaara LGA.
Urban industrial	
7	Sumal Ind. Ltd., Oluyole Industrial Estate
8	P&G Oluyole Industrial Estate
9	Steel Works Ltd, Oluyole Industrial Estate
10	Sanusi Steel Ind. Ltd., Oluyole Industrial Estate
11	CAPL area Oluyole Industrial Estate
12	Yale Foods Oluyole Industrial Estate
13	Zartech (Agrobased), Oluyole Industrial Estate
14	Sumal Ind. Ltd., (Biscuit), Oluyole Industrial Estate
15	West African Batteries Ltd, (EXIDE)
16	Nigerian Breweries PLC., New Ife Road.
17	NNPC Depot, Apata.
Urban high traffic	
18	Around Total, Ibadan – Ilorin road, Ojo
19	Dugbe (around GPO)
20	Around Bodija Market, Bodija
21	Ibadan – Abeokuta Road, Apata
22	Eleyele (along Sango Eleyele Rd)
23	Secretariat Mapo
24	Iwo – Road (100m from the bridge)
25	Monatan (near refuse dump)
26	Akanran Rd by Lagos Ibadan Express
27	Ring Road by High court
28	Orita Challenge
29	Sango (by an automechanic workshop)
30	New Ife – Ibadan Road by NBL
Urban low traffic	
31	Aare, Bodija
32	Awosika Avenue, Bodija
33	Sabo area, Mokola
34	Oluyole Extension Residential
Special zone	
35	Around Chemistry/Physical Laboratories: UI
36	Solid waste Disposal Site, Akanran
37	Solid waste Disposal area (along the Road)
38	Botanical garden University of Ibadan.

Soil sample: (Wet digestion method): 0.5g of air-dried, ground and sieved soil sample was weighed into a clean 30cm³ platinum crucible and concentrated HNO₃/HClO₄/HF mixture added. The soil-acid mixture was then heated on a hot plate at a temperature between 80-90°C. Further heating at 150°C was done, the crucible plus content cooled and 10cm of distilled water added. This was then filtered and stored in a pre-cleaned polyethylene bottle for analysis. The digestion was done in triplicate and a blank sample was also prepared.

Plant sample (Dry ash)

2.0 g of air dried sample was weighed into a platinum crucible and then ashed in a muffle furnace at 500°C for 4 hours. To the cooled ash 5cm³ of 6M HNO₃ was added and then boiled for 20 minutes on a hot plate. The extract was diluted, filtered and stored for analysis.

The calculation of the metal concentration and ionic impulsion was done using the equation of Romero *et al* (18)

$$\text{Metal concentration } (\mu\text{g/g}) = \frac{(S-B) \times 50\text{cm}^3}{0.5\text{g (soil sample) or } 2.0\text{g (plant sample)}}$$

Where S = concentration of metal

B = concentration of blank

Ionic impulsion, $I = EC_1^{1/n}$

Where C_1 = metal concentration of the sample

n = oxidation number of the considered metal

$$\text{pollution index} = \frac{(I_{p \text{ or } s} - I_{\text{unpolluted}})}{(I_{\text{toxic}} - I_{\text{unpolluted}})} \times 100$$

$I_{p \text{ or } s}$ = ionic impulsion of the plant or soil sample

I_{toxic} = ionic impulsion for toxic level of metal

Results and Discussions

Iron has the highest concentration of all the metals studied for both plant and soil samples (Tables 2 and 3), which could be due to its prominence in tropical upland soils (Ogunwale and Adesoye, 1994). There seems to be a relationship between Pb and Fe and this was earlier observed (Adekola and Dosunmu, 2003). Cd has the least mean concentrations of the metals studied in both plant and soil samples for all the zones (Tables 4 and 5) and this may be due to deposits around the areas (Yankov, *et al*, 1998). Rural zone had the least metal concentration due to less exposure to pollution and the plant *E. Odorum* recorded a plant concentration of $11.57 \pm 4.15 \mu\text{g/g}$ which suggests that it has a poor ability in picking metals from the soil. (Sinha *et al*, 2002)

Tables 4 and 5 further showed that Pb recorded the highest concentration in the urban traffic zone out of all the zones for the plant samples with high range of 5.00 – 125 while it is second after special zone in the soil samples with a range of 76.0 – 480.0, which may be due to leaded petrol. The soil sample of the special zone had more Pb than the urban high traffic zone because of lead containing salts regularly deposited on the soil. Cu concentration is almost uniform and constant for the entire zone and also zones have a uniform concentration in the soil sample.

Ni and Cr recorded high concentration at the urban high traffic zone than any other zone, which is indicative that these metals are released from exhaust of automobiles (Lagerweff, J.V and Specht, A.W, 1970). Zn concentration is generally high for all the zones except the rural zone where most of the houses are with thatched roofs.

The summation of the metals ionic impulsion per sampling point is shown in table 6. High ionic impulsion value indicate high pollution index. Urban industrial had the highest pollution index for plant with 217% value while urban high traffic zone for the soil sampling point was 226%. Table 6 shows that urban – industrial and urban high traffic zones are the most polluted and it is indicative that industrial wastes, effluent, burning of refuse, and releases from automobile exhaust are the major sources of pollutants in Ibadan and its environs. Table 6 also revealed that rural zone is the least contaminated for the plant and soil samples.

Figure 1 shows a linear relationship between the plant and soil pollution indexes, which implies that the metal concentration in the plant samples is reflective of the concentration in the soil samples. Apart from rural zone where the mean plant pollution index (25.02%) is higher than that of the soil (10.95%) (table 7) which we could not explain, all zones have their soil pollution index higher than that of plant. It is conclusive that traffic is a major contributory factor to pollution in Ibadan and its environs, because urban – high traffic zone has the highest pollution indexes for both plant and soil.

Table 2: Average metal concentration ($\mu\text{g/g}$) for unpolluted plant value and the metal toxic level

	Pb	Cd	Zn	Cr	Co	Ni	Cu	Fe
Unpolluted plant	3.30	0.70	10.10	2.80	2.50	6.50	10.40	4.00
Toxic level	150.00	5.00	400.00	10.00	5.00	40.00	40.00	72000

Table 3: Average metal concentration ($\mu\text{g/g}$) for unpolluted soil value and the metal toxic level

	Pb	Cd	Zn	Cr	Co	Ni	Cu	Fe
Unpolluted plant	3.00	1.40	10.00	42.00	26.00	21.00	7.00	23300
Toxic level	100.00	5.00	300.00	100.00	50.00	100.00	100.00	-

Table 4: Mean Plant Metal concentrations ($\mu\text{g/g}$) $\pm$ standard deviation and range of metal contents in plants according to sampling zones

Element		Rural zone	Urban industrial	Urban high traffic zone	Urban low traffic zone	Special zone
Pb	Mean $\pm$ SD	7.88 $\pm$ 3.73	17.20 $\pm$ 11.50	22.84 $\pm$ 29.15	11.57 $\pm$ 4.15	11.45 $\pm$ 3.02
	Range	3.25 - 14.50	8.00 - 28.00	5.00 - 1230	8.25 - 16.50	8.25 - 16.0
Cd	Mean $\pm$ SD	0.88 $\pm$ 0.14	0.86 $\pm$ 0.30	2.05 $\pm$ 2.83	1.53 $\pm$ 0.21	3.79 $\pm$ 2.61
	Range	0.68 - 1.05	0.50 - 1.40	0.83 - 11.8	1.18 - 1.73	1.15 - 7.40
Zn	Mean $\pm$ SD	26.50 $\pm$ 14.53	173.25 $\pm$ 268.27	252.02 $\pm$ 176.13	111.88 $\pm$ 86.16	110.05 $\pm$ 96.08
	Range	10.10 - 45.50	2.43 - 894	34.90 - 661.00	12.10 - 220.00	16.00 - 260.0
Cr	Mean $\pm$ SD	3.13 $\pm$ 1.53	11.39 $\pm$ 6.57	8.16 $\pm$ 5.78	3.75 $\pm$ 0.88	4.88 $\pm$ 1.42
	Range	1.75 - 6.25	3.75 - 26.00	1.50 - 22.8	3.00 - 5.25	3.25 - 7.00
Co	Mean $\pm$ SD	3.92 $\pm$ 0.79	6.32 $\pm$ 1.35	5.08 $\pm$ 1.01	4.75 $\pm$ 1.25	3.63 $\pm$ 0.28
	Range	2.50 - 5.00	4.25 - 8.25	3.75 - 7.50	3.00 - 6.50	3.25 - 4.00
Ni	Mean $\pm$ SD	2.06 $\pm$ 2.02	17.59 $\pm$ 22.31	9.79 $\pm$ 3.04	9.33 $\pm$ 2.33	6.06 $\pm$ 0.82
	Range	5.25 - 59.5	5.25 - 17.0	6.75 - 17.00	6.25 - 12.50	5.25 - 7.00
Cu	Mean $\pm$ SD	16.31 $\pm$ 5.73	14.98 $\pm$ 6.41	13.80 $\pm$ 6.48	15.90 $\pm$ 3.78	15.10 $\pm$ 5.36
	Range	9.75 - 26.00	6.25 - 26.80	8.00 - 32.50	12.80 - 22.30	6.75 - 21.00
Fe	Mean $\pm$ SD	780.33 $\pm$ 322	2971 $\pm$ 1592	1606 $\pm$ 580	1311.25 $\pm$ 580	1311.25 $\pm$ 576
	Range	400 - 1240	1180 - 8050	565 - 7300	925 - 2470	660 - 1970

Table 5: Mean Soil metal concentrations (ug/g) $\pm$ standard deviation and range of metal contents in soils according to sampling zones.

Element	Rural zone	Urban industrial	Urban high traffic zone	Urban low traffic zone	Special zone
Pb	Mean $\pm$ SD 28.50 $\pm$ 18.68 Range 8.0 – 66.0	155.09 $\pm$ 202.26 19.0 – 752.0	196.77 $\pm$ 110.06 76.0 – 480	136.5 $\pm$ 98.35 44.0 – 301	26.5 $\pm$ 257.09 32.00 – 696.00
Cd	Mean $\pm$ SD 1.67 $\pm$ 0.50 Range 0.80 – 2.20	7.14 $\pm$ 7.25 1.70 – 22.90	3.49 $\pm$ 0.87 2.00– 5.50	3.45 $\pm$ 0.32 3.10– 3.90	4.38 $\pm$ 2.10 1.70 – 7.20
Zn	Mean $\pm$ SD 21.6 $\pm$ 6.33 Range 7.80 – 26.2	828.02 $\pm$ 992.78 16.60–3480.0	1200 $\pm$ 1206 68.30 – 3650.00	232.48 $\pm$ 169.15 52.90 – 480.00	506.43 $\pm$ 463.72 28.00 – 1030
Cr	Mean $\pm$ SD 46.50 $\pm$ 9.22 Range 38.0 – 462.0	120.18 $\pm$ 56.66 44.00 – 189.00	177.15 $\pm$ 100.72 64.00 – 462.00	118.25 $\pm$ 47.70 76.00 – 197.00	150.25 $\pm$ 154.91 39.00 – 416.00
Co	Mean $\pm$ SD 24.5 $\pm$ 9.22 Range 10.0 – 37.0	50.73 $\pm$ 25.07 30.0 – 104.0	33.0 $\pm$ 13.45 12.0 – 53.0	41.75 $\pm$ 2.59 39.0 – 46.0	29.5 $\pm$ 19.73 2.00 – 56.00
Ni	Mean $\pm$ SD 22.83 $\pm$ 1.86 Range 21.0 – 25.0	83.91 $\pm$ 38.04 32.0 – 147.0	105.0 $\pm$ 63.08 47.0 – 228.0	67.50 $\pm$ 21.48 51.0 – 104.0	78.5 $\pm$ 73.26 16.0 – 202.60
Cu	Mean $\pm$ SD 15.33 $\pm$ 5.91 Range 7.00 – 23.00	35.23 $\pm$ 31.69 5.50– 116.000	43.5 $\pm$ 22.76 19.00– 95.00	31.25 $\pm$ 7.98 20.00 – 42.00	91.25 $\pm$ 64.4 12.0 – 170.00
Fe	Mean $\pm$ SD 18608 $\pm$ 7013 Range 9850 – 27600	44000 $\pm$ 6800 6500 – 25700	2129231 $\pm$ 9834 3000 – 40400	32075 $\pm$ 100334 18600 – 46900	22625 $\pm$ 8079.72 7850 – 35900

Table 6: Ionic impulsion and pollution indexes for studied sampling points

Sampling Point/zones	I_{p-mico}	Plant pollution index(%)	I_{omico}	Soil pollution index (%)
Rural				
Q1	0.1917	10.00	0.1832	10.6
2	0.1889	8.7	0.1702	2.8
3	0.2104	19.1	0.1866	12.7
4	0.2481	37.5	0.1959	18.3
5	0.2526	39.7	0.1952	17.9
6	0.2433	35.2	0.1710	3.3
Urban-industrial				
7	0.4171	120.0	0.3151	90.5
8	0.2654	45.9	0.2833	71.2
9	0.3179	71.5	0.4205	154.0
10	0.4618	142.0	0.5231	216.0
11	0.3434	89.2	0.2335	41.1
12	0.3672	95.5	0.2901	75.4
13	0.3039	64.7	0.2120	28.1
14	0.4166	120.0	0.2984	80.4
15	0.3114	68.3	0.5365	225.0
16	0.3754	99.5	0.3202	93.6
17	0.6171	217.0	0.3919	137.0
Urban high traffic				
18	0.5152	168.0	0.4688	184.0
19	0.4049	114.0	0.4889	195.0
20	0.3452	84.8	0.4197	154.0
21	0.3440	84.2	0.5389	226.0
22	0.2969	61.2	0.4811	191.0
23	0.2189	23.3	0.3363	103.0
24	0.4064	115.0	0.3188	92.7
25	0.3437	84.0	0.3424	107.0
26	0.4624	123.0	0.4119	149.0
27	0.435	123.0	0.4067	146.0
28	0.3697	96.7	0.2393	44.6
29	0.4695	145.0	0.2920	76.5
30	0.4593	140.0	0.3180	130.0
Urban low traffic				
31	0.2979	27.7	0.2929	77.1
32	0.2927	59.2	0.2354	42.3
33	0.3578	90.9	0.2957	78.8
34	0.2959	60.8	0.3615	19.0
Special				
35	0.2235	25.5	0.2190	32.3
36	0.3191	72.1	0.3880	135.0
37	0.2955	60.6	0.4941	199.0
38	0.2690	47.7	0.2075	25.4

Table 7: Mean zone plant Ionic impulsion (Ip) and Mean soil Ionic impulsion (Is) with plant and soil pollution index

Zone	I _p	Plant pollution index(%)	I _s	Soil pollution index (%)
Rural	0.2225	25.02	0.1837	10.95
Urban industrial	0.3816	102.46	0.3477	109.86
Urban high traffic	0.3892	106.18	0.3894	135.46
Urban low traffic	0.2936	59.63	0.2964	79.91
Special	0.2768	51.45	0.3272	97.79

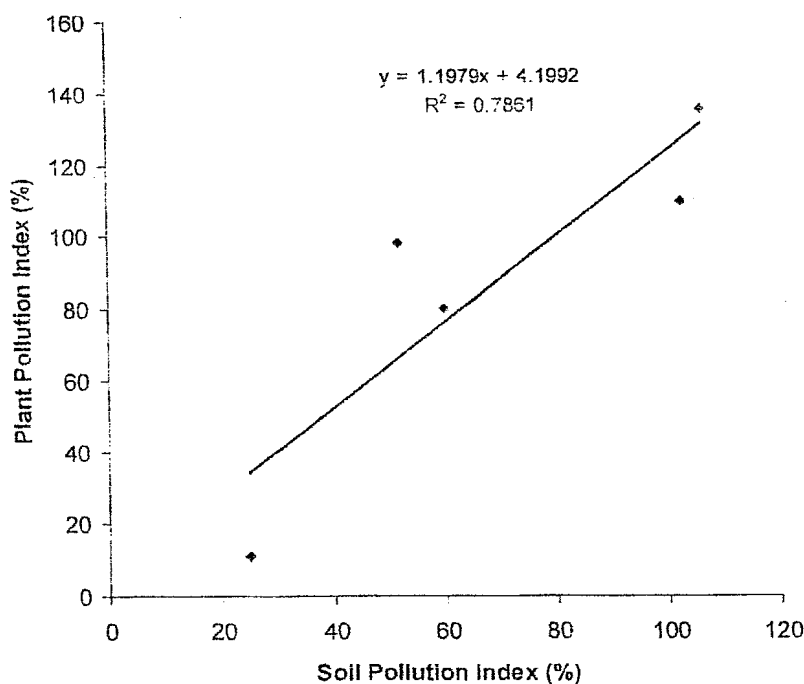


Figure 1:1 Graph of plant pollution index versus soil pollution index

Acknowledgement

The effort of Dr P.C Onianwa. Department of Chemistry, University of Ibadan is appreciated for the success of this research work.

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