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Original Research Article

Atmospheric contamination by heavy metals in Ilupeju industrial area of Lagos

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A B S T R A C T

The central aim of this paper is to assess the level of atmospheric pollution by heavy metals in Ilupeju industrial area of Lagos using plants as indicators. To realise this aim, a methodology was developed and implemented which involved collection and analysis of samples of bark and leaf of Mango (*Magnifera indica*) and Almond (*Terminalia catappa*) plant species in the area. The samples were analysed for Cu, Mn, Zn and Pb. The results obtained revealed that, first, with the exception of Zn, the various metals are concentrated in higher amounts in the bark than leaf samples in both the two tree species. Second, Mn is having the highest concentrations in both the bark and leaf samples of the two trees. Third, the mean values of the various metals in the bark and leaf samples are in general not significantly different among the various industrial density zones in the area. Fourth, among the various metals examined, Pb was found to have a very low or even near zero accumulating tendencies in plant samples in the area. Fifth, the bark samples of the two tree species were found to be the best indicators of assessing accumulation of the metals in the two plant types selected. Of the two tree species however, Almond specie *(Terminalia catappa)* serve as the best indicator of assessing the accumulation of the metals considered. It was thus concluded that there are evidences of accumulations of Cu, Mn and Zn in the area following occurrence of some industrial activities involving mainly metallurgical and metal-related industrial works. Since the three are among of the most unwanted heavy metals in human bodies, and that the plant types studied have high nutritional value to the people of the area, then controlling the levels of the accumulations requires that a deliberate effort towards controlling these human-related emissions of the metals into the atmosphere in the area is necessary.

Introduction

Under a farming ecosystem, plants could get polluted with heavy metals when heavy metals - bearing chemicals are sprayed on them to destroy weeds or where micronutrient fertilers are applied in soil fertility maintenance. In built up areas however, pollutants are routed to plants through three main sources, namely (i) emissions into the atmosphere from vehicular traffic, industrial complexes and burning of wastes containing traces of heavy metals. Metals that settle in the atmosphere can fall out directly on the plants or onto soils, through rainfall for instance, from where the plants can take them up (ii) disposal of heavy-metals bearing wastes on soil surfaces from where plants can take them up, and (iii) disposal of heavy-metals bearing wastes in water bodies from where plants can take them up. Lagos is the most industrialised city in Nigeria. In areas like Ilupeju, Ikeja, Agbara, there are chains of industries whose products differ from each other due to the varying raw materials used in proportion. It is therefore expected that some end products like gases and metals are being released alongside the main products. People who live around inhale these gases and plants absorb the released metals (which are both dangerous to both the plants and humans). It is hence expected that due to industrialisation in the area, the air is being polluted, and metals are being absorbed into plants and animals, which are then cycled into human beings on the long run. Because of the health implication of such cycling, studies are no doubt needed which shall from time to time assess the levels of such metals in plants. The need for such studies constitutes the problem of interest to this research.

The aim of this research is to assess the level of air pollution in Ilupeju area of Lagos using plants as indicators. Specifically, the objectives of this study are:

To identify the main plant types found in the areas;

To collect bark and leaf samples of these plants in the area and analyse them for the presence of trace metals;

To identify the types and levels of metals found in the barks and leaves of the sampled trees;

To find out the particular specie(s) of plants that is best indicator(s) of air pollution in the area.

Study Area

Lagos State is situated in the southwestern corner of the country. It is bound on the east by Ondo State, west by Benin Republic, north by Ogun State and spans the Guinea coast of the Atlantic Ocean for over 180km as its southern boundary. It is approximately between latitude 6°45'N and longitude 4°30'E Its total area is 3577sq.km. About 787sq.km or 22percent is water.

Ilupeju is a town located in Mushin LGA of Lagos State. The area is divided into residential and industrial area. Both areas are situated along the Town Planning Way in Mushin LGA. The industrial area occupies about twenty-five percent of Ilupeju, while the remaining 75 percent is designated to the residential area.

The geology of Lagos is mainly composed of Basement Complex rock, overlain by thick deposits of sedimentary rock, which is as a result of marine denudational processes.

Recent coastal deposits however occur widely in Lagos State since it lies entirely within the coastal plains of the country. Consequently, it is characterised by sandbars, lagoons, and creeks, and the land does not rise very much above sea level anywhere in the state (Akintola-Arikawe, 2000).

Annual rainfall ranges from 1524-2031mm in the western half of the state to 2032-2540mm in the eastern half. The abundance of rainwater makes the state a relatively drought free zone. With a rich supply of moisture, Lagos has a relative humidity, which is high, the annual mean being about 88percent. The relative humidity is higher in the early hours of the morning (7-10am) and lower in the afternoon hours (1-4pm). A mean annual temperature maximum of 30^0C (86^0F) and a minimum of 23.8^0C (75^0F) satisfy this condition. The lowest temperature in Lagos occurs at the peak of the rainy season in July but remains high almost through out the year.

Two main vegetation types are identifiable in Lagos State: swamp forest of the coastal belt and dry lowland rain forest. The swamp forests in the state are a combination of Mangrove forest and coastal vegetation developed under the brackish conditions of the coastal areas and the swamp of the fresh water lagoons and estuaries. Characteristic of the swamp forest zone are the Red Mangrove (with heights of 592m) as well as Mangrove shrubs, stilt-rooted trees with dense under growths and rafia and climbing palms.

Lying to the north of the swamp forest is the lowland (tropical) rain forest zone. This zone stretches from Ikeja through Ikorodu to an area slightly north. In this area can be found economically valuable trees as teak, tripochiton, seletrocylon (Arere), baclea didrrichil (opepe) and terminalia (idigbo)

Lagos state has very little arable land and four soil groups are identifiable. The first group can be found on the western half of the coastal marine i.e. the juvenile soils on the recent wind-borne sands. The second group is found east of the coastal area, covered by juvenile soils on fluvio-marine alluvium (Mangrove swamp).

The third is a narrow and rather discontinuous band of mineral and/or organic hydromorphic soils which occur in the middle and northeastern section of the state. The fourth group consists dominantly of red ferralitic soils on loose sandy sediments as they occur in two tiny and discontinuous patches along the northern limits of the state (Arikawe, 2000).

Land in use in Lagos state can be viewed under the following: Residential, Industrial, Commercial and Agricultural. Approximately 40 percent of the total area of Lagos State is used for residential purposes. The industries about 20 percent of the land mass and as such we have some industrial estates in places like Ilupeju, Ikeja, Apapa etc. these industrial estates are well planned and are easily distinguished from residential areas. The state has been a well known commercial nerve centre having various establishments like banks, research institutes, ports, markets, ministries, hotels and tourist attractions etc. the state has been a zone of convergence for business men and their counterparts because most headquarters of these establishments are situated in the state because of its proximity to the coast. Agriculture on the other hand has little or no influence on the state. Within the state, arable crops like maize, cassava, vegetable, yam, pineapples etc are grown by peasant farmers on small holding. Tree crops are also grown in varying quantities, which includes coconut, kolanut, oilpalm etc. Also, the range of livestock reared in the state includes poultry, pig, sheep, goat, cattle and rabbit. Commerce only takes up about 10 percent of teh land mass (Akintola-Arikawe, 2000).

Materials and Methods

Selection of Sampling Sites, and Collection of Samples

The following procedure was employed to select suitable experimental sites, and the plants samples;

A reconnaissance survey was first carried out at Ilupeju Town (Mushin LGA) of Lagos State to obtain information on the types of industries and their location; and the main types of trees and their location in the area.

Tree species were then selected at different location across the Ilupeju area to ensure spatial spread and representativeness. Among the various types of trees found in the area, two were found to be the main ones that have direct nutritional and economic importance to human beings and livestock in the area, because both are edible fruits-bearing tree species, and their leaves have some pastural values. These are Mango (*Magnifera indica*) and Almond (*Terminalia catappa*). They were hence considered as the main ones that suit the scope of this study, since it is expected that the metals that accumulate in them can get cycled into human body systems in the area.

The study area was categorised into three areal units on the basis of densities of industrial activities. This was done on the basis of enumerating the number of industries per given land area. The three units were subsequently classified as high, medium and low vehicular traffic and industrial activity density areas.

Within unit, ten tree species of each of the two tree types were selected at locations randomly selected across every unit, but selected in a way as to ensure representativeness in each unit.

Samples of leaves and barks were taken from each of the selected tree specie. This gave a total of ten bark and ten leaf samples per unit. The collected samples were adequately marked and labelled.

The collected samples were taken to the laboratory and analysed for the presence of trace metals using standard laboratory procedures.

Laboratory Analysis

Each of the collected samples was first air-dried, crushed to powder and then sieved using a 5mm sieve. The resulting powder was then oven dried at 105^0C. 0.200g sub sample of the oven-dried material was then weighed into a 100ml long-necked Kjeldahl flask. 1.0ml of sulphuric acid (SG 1.84), 5ml of nitric acid (SG 1.42) and 1ml of perchloric acid (72%) were then added. The mixture was then heated gently until the reaction subsided. After that, the heat was then increased until the mixture boiled. The digestion was continued until white flumes of sulphuric acid appeared and the mixture was then heated for another 15 minutes. The mixture was cooled and then transferred into 100ml volumetric flask and make up to mark with water. The total digestion time was one hour thirty minutes. From the results of the digestion concentrations of Copper (Cu), Zinc (Zn), Manganese (Mn) and Lead (Pb) were determined using atomic absorption spectrophotometry. Table 3.1 gives the condition of the instrument as at the time of analysis. Prior to the digestion, four stock solutions for each of the metals to be determined from the samples were prepared. These include:

Stock Copper Solution (100mg/l)

0.1000g of pure Copper metal was dissolved in 250ml of 5N nitric acid and made up to 1liter mark in a volumetric flask. 5ml of the stock solution was then pipetted into a 100ml volumetric flask and made to mark with distilled water.

Stock Zinc Solution (100mg/l)

0.1000g of pure zinc metal was dissolved in diluted hydrochloric acid and made up to 1 litre mark in a volumetric flask. 5ml of the stock solution was then pipetted into a 100ml volumetric flask and made to mark with distilled water.

Stock Manganese Solution (100mg/l)

0.1000g of oxide free manganese metal was dissolved in hydrochloric acid and made up to 1 litre mark in a volumetric flask. 5ml of the stock solution was then pipetted into a 100ml volumetric flask and made to mark with distilled water.

Stock Lead Solution (100mg/l)

0.1000g of pure lead metal was dissolved in hydrochloric acid and made up to 1 litre mark in a volumetric flask. 5ml of the stock solution was then pipetted into a 100ml volumetric flask and made to mark with distilled water.

Statistical Analysis

Descriptive statistics (mean and standard error of the mean) values were computed for the determinations made of every metal in both the bark and leaf samples of each of the three industrial density areas. Analysis of variance statistical test was then used to assess the significance of the difference in the mean values of every metal for the two tree species, for both the bark and leaf samples, among the industrial density areas.

Results and Discussion

The results of the determinations are summarised in mean and standard error of mean values of every metal in Tables 4.1 and 4.2 respectively for the Mango (*Magnifera indica*) and Almond (*Terminalia catappa*) tree species respectively.

Concentrations of the Metals in the Various Plant Samples

A close look at Tables 1 and 2 reveals that with the exception of Zn, the various metals are concentrated in higher amounts in the bark than leaf samples in both the two tree species. Higher concentrations of the various metals in the bark compared to the leaf samples, as observed here, could be attributed to the influence of texture of a surface on accumulation of metal in the environment. As explained by Barnes et al. (1976) and Odukoya et al. (1999), rough surface favour higher extent of accumulation of metals than do smooth ones. The two tree species studied here have barks that are rough in nature. Such roughness can therefore promote greater accumulation of the metals in the bark compared to the tree leaf samples.

Among the various metals, Mn is having the highest concentrations in both the bark and leaf samples of the two trees. The Mn values are in most cases over 50% greater than the values of the other metals. In Ilupeju industrial area, there a number of vehicle assembling industries and those specialising in varieties metals of workings such as fabrication of spare parts of engines, containers, domestic metallic goods such as doors and windows, and bodies of vehicles. In such kinds of metallurgical industries, Fe and Mn are usually the most important metallic raw materials being utilised. Consequently, the two metals tend to be the most frequently released as pollutants. The observed higher levels of Mn in the samples analysed here is therefore not surprising.

Table 3 compares the mean values of the various metals in both the bark and leaf samples among the three industrial density areas. It is clear from the table the mean values are in general not significantly different in the samples collected from the various industrial density zones in the area. This trend probably suggests that variation in density of industrial activities in the area is not causing variation in the extent of accumulation of the metals in the plant samples. This trend thus suggests that industrial activities in the area, whether heavy or light, are associated with release of some metallic elements into the atmosphere.

Among the various metals examined, Pb has a very low or even near zero accumulating tendencies in plant samples in the area. The element has variously been described as being mainly associated with emissions from vehicular traffic, as Pb is used in fuel and additives being used in motor vehicles (Madany et al., 1990; Nyagababo and Hamya, 1991; Onasanya et al., 1993; AECLP, 1994; Odukoya et al, 1999; Howari and Banat, 2001). In the study area, vehicular traffic is very light because of fewer residential areas. Instead, what mostly ply the roads in the industrial area are tonnage vehicles that move in and out of the industrial area to carry in raw materials and evacuate finished products. Such movements are usually light since delivery of raw materials and evacuation of finished products are not frequently being done in the area.

It is clear from the Tables 1 and 2 that the bark samples are the best indicators of assessing accumulation of the metals in the two plant types selected. Of the two tree species however, Almond specie *(Terminalia catappa)* serve as the best indicator of the accumulation as the samples collected from it maintain generally higher levels of the metals studied. This means that using Almond specie would give a better picture of the extent of atmospheric pollution by the studied metals in the area.

The results obtained in this study appear to be supportive of the following conclusions:

The bark samples of the two tree species are the better indicators Mn and Cu pollution in the area.

Mn is the metal with the highest accumulative tendency in both the bark and leaf samples analysed in the area.

Variation in density of industrial activities in the area is not causing variations in the extent of accumulation of the metals in the plant samples.

Pb has a very low to near zero accumulating tendency in the plant samples in the area.

Of the two tree species however, Almond specie *(Terminalia catappa)* serve as the

Table.1 Levels of Heavy Metals in Bark and Leaf Samples of Mango (*Magnifera indica*) tree species

S.No.	Heavy Metal	Concentration in Bark Samples (ppm) in Zones of Varying Densities of Industrial Activities			Concentration in Leaf Samples (ppm) in Zones of Varying Densities of Industrial Activities		
		High Density Zone	Medium Density Zone	Low Density Zone	High Density Zone	Medium Density Zone	Low Density Zone
1	Copper	12.4±3.7	10.3±4.2	9.9±2.5	10.6±3.0	8.2±0.7	10.5±2.1
2	Zinc	1.2±0.3	1.02±0.5	0.7±0.2	1.24±0.4	0.7±0.1	1.0±0.3
3	Manganese	101.0±31.8	88.0±31.2	110.0±23.2	7.5±1.4	10.8±1.6	8.7±1.2
4	Lead	BDL	BDL	0.01±0.001	0.001±0.0001	0.001±0.0001	BDL

Note: The means are for ten values per density zone; ± Means standard error of the mean
BDL Means below detection limit

Table.2 Levels of Heavy Metals in Bark and Leaf Samples of Almond (*Terminalia catappa*) Tree Specie

S/No.	Heavy Metal	concentration in Bark Samples (ppm) in Zones of Varying Densities of Industrial Activities			centration in Leaf Samples (ppm) in Zones of Varying Densities of Industrial Activities		
		High Density Zone	Medium Density Zone	Low Density Zone	High Density Zone	Medium Density Zone	Low Density Zone
1	Copper	30.3 ±14.2	28.8±12.6	30.2±10.2	10.6±3.0	8.0±3.3	12.5±3.6
2	Zinc	0.63±0.21	0.5±0.09	0.48±0.11	1.37±0.5	1.2±0.1	1.28±0.5
3	Manganese	112±42.1	144±43.5	116±21.8	29.2±9.4	32.8±11.3	30.4±12.6
4	Lead	BDL	BDL	0.001±0.0001	BDL	BDL	BDL

Note: The means are for ten values per density zone; ± Means standard error of the mean
BDL Means below detection limit

Table.3 Comparison of Heavy Metal Contents in Plant Samples Among the three Industrial Density and Vehicular Traffic Density Zones

S/No.	Heavy Metal	Significance of the Difference Among the Three Industrial Activity Zones							
		Mango (*Magnifera indica*) Tree				Almond (*Terminalia catappa)* Tree			
		Bark Samples		Leaf Samples		Bark Samples		Leaf Samples	
		F-Val	SD	F-Val	SD	F-Val	SD	F-Val	SD
1	Cu	1.45	NS	0.98	NS	0.76	NS	1.25	NS
2	Zn	0.97	NS	2.16	S	1.28.	NS	0.76	NS
3	Mn	2.43	S	2.05	NS	3.12	S	1.16	NS
4	Pb	0.78	NS	1.53	NS	0.82	NS	0.91	NS

Note:
F-Val means calculated value of critical F (from the ANOVA test formula)
SD means significance of the difference revealed between the compared mean values
NS means difference between the means is not significant
S means difference between the means is statistically significant

best indicator of assessing the accumulation of the considered metals in the area. It is clear from the results obtained in this study that there are evidences of accumulations of Cu, Mn and Zn in the area following occurrence of some industrial activities involving mainly metallurgical and metal-related industrial works. Since the three are among of the most unwanted heavy metals in human bodies, and that the plant types studied have high nutritional value to the people of the area, then controlling the levels of the accumulations requires that a deliberate effort towards controlling these human-related emissions of the metals into the atmosphere in the area is necessary. In this regard the following options could be tried. First, industrial activities could be restricted to only those employing catalytic converters in their industrial machineries. Such converters are designed to reduce tailpipe emissions of various pollutants. Second, all industries involving direct use Cu, Mn and Zn among their raw materials should be strictly monitored to ensure that the usages are not promoting indiscriminate releases of the metals among industrial wastes. Where defaulters are identified severe sanctions should be identified to serve as deterrents to others.

References

AECLP Alliance to End Childhood Lead Poisoning 1994. The Global Dimension of Lead Poisoning, Washington DC

Akinjide, O. 1997. Dimension of Environmental Problems in Nigeria. Davidson Press, University of Ibadan, Ibadan.

Akintola-Arikawe, J.O. 2000. Lagos State. In: A.B. Mamman et al., Nigeria: A People United a Future Assured. Volume 2: pp 357-368. Gabumo Publishers Calabar.

Al-Yakoob, S.N. and Addal, S. 1993. Exposure to particle bound polyaromatic hydrocarbons in the Al-Mansoria residential area during the Kuwait oil fires: A qualitative appraisal of the absorption role. Environment International Volume 19: 319.

Botkins, D.B. and E.A. Keller 1995. An Introduction to Environmental Sciences. John Wiley and Sons Incorporated, London.

Chan, L.Y and Helen, W.Y. Wu. 1992. A study of bus commuter and pedestrian exposure to traffic air pollution in Hong Kong. Environment International Volume 19: 121-132.

Fatoki, S.O. 1995. Trace zinc and copper concentrations in roadside surface soils and vegetation – measurement of local atmospheric pollution in Alice South Africa. Environment International Volume 226: 121-132.

Howari, F.M. and K.M. Banat 2001. Assessment of Fe, Zn, Cd, Hg and Pb in Jordan and Yarmuk river sediments in relation to their physiochemical properties and sequential extraction characterization. Water, Air, and Soil Pollution Volume 132: 43-59.

Madany, I.M., Ali, S.M. , Aktor, M.S. 1990. Assessment of lead in roadside vegetation in Bahrain. Environment International 16: 123-126.

Malanca, A. 1993. Indoor air pollutants in a building block in Parma Northern Italy. Environment International Volume 19: 313-318.

Nyagababo, J.T. and Hamya, J.W. 1991. The deposition of lead, cadmium, zinc and copper from motor traffic on Brachiana eimini and soil along a major Bombo road in Kampala City. International Journal of Environmental Studies Volume 27: 115-119.

Odukoya, O.O., Arowolo, T.A. and Bamgbose, O. 1998. Lead, zinc and copper levels in tree barks as indicators of atmospheric pollution. Bioresearch Communications. Volume 114: 299-306.

Onasanya, L.O., Ajewole, K. and Adeyeye, A. 1993. Lead content in roadside vegetation as indicator of atmospheric pollution. Environment International Volume 19: 615-618.