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Original Article

Influence of vehicular traffic level on lead content of leaves of some roadside trees in Kaduna City, Nigeria

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ABSTRACT

Pollution of the city/urban atmosphere by contaminants arising from automobile and other sources is considered a real and serious problem. Lead (Pb) has long been known as potential hazard to health especially in the city where petrol is burnt from motor vehicles, various anthropogenic activities release high quantity of Pb to the environment. Consequently, this study aims to assess Pb content of leaves of roadside trees in Kaduna city. Leaves of six dominant tree species were selected (*Mangifera indica* L.; *Eucalyptus camaldulensis* Dehnh.; *Albizia lebbeck* Linn.; *Anacardium occidentale* L.; *Azadirachta indica* Linn.; and *Psidium guajava* L.) for screening from ST_1 (Roadside – Ali Akilu Road, with high vehicular traffic route); ST_2 (Roadside – Waff Road, with medium vehicular traffic route); and ST_3 (Roadside – Kanta Road, with low vehicular traffic route). Ten matured sample leaves were detached from the side of each selected tree facing the road from different locations during and end of raining season (dry season) using subjective sampling method. The leaves were washed to remove dust particles, oven dried for 24 h and crushed into fine powder, stored in plastic container with lids, and labeled before moving to the laboratory for analysis of Pb content using spectrophotometer (AA220fs). The results show that the mean Pb content of tree leaves at the three vehicular routes ranged from 0.14 mg/kg at ST3 to 0.99 mg/kg at ST1.This implies that the high traffic route had the highest concentration of Pb in the tree leaves. However, there was no significant difference in Pb content between the three vehicular routes. Mean Pb content ranged from 0.27 mg/kg in *Mangifera indica* and *P. guajava* to 0.88 mg/kg in *A. occidentale.* Moreover, significant differences were not found in the Pb content of the six tree species. With increasing urbanization, the concentration of this metal might increase and possibly create health hazards. Bioremediation methods can be adopted by planting favorable tree species capable of absorbing Pb metal in the atmosphere for reduction in urban/city heat, mitigation of air pollution, and biomonitoring. Furthermore, the law should be promulgated for prescribed standards for the level of emission from automobile exhaust and energy generating plant and stations. Finally, it is of paramount importance to educate those living in the vicinity of high traffic routes of the possible danger in consuming tree leaves and other parts of the plant collected from roadside vegetation.

Keywords: Danger, lead, pollution, roadside, vehicle traffic route

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INTRODUCTION

The city atmosphere is subjected to large inputs of contaminants the composition of which reflects the contribution of different sources.[1] These sources are mainly anthropogenic and include asphalt, weathered street materials, biomass combustion, industries, and automobiles.[2] Roads are important infrastructure that plays a major role in stimulating social and economic activities. However, road construction has also resulted in heavy environmental pollution.[3] Several researchers have indicated the need for a better understanding of trace metal pollution of roadside soils.[4,5] Trace metals in roadside soils may come from various human activities, such as industrial and energy production, construction, vehicular movement, waste disposal, as well as coal and fuel combustion but a larger proportion of it comes from vehicular movement.[6] Air pollution is a major problem of the city and may occur in gaseous or particulate form. The contribution of city

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atmospheric contaminants by automobiles appears to be more significant particularly in developing countries.[7,8] According to Adefolalu and Mabogunje[9,10] in developing countries like Nigeria, improved road accessibility apart from increases the number of vehicles it also creates a variety of ancillary employment which ranges from vehicle repairs, vulcanizer and welders to autoelectricians, battery chargers, and dealers in other facilitators of motor transportation. These activities send trace metals, especially lead (Pb) into the air and the metals subsequently are deposited into nearby trees and soils, which are also absorbed by plants on such soils.

Heavy metals such as iron, copper, zinc, and manganese are essential components of many alloys, pipes, wires, and tyres in motor vehicles and are evolved into the roadside environment due to mechanical abrasion and usual wear and tear. The metallic pollutants in the air gradually and eventually precipitated on the ground surface depending on wind flow patterns and their concentrations are, therefore, elevated in adjacent areas.[11] In view of the increasing anthropogenic activities, the heavy metals pollution of soil, water, and atmosphere represent a growing environmental problem in the city and concern affecting food quality and human health. Excessive accumulation could lead to heavy metal contaminations of roadside vegetation, wildlife, domestic animals, and the human settlements. Due to the disturbance and acceleration of nature's slowly occurring geochemical cycle of metals by man, most soils of rural and urban environments may have one or more of the heavy metals above defined background values, high enough to cause risks to human health, plants, animals, and ecosystem.[12] Among the heavy metals, Pb has long been known as potential hazard to health.[13-17] However, in humans, Pb is known to cause various diseases which include retardation in mental development, damage to central nervous system, and inhibition of hemoglobin synthesis.[18-20] Noted that the nature of these effects may be acute, chronic, neurotoxic, carcinogenic, mutagenic, or teratogenic.

In automobile, Pb is mainly a component of engine oil, other lubricants, and fuel.[21,22] Leaded fuel is still widely used in most developing countries because it is less expensive. Fossil fuel combustion and exhaust emission have been identified as primary source of atmospherics metallic nuisance.[23-25] Aerosol and deposited dust in urban area comprise ample amounts of many potentially toxic trace metals in comparison with those found in non-urban areas. The variation of isotopic ratios is used as an indicator of Pb contamination in the environment (fingerprint of the Pb sources). Deduction concerning the isotope ratios is based on the different half-lives of the 206Pb, 207Pb, and 208Pb parent isotopes. The Pb source can have diverse or overlapping isotopic ratio ranges based on which the origin of the pollution can be verified. In environmental sciences 206Pb/207Pb, 208Pb/206Pb, and 207Pb/208Pb ratios are commonly used. According to Sun *et al*.,[26] the anthropogenic sources of Pb have relatively low 206Pb/207Pb ratios in the ranges from 0.96 to 1.20, while naturally occurring Pb has generally higher 206Pb/207Pb ratios (>1.20) Zaborska [27] reported the ratio of 206Pb/207Pb equal to 1.22 as a representative for old and uncontaminated polish rocks. The ratio of 206Pb/207Pb in leaded gasoline used in Central and East Europe was 1.16–1.17, while in unleaded gasoline and diesel used in Africa and other undeveloped countries fell within the ranges 1.14–1.15 and 1.14–1.16, respectively.[28] Flora in cities is more prone to heavy metal pollution due to pervasive pressure of auto-vehicular emissions.[29] Leaves of tree are the most sensitive part to be affected by air pollutants as major physiological processes are concentrated in the leaf.[30]

Vehicular movement is an important source of Pb and other heavy metals in the environment. Plants play very crucial environment roles including serving as contaminant sink and indicator of air pollution. A lot of studies have shown that heavy metal is responsible for certain diseases that have lethal effect on human, flora and fauna[31-33] for this reason various government departments and several non-government organizations are much concerned about the effect of vehicular emission of Pb in the environment. The objective of the study is to evaluate Pb content of leaves of some roadside trees in Kaduna City, Nigeria. However, information on roadside contamination with heavy metals, especially Pb in Kaduna city, is limited and attempt to bridge this gap form the thrust of this study.

MATERIALS AND METHODS

Study Area

The study was carried out in Kaduna state. The state lies within the Guinea Savanna eco-region. It is located between longitudes 06^{o}15^{1}E, 08^{o}50^{1}E and latitude 09^{o}2^{1}N and 11^{o}32^{1}N [Figure 1]. It covers an area of about 48,473 km^2 and has an estimated population of 6,113,503 in which 3,090,438 are male and 3,023,065 are female.[34,35]

Sampling Procedure and Treatment

In line with the criteria adopted from Witting and Market,[36,37] six dominant tree species were selected (*M. indica* L.; *Eucalyptus camaldulensis* Dehnh.; *Albizia lebbeck* Linn.; *A. occidentale* L.; *Azadirachta indica* Linn.; and *Psidium guajava* L.) for screening from ST_1 (Roadside – Ali Akilu Road, with high vehicular traffic route); ST_2 (Roadside – Waff Road, with medium vehicular traffic route); and ST_3 (Roadside – Kanta Road, with low vehicular traffic route). Ten matured sample leaves were detached from the side of each selected tree facing the road from different locations at the end of raining season (dry season) to avoid rain washing out the metal using subjective sampling method. Heavy metal load of plant leaves is known to correlate more with surface level than that of the soil.[38] The experimental design adopted was completely randomized design.

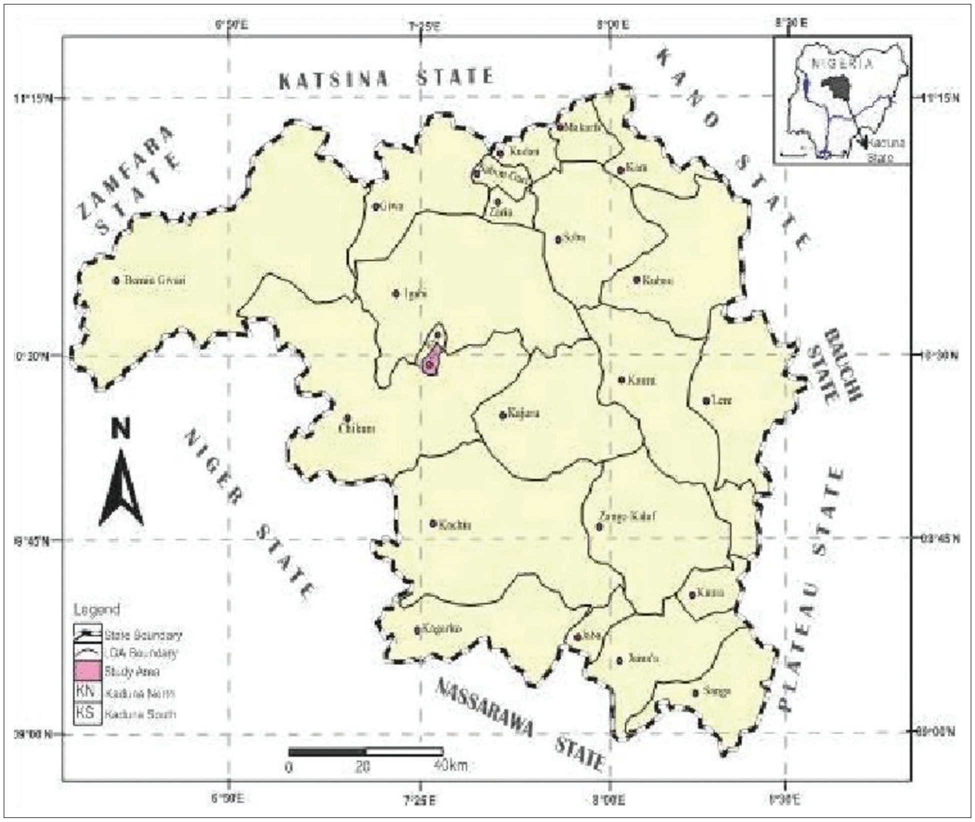

Figure 1: Map of Kaduna state showing the study areas. Source: Sodimu[35]

Laboratory Analysis

Leaf samples from different vehicular traffic routes were washed to remove dust particles and oven dried for 24 h. Leaf samples were crushed into fine powder, stored in black plastic container with lids, then carefully labeled, and kept on a bench away from sunlight until used.

Analytical Procedure

The method of AOAC[39] was adopted. One gram of each sample was digested using aqua regia (1:2 Vol. of NHO_3, HCL) and extracted with deionize water. The extract was then aspirated into the spectra AA220fs spectrophotometer after inserting Pb hollow cathode lamp. The analysis was carried out at Federal Ministry of Agriculture and Rural Development Annex, Gonigora, Kaduna state. Data collected were subjected to descriptive analysis and ANOVA at $P < 0.05$.

RESULTS AND DISCUSSION

The results of the analysis of heavy metal (Pb) content of the various plants at the sample location STI, ST2, and ST3 are presented in Table 1.

Table 1 indicates that Pb content of tree leaves at ST1 ranged from 0.01 mg/kg in *P. guajava* to 2.60 mg/kg in *A. occidentale* with mean of 0.99 mg/kg. At ST2, it ranged from 0.01 mg/kg in other trees to 2.00 mg/kg in *A. lebbeck* with a mean of 0.69 mg/kg, while at ST3 0.01 mg/kg in other trees to 0.80 mg/kg in *Psidium guajava* with a mean of 0.14 mg/kg. No significant differences were found in Pb content of plant leaves with respect to vehicular traffic routes ($P = 0.80 > 0.05$). Mean Pb content was the highest in *A. occidentale* (0.88 mg/kg) and least in *M. indica* and *P. guajava* (0.27 mg/kg). No significant differences were found in Pb content with respect to tree species ($P = 0.88 > 0.05$). The above results are in agreement with Don-Sheng and Peart, Atayese *et al*., Bako *et al*., Magaji *et al*., Sodimu *et al*.,[21,40-43] who observed that heavy metal levels in vegetation correspond with traffic intensity.

It was observed that Pb content of leaves was highest at the heavy traffic route (ST1). Four of the six tree leaves analyzed, namely, *M. indica* L.; *A. occidentale* L.; *A. lebbeck* Linn.; and *Eucalyptus camaldulensis* Dehnh. show this trend [Figure 2].

However, exception was noticeable in *A. indica* L. at ST2 and *P. guajava* L. at ST3. The higher concentration of Pb in plant leaves at ST1 can be mostly likely attributed to higher volume of traffic on this route. Similar observation was made by Sodimu, Aksoy and Ozturk, Al-Shayeb *et al*.[35,44,45] Other possible reason for this observation is that ST2 route is a single carriage road in comparison with ST1 which is a dual carriage road[46,47] who emphasized that carriage road can influenced

Table 1: Pb content of selected trees in mg/kg

Species	ST1	ST2	ST3	Mean
	Pb (mg/kg)	Pb (mg/kg)	Pb (mg/kg)	
Mangifera indica	0.80	0.01	0.01	0.27
Anacardium occidentale	2.60	0.01	0.01	0.88
Albizia lebbeck	1.00	2.00	0.01	1.00
Eucalyptus camaldulensis	1.50	0.01	0.01	0.51
Azadirachta indica	0.02	2.10	0.01	0.71
Psidium guajava	0.01	0.01	0.80	0.27
	R=0.01–2.60	R= 0.01–2.00	R=0.001–0.80	
	Mean= 0.99	Mean = 0.69	Mean= 0.14	

Pb: Lead

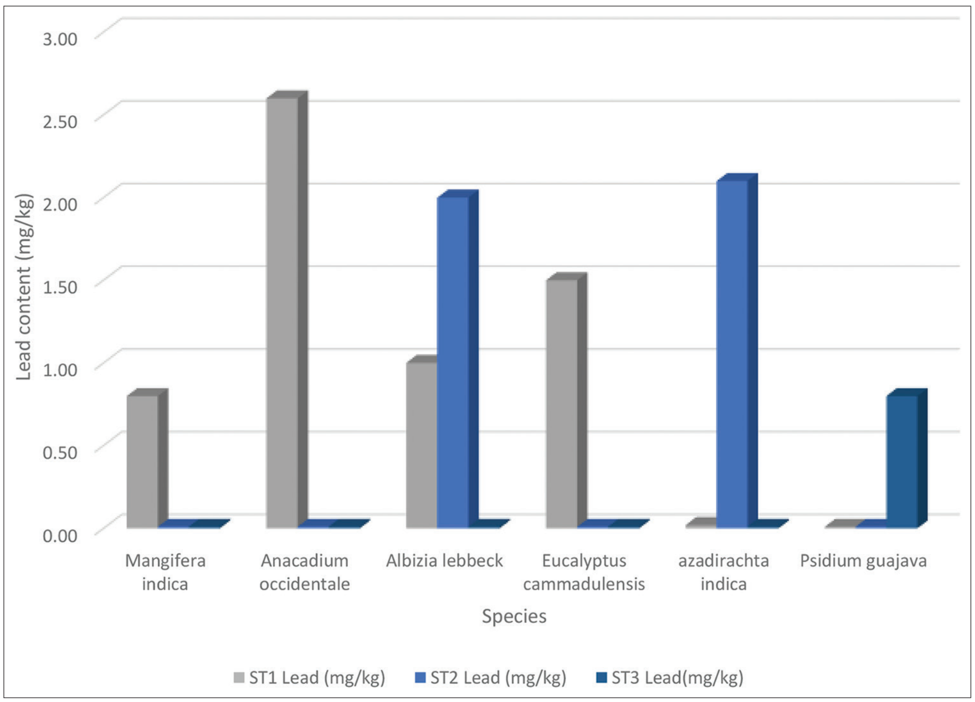

Figure 2: Variation in lead content of different vehicular routes in Kaduna city

contaminant levels. The higher concentration of Pb in *A. indica* L. at ST2 and *P. guajava* at ST3 may be attributed to other factors and sources of Pb such as vehicle type and condition, vehicle speed, generators, plant resistance and arrangement of leave structure, and types of soil uptake. Similar observations were also made by Sodimu *et al*., Kabata-Pendias and Pendias. Zaidi *et al*.[22,38,48]

The atmospheric deposition of heavy metals contributes to the contamination of plants. Pb occurs naturally in plants but is considered non-essential to their growth and development.[38] Plant-related factors can also introduce variation in leaf concentration of Pb in the various plants. Such factors may include low exposure to and low uptake of metals,[21] plant resistance,[49] and differences in leaf cuticle.[38,50]

A. occidentale L. which accumulated the highest amount of Pb in ST1 have been reported to have good potentials for biomonitoring of urban/city air pollution.[43,51]

CONCLUSION AND RECOMMENDATION

Conclusion

Pb concentration is found to be generally higher in the route with the high traffic route than medium and low routes in Kaduna city. The study indicates that traffic volume may influence Pb concentration in leaves of roadsides plants and this may have adverse health implication for urban/city residents, road users, and vegetation.

Recommendation

Promulgation of favorable tree planting capable of absorbing Pb metals (bioremediation) in the city for reduction in urban/city heat, mitigation of air pollution, and biomonitoring can be adopted. Furthermore, the law should be promulgated for prescribed standards for the level of emission from automobile exhaust and energy generating plant and stations. Furthermore, private automobile use and vehicle traffic volume need to be decreased, which can be achieved by encouraging the use of sustainable transport system, especially mass transit and other sustainable transport system.

Finally, it is of paramount importance to educate those living in the vicinity of high traffic routes of the possible danger in consuming tree leaves and other parts of plant collected from roadside vegetation.

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