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Heavy Metal Content in Soil and Medicinal Plants in High Traffic Urban Area

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Abstract: The heavy metals (Zn, Pb and Zn) concentrations in soil and medicinal plant samples from Aba city, Nigeria using atomic absorption spectrophotometer UNICAM 919 model was evaluated in a randomized complete block design. The results showed that there was a clear accumulation of metals in soil and medicinal plants in relation to vehicular emission in the city. A highest concentration of Zn (133.56±7.70 mg/kg) in soil was obtained from X_2, Pb (29.71±1.56 mg/kg) and Cd (21.11±1.28 mg/kg) was in X_5. The levels of Zn, Pb and Cd in soil were 15.85±18.03 - 133.56±7.70 mg/kg, 10.06±0.36 - 29.71±1.56 mg/kg and 1.07±0.08 - 21.11±1.28 mg/kg, respectively. In medicinal plants, the highest concentration of Zn was obtained in *Azadiractha indica* (34.58±2.07 mg/kg), Pb was in *Psidium guajava* (10.47±0.93 mg/kg) and levels of Zn, Pb and Cd were 9.02±1.40 - 34.58±2.07 mg/kg, 1.55±0.35 - 10.47±0.93 mg/kg and 0.02±0.0 - 1.44±0.11 mg/kg, respectively. The concentrations of metals in soil and medicinal plant were in decreasing order: Zn>Pb>Cd. Zinc in soil significantly correlated positively with Zn (0.956, $p<0.01$) and Cd (0.631, $p<0.01$) in plants; Pb in soil significantly correlated positively with Zn (0.825, $p<0.01$), Pb (0.810, $p<0.01$), Cd (0.578, $p<0.05$) in plants. The level of Cd in soil reflected significant pollution compared to concentrations in soils of urban cities in developing countries.

Key words: Heavy metals, soil, medicinal plants, traffic area

INTRODUCTION

There is an increasing concern on the use of medicinal plants to combat sickness and diseases in Nigeria. In recent decades, the low cost and milder side effects of herbal medicines, compared to conventional synthetic drugs, have enhanced their worldwide use (Rai and Mehrotra, 2005). Medicinal plants are applied as a single plant, which action is directed at individual ailments; as plant mixtures, plant and fruit-plant teas and as spices.

Emission from heavy traffic on roads contain lead (Pb), cadmium (Cd), zinc (Zn) and nickel (Ni), which are present in fuel as anti-knock agents (Suzuki *et al.*, 2008; Atayese *et al.*, 2009). The deposition of vehicle derived metal and the relocation of metals deposited on road surface by air and runoff water have led to contamination of soil (Turer and Maynard, 2003; Viard *et al.*, 2004; Nabuloa *et al.*, 2006; Ogbonna and Okezie, 2011). Contamination of soils by Heavy Metals (HM) is the most serious environmental problem and has significant implications for human health (Moore *et al.*, 2009). Soil to plant transfer is one of the key processes of human exposure to HM through the food chain. HM uptake via the roots from contaminated soils and direct deposition of contaminants from the atmosphere onto plant surfaces can lead to plant contamination by HM (Zhuang *et al.*, 2009). HM contamination may alter the chemical composition of plants and thereby seriously affect the quality and efficacy of the natural plant products produced by medicinal plants species.

The consumption of plants produced in contaminated areas, in addition to ingestion or inhalation of contaminated particles (Zhuang *et al.*, 2008) from vehicular emissions, are two principal factors contributing to human exposure to metals (Ogbonna and Okezie, 2011). Thus, therapeutic uses of metal contaminated medicinal plants may lead to hazard of enriching human alimentary canal with toxic metals.

Consequently, serious systemic health problems such as belly ache, renal dysfunction, pulmonary emphysema (Yeung and Hsu, 2005; Kirkham, 2006) can develop from excessive dietary accumulation of toxic metals in human body (Oliver, 1997). For instance, Pb and Cd are known as potential carcinogens and are associated with kidney, nervous system, blood and bone diseases (Jarup, 2003).

The determination of metal in environmental samples such as soils and plants is very necessary for monitoring environmental pollution (Zhou *et al.*, 1997; Tuzen, 2003; Al-Khashman, 2007). Aba also known as Enyimba city is the major commercial centre in south eastern Nigeria. Aba has experienced a rapid urbanization and vehicular density in the last decades and the rapid increase in the number of vehicles exerts

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heavy pressure on the urban environment. Consequently, medicinal plants growing on such environment may have accumulated pollutants (HM) released from the wear of tyres, degradation of parts and greases, exhaust fumes as well as peeling paint. Several studies have been carried out on medicinal plants in Nigeria which include: Essential and trace element contents of *Calotropis procera* (Ait. F.), *Cassia alata* Linn, *Chromolaena odorata* Linn. (Obiajunwa *et al*., 2002), heavy trace metals and macronutrients status in *Anacardium occidentale*, *Butyrospermum paradoxum*, *Solanum erianthum*, *Solanum torvum*, *Zingiber officinale*, *Mangifera indica*, *Morinda lucida*, *Ocimum canum*, *Hyptis suaveolens* and *Azadiractha indica* (Isiaka *et al*., 2004), screening of some Nigerian medicinal plants for antioxidant (Oke and Hamburger, 2002), heavy metal and macronutrient content in *Alafia bateri* oliver, *Berlinia confuse*, *Kigelia africana*, *Malacantha alnifolia*, *Dracaena fragrans*, *Alternanthera pungens* and *Berlinia grandiflora* (Lasisi *et al*., 2005), evaluation of human exposure to Pb and Cd content of herbal soap, oral preparations, powders, oily preparations and eye cleansers (Nnorom *et al*., 2006), phytochemical analysis and mineral elements composition of *Anchomanes difformis*, *Anisopus mannii*, *Pavetta crassipes*, *Stachytarpheta angustifolia* and *Vernonia blumeoides* (Aliyu *et al*., 2008), assessment of element accumulation from bitumen deposit in *Vernonia tenoreana*, *Talinum triangulare*, *Cola nitida*, *Mangifera indica*, *Elaeis guinensis*, *Theobrama cacao*, *Xanthosoma mafaffa*, *Eucus meloz*, *Capscicum annum*, *Manihot esculenta*, *Occimmum gratissimium*, *Lycopersicum cernunm*, *Vigna unguculata*, *Celosia argentia*, *Zea mays*, *Amaranthus hybridus*, *Corchorus tridens* and *Abelmuscus esculentum* (Adebiyi and Asubiojo, 2008), physiochemical analysis of the aqueous extracts of *Picralima nitida*, *Detarium microcarpum*, *Aframomum melegueta*, *Terminalia catappa*, *Acacia nilotica* and *Morinda lucida* (Ameh *et al*., 2010), phytoconstituents, proximate and nutrient investigations of *Saba florida* Benth (Omale, 2010) and antimicrobial evaluation, acute and subchronic toxicity levels of *Leone bitters* (Ogbonnia *et al*., 2010). However, thorough literature search has shown that no research work has been done on HM content of soil and medicinal plants (*Carica papaya*, *Vernonia amygdalina*, *Citrus sinensis*, *Psidium guajava*, *Mangifera indica*, *Occimum gratissimum* and *Azadiractha indica*) in Nigeria. This work, therefore, is aimed at investigating (a) the HM content in soil and (b) HM content in medicinal plants in high traffic density urban environment in Aba, Nigeria.

MATERIALS AND METHODS

Description of the study area: The study on HM content in soil and medicinal plants was carried out in Aba metropolis, Abia State of Nigeria. Aba is the major commercial centre in the south eastern Nigeria. It is located on the lowland rainforest zone of Nigeria (Keay, 1959) and lies on latitude 5°11^{1}N and longitude 7°35^{1}E. The mean annual rainfall is 150-186 mm; annual relative humidity is over 80°C while the mean annual temperature exceeds 21°C.

Sample collection and analysis: Medicinal plant samples and corresponding surface soil samples (0-15 cm) were collected from seven sampling locations around high traffic density urban environment of Aba metropolis in February 2010. According to the regional therapeutic practices, the following medicinal plants were sampled: *Carica papaya*, *Azadiractha indica*, *Vernonia amygdalina*, *Citrus sinensis*, *Psidium guajava*, *Mangifera indica* and *Occimum gratissimum*. The plant samples were collected with well cleaned secateurs at the normal stage of harvest, taking a representative sample of the plants. Soil and plant samples were collected and stored (at ambient temperature) in paper bags in the field and transferred to the laboratory as soon as possible for pre-treatment and analysis (Zhuang *et al*., 2009). The plant samples were thoroughly washed with de-ionized water to remove dust and other particles. The cleaned plant samples were dried in an oven at 80°C to constant weight and ground to powder with a Thomas wiley milling machine (Model ED-5) for analysis of HM such as zinc (Zn), lead (Pb) and cadmium (Cd).

Chemical analysis: The soil samples were air-dried at room temperature, then pulverized and sieved through a 150-mesh stainless-steel screen. Samples were wet-digested with a concentrated acid mixture (HNO_3, $HClO_4$ and HF). Plant samples were digested with HNO_3 and $HClO_4$ in 5:1 ratio until a transparent solution was obtained (Allen *et al*., 1986; Markert, 1996). The soil and plant digested solutions were cooled to room temperature, filtered, transferred quantitatively to 50 and 25 ml volumetric flasks, respectively, made up to volume with distilled water and kept in clean plastic vials before metal analysis (Zhuang *et al*., 2009). Triplicate digestion of each sample together with a blank was also carried out. Thereafter, quantitization of metallic content of digested samples was carried out with a flame atomic absorption spectrophotometer, AAS (UNICAM 919 model).

Experimental and data analysis: The experimental design was a simple factorial experiment in Randomized Complete Block Design (RCBD). Data generated from this study were subjected to one-way Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) v. 15 and mean separation done according to Steel and Torrie (1980) at $p<0.05$.

Table 1: Concentration of heavy metals in soils of high density traffic urban area

Plant samples	Zn	Pb	Cd
X_1	$38.06^{c}\pm2.88$	$10.51^{e}\pm0.42$	$8.50^{b}\pm0.57$
X_2	$133.56^{a}\pm7.70$	$21.70^{b}\pm1.98$	$10.06^{b}\pm0.48$
X_3	$73.01^{b}\pm4.26$	$14.90^{d}\pm0.14$	$3.25^{c}\pm0.78$
X_4	$31.26^{cd}\pm1.75$	$19.01^{c}\pm0.43$	$1.07^{d}\pm0.08$
X_5	$81.90^{b}\pm3.25$	$29.71^{a}\pm1.56$	$21.11^{a}\pm1.28$
X_6	$15.85^{de}\pm18.03$	$10.06^{e}\pm0.36$	$9.92^{b}\pm1.14$
X_7	$83.72^{b}\pm3.42$	$13.26^{d}\pm1.21$	$9.96^{b}\pm0.91$
Control	$4.71^{e}\pm0.45$	$0.09^{f}\pm0.01$	$0.02^{d}\pm0.01$

Values are mean±standard deviations of 3 replications.
^{a,b,c}Means in a column with different superscripts are significantly different ($p<0.05$)

RESULTS AND DISCUSSION

HM concentration in soil: The concentration values of soils sampled from the study area are presented in Table 1. The lowest values of metals were obtained at location X_6 compared with locations X_1, X_2, X_3, X_4, X_5 and X_7 in the study area except for Cd. The concentration of Zn in soil samples was highest in X_2 (133.56±7.70 mg/kg) and this value is significantly ($p<0.05$) higher than values obtained from X_1 (38.06±2.88 mg/kg), X_3 (73.01±4.26 mg/kg), X_4 (31.26±1.75 mg/kg), X_5 (81.90±3.25 mg/kg), X_6 (15.85±18.03 mg/kg) and control (4.71±0.45 mg/kg), respectively. The high value of Zn in X_2 is presumably from vehicular emissions. The fragmentation of tyres has been implicated for higher concentrations of Zn in heavy traffic zones in (Elik, 2003; Pratt, 2006). The concentration of Zn was found in the range of 15.85±18.03 to 133.56±7.70 mg/kg. The level of Zn in this study is lower than 9.0-400 mg/kg obtained in urban soils of Poznan municipality, Poland (Grzebisz *et al*., 2002), 0.90-169 mg/kg in Florida soils (Ma *et al*., 1997), 58-330 mg/kg in roadside soils of Dortmund, Germany (Munch, 1992) but higher than 0.774±0.070 - 13.40±1.52 in soils of Malaysia (Yap *et al*., 2010) and 47.6 mg/kg in urban soils of Dortmund, Germany (Munch, 1992).

The minimum Pb concentration was found in soil sampled from X_6 (10.06±0.36 mg/kg). The concentration of Pb in soil was highest in X_5 (29.71±1.56 mg/kg) and this value was significantly ($p<0.05$) different from values obtained from X_2 (21.70±1.98 mg/kg), X_3 (14.90±0.14 mg/kg), X_4 (19.01±0.43 mg/kg), X_6 (10.06±0.36 mg/kg) and control (0.09±0.01 mg/kg), respectively. Lead (Pb) contamination in soil may be attributed to vehicular emissions since there was no other visible source of pollution in the study site. Lead pollution in urban soil comes from combustion of gasoline that contains tetraethyl lead as anti-knock agent (Tuzen, 2003; Ogbonna and Okezie, 2011). Zinc and Pb are amongst the metal referred to as common urban pollutants (Birke and Rauch, 2000; De Miguel *et al*., 2007). The concentration of Pb was found in the range of 10.06±0.36 to 29.71±1.56 mg/kg). The level of Pb in this study is lower than 0.18-290 mg/kg in Florida soils (Ma *et al*., 1997), 280 mg/kg in soils of Honolulu, USA (Sutherland and Tolosa, 2000), 1,925 mg/kg Pb in urban soils of Amman, Jordan (Jiries, 2003) and 1,999 mg/kg Pb in urban soils of Sidney, Australia (Birch and Scollen, 2003) but higher than 0.013±0.006 - 0.225±0.020 μg/g in soils of Malaysia (Yap *et al*., 2010).

The highest concentration of Cd was obtained in X_5 (21.11±1.28 mg/kg) and this value was significantly ($p<0.05$) higher than values obtained from X_1 (8.50±0.57 mg/kg), X_2 (10.06±0.48 mg/kg), X_3 (3.25±0.78 mg/kg), X_4 (1.07±0.08 mg/kg), X_6 (9.92±1.14 mg/kg), X_7 (9.96±0.91 mg/kg) and control (0.02±0.01 mg/kg), respectively. The source of Cd in soil may be attributed to vehicular emissions. Cadmium is released as a combustion product in the accumulators of motor vehicles or in carburetors (Ordonez *et al*., 2003; Divrikli *et al*., 2003). In the study area, the minimum concentration of Cd in soil was recorded in X_4 with the value 1.07±0.08 mg/kg. The level of Cd in this study ranged from 1.07±0.08 to 21.11±1.28 mg/kg, which is higher than 0.006±0.002 - 0.030±0.005 μg/g in soils of Malaysia (Yap *et al*., 2010). Contamination of soil by HM poses a serious threat to the environment and there is a risk of transfer of toxic and available metals to biota. From the results, the metal concentration values are arranged in the decreasing order: $C_{Zn}>C_{Pb}>C_{Cd}$ where C stands for concentration.

HM concentration in medicinal plants: The values of the concentrations of metal in medicinal plants sampled from the study area are shown in Table 2. The lowest values of metals were obtained in *Occimum gratissimum* except for Cd. The highest concentration of Zn in medicinal plants was obtained in *Azadiractha indica* (34.58±2.07 mg/kg) and this value was significantly ($p<0.05$) higher than values obtained from *Psidium guajava* (26.96±0.23 mg/kg), *Mangifera indica* (20.85±2.62 mg/kg), *Vernonia amygdalina* (20.21±0.56 mg/kg), *Citrus sinensis* (13.43±1.94 mg/kg), *Carica papaya* (9.08±1.31 mg/kg), *Occimum gratissimum* (9.02±1.40 mg/kg) and the control (0.86±0.22 mg/kg), respectively. Exhaust emission have been identified as primary sources of metallic nuisance (Moller *et al*., 2005) such as zinc. Trees in cities are more prone to HM pollution due to pervasive pressure of auto vehicular emissions (Li *et al*., 2007) and plant leaf is the most sensitive part to be affected by air pollutants as major physiological processes are concentrated in the leaf (Rejini and Janardhanan, 1989; Naveed *et al*., 2010). Zinc plays essential metabolic roles in the plant, of which the most significant is its activity as a component of a variety of enzymes, such as dehydrogenase, proteinases, peptidases and phospohydrolases (Yap *et al*., 2010). It (zinc) balances copper (Cu) in the body and is essential for male reproductive activity (Nolan, 2003). Zinc deficiency causes anaemia and retardation of

Table 2: Concentration of heavy metals in medicinal plants in high density traffic urban area

Plant samples	Zn	Pb	Cd
Carica papaya	$9.08^{e}\pm1.31$	$1.82^{cd}\pm0.27$	$0.93^{b}\pm0.13$
Azadirachta indica	$34.58^{a}\pm2.07$	$2.56^{cd}\pm0.64$	$1.30^{a}\pm0.12$
Vernonia amygdalina	$20.21^{c}\pm0.56$	$3.10^{c}\pm0.42$	$0.49^{c}\pm0.13$
Citrus sinensis	$13.43^{d}\pm1.94$	$7.15^{b}\pm1.20$	$0.02^{d}\pm0.01$
Psidium guajava	$26.96^{b}\pm0.23$	$10.47^{a}\pm0.93$	$1.44^{a}\pm0.11$
Occimum gratissimum	$9.02^{e}\pm1.40$	$1.55^{d}\pm0.35$	$1.01^{b}\pm0.11$
Magnifera indica	$20.85^{c}\pm2.62$	$5.91^{b}\pm0.27$	$1.01^{b}\pm0.13$
Control	$0.86^{f}\pm0.22$	0.00 ± 0.00	$0.00^{d}\pm0.00$

Values are mean±standard deviations of 3 replications.

^{a,b,c}Means in a column with different superscripts are significantly different ($p<0.05$)

growth and development (Mc Cluggage, 1991) in human. The utilization of the decoction or infusion of *A. indica* and *P. guajava* by anaemic patient in Aba city might enhance their growth as well as reduce the adverse effect of anaemia due to high content of Zn in these plants (Table 2). Notwithstanding this, dietary intakes of these medicinal plants (*A. indica* and *P. guajava*) have to be maintained at regulatory limits, as excesses may result in poisoning or toxicity. The range of Zn in this study is 9.02±1.40 to 34.58±2.07, which is lower than 38.8±0.05 - 60.0±0.17 of Zn in aerial parts of *Polygonatum verticillatum* (Saeed *et al.*, 2010) but higher than 0.02±0.10 - 0.06±0.10 mg/g in *Saba florida* in Nigeria (Omale, 2010).

The highest concentration of Pb was obtained in *P. guajava* (10.47±0.93 mg/kg) and this value was significantly ($p<0.05$) higher than values obtained from *C. sinensis* (7.15±1.20 mg/kg), *M. indica* (5.91±0.27 mg/kg), *V. amygdalina* (3.10±0.42 mg/kg), *A. indica* (2.56±0.64 mg/kg), *C. papaya* (1.82±0.27 mg/kg) and *O. gratissimum* (1.55±0.35 mg/kg), respectively. The source of Pb is attributed to vehicular emissions. The installation of catalytic converter in some vehicles has continually released Pb into the environment due to abrasion within these vehicular components (Zereni and Alt, 2000). Lead (Pb) was determined in topsoils in South Australia, up to 50 kms from any major roads and this was attributed to petrol exhaust, as no other sources could be reasonably identified in the region (Gulson *et al.*, 1981; Pratt, 2006). Metals transported by road runoff waters are leached into topsoils (Dierkes and Geiger, 1999) where they may be taken up via the roots by plants. In addition, Pb released from exhaust emissions (Al-Chalabi and Hawker, 2000; Sutherland *et al.*, 2003) into the atmosphere may be deposited on leaf surfaces and absorbed inside plant cells (Dalenberg and Van Driel, 1990; Ogbonna and Okezie, 2011) where it may affect a number of cytoplasmic enzymes (Assche and Clijsters, 1990). Thus, therapeutic uses of *P. guajava* on a regular basis for treatment of malaria and similar ailment in the study area may result in Pb poisoning. Lead is the most significant toxin of HM and the inorganic forms are absorbed through ingestion by food (Ferner, 2001). Its (Pb) poisoning causes inhibition of synthesis of haemoglobin; cardiovascular system and acute and chronic damage to the central nervous system and peripheral nervous system (Ogwuegbu and Muhanga, 2005), poor development of grey matter in the brain of children, resulting in poor intelligent quotient (Udedi, 2003). Consequently, caution must be taken by urban dwellers in Aba, Nigeria who depend solely on medicinal plants from the city for prevention, curative and treatment of diseases or infection, since Pb concentration in this study exceed the toxicity level of 2-6 mg/L (Broyer *et al.*, 1972; Zakir *et al.*, 2006). The range of Pb in this study is 1.55±0.35 to 10.47±0.93 mg/kg, which is higher than 0.17±0.02 in aerial parts of *Polygonatum verticillatum* (Saeed *et al.*, 2010), 0.04±0.01 - 0.30±0.01 mg/g in leaves of *Saba florida* in Nigeria (Omale, 2010) and 11.0-20.9 µg/g in leaves of *Centella asiatica* in Malaysia (Yap *et al.*, 2010).

Cd was found to be highly accumulated in *P. guajava* (1.44±0.11 mg/kg) but its concentration was not different ($p>0.05$) from the value obtained from *A. indica* (1.30±0.12 mg/kg), however, it was different ($p<0.05$) from values obtained from *O. gratissimum* (1.01±0.11 mg/kg), *M. indica* (1.01±0.13 mg/kg), *C. papaya* (0.93±0.13 mg/kg), *V. amygdalina* (0.49±0.13 mg/kg) and *C. sinensis* (0.02±0.01 mg/kg), respectively. The source of Cd may be attributed to lubricants (Birch and Scollen, 2003), wearing of paints on the body of vehicles (Asthana and Asthana, 2006; Ogbonna and Okezie, 2011), tear and wear of tyres (Viklander, 1998; Smolders and Degryse, 2002). The ultimate sink for HM is atmospheric deposition and burial in soil (Khan *et al.*, 2000). They (HM) often accumulate in the top layer, therefore, are accessible for uptake by plants via roots, which is a major entry point of HM that ultimately affects different physiological processes. Cadmium has no known bio-importance in human biochemistry and physiology and consumption even at very low concentrations can be toxic (Nolan, 2003; Young, 2005) and long term exposure results in renal dysfunction, characterized by tubular proteinuria (Duruibe *et al.*, 2007) in humans. Thus, households or individuals that have been making therapeutic uses of *A. indica* and *P. guajava* from the study site may have predisposed themselves to serious health risk. The range of Cd in this study is 0.02±0.01 to 1.44±0.11 mg/kg, which is higher than 0.08±0.01 - 0.21±0.01 mg/g in leaves of *Saba florida* in Nigeria (Omale, 2010) and 0.006±0.002 - 0.030±0.005 µg/g in *Centalla asiatica* (Yap *et al.*, 2010). Indeed, metal contamination in urban soil is of increasing concern (Manta *et al.*, 2002) due to food safety issues and potential health risks associated with intake of contaminated medicinal plants. From the results, *P. guajava* and *A. indica* have the inherent ability to take up metals more than other plants sampled in this study. The pattern of result shows that $C_{Zn}>C_{Pb}>C_{Cd}$.

Table 3: Correlation between heavy metals in soil and medicinal plants in high density traffic urban area

	Zn plants	Pb plants	Cd plants	Zn soil	Pb soil	Cd soil
Zn plants	1					
Pb plants	0.498*	1				
Cd plants	0.663**	0.300	1			
Zn soil	0.956**	0.334	0.631**	1		
Pb soil	0.825**	0.810**	0.578*	0.664**	1	
Cd soil	0.566*	0.568*	0.902**	0.466	0.679**	1

*Significant at 5%; **Significant at 1%

Correlation coefficient between Heavy metals in soils and plants: The correlation coefficient between the concentrations of HM in soils and medicinal plants in the study area is summarized in Table 3. Zinc in soil significantly correlated positively with Zn (0.956, $p<0.01$) and Cd (0.631, $p<0.01$) in plants; Pb in soil significantly correlated positively with Zn (0.825, $p<0.01$), Pb (0.810, $p<0.01$), Cd (0.578, $p<0.05$) in plants and Zn (0.664, $p<0.01$) in soil; Cd in soil significantly correlated positively with Zn (0.566, $p<0.05$), Pb (0.568, $p<0.05$) and Cd (0.902, $p<0.01$) in plants as well as Pb (0.679, $p<0.01$) in soil. This result corroborated the finding of Ogbonna and Okeke (2011) that there was a strong relationship among these HMs in soil and plants. In addition, Pb and Cd in plants significantly correlated positively with Zn (0.498 and 0.663) at $p<0.05$ and $p<0.001$, respectively. The strong correlation between metals in soils and medicinal plants signified that the source of pollution is from the study area and vehicular emissions are implicated. Indeed, there were positive but non-significant correlation between Cd in plants with Pb (0.300, $p>0.05$) in plants; Zn in soil with Pb (0.334, $p>0.05$) in plants and Cd in soil with Zn (0.466, $p>0.05$) in soil. The non-significant correlation signified that these metals might have resulted from sources other than vehicular emission.

Conclusion: In this study, HM (Zn, Pb and Cd) concentration in soil and medicinal plants in Aba, Nigeria, was investigated. The results showed that the soil samples from X_2 in the vicinity of the high traffic density urban environment exhibited high concentration of Zn (133.56±7.70 mg/kg), while X_5 had the highest concentration of Pb (29.71±1.56 mg/kg) and Cd (21.11±1.28 mg/kg). The concentration of Cd in this study significantly exceed the critical soil ranges of Cd given by Kabata-Pendias and Pendias (1984) and Yap *et al.* (2010). The elevated concentration of Cd in soil and medicinal plants undoubtedly indicated HM contamination due to vehicular emission. Therapeutic uses of decoction or infusion of *A. indica* and *P. guajava* by anaemic patient in Aba city might enhance their growth as well as reduce the adverse effect of anaemia due to high content of Zn in these plants. Notwithstanding this, therapeutic uses of the medicinal plants (*A. indica* and *P. guajava*) by people in Aba city may result in Cd toxicity or poisoning due to its high concentration in the studied samples.

Given the results of the anthropogenic impact on the urban soil and medicinal plants, a further study on the HM concentrations in other medicinal plants and a dietary study of the urban population in relation to therapeutic uses of medicinal plants are unavoidably needed.

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