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Heavy metal contents of five major medicinal tree species in two communities reflecting high and low pollution gradients in Greater Port Harcourt city, Rivers state, Nigeria

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ABSTRACT: This study was conducted at Ogbogoro Community and Eleme Petro-Chemical Company environs located within the Greater Port Harcourt City, Rivers State, Nigeria to evaluate the concentrations of heavy metals in five most used medicinal plant species along a low (Ogbogoro) to high (Eleme Petro-Chemical environs) pollution gradient. The user preference approach was used to rank and select five major medicinal plant species - *Azadirachta indica, Annona muricata, Mangifera indica, Moringa oleifera and Persea americana*, at each location, for the evaluation of heavy metal contents. Most of these species in addition to their medicinal importance also serve as sources of food and income to the people residing at both locations. Plant samples were collected in triplicates from the leaves and bark of the plant species depending on the identified parts used for treating ailments. Heavy metals – Copper (Cu), Lead (Pb), Cadmium (Cd) and Nickel (Ni) contents of the samples were determined using standard laboratory methods. Student t-test was used to test for significant difference ($p \leq 0.05$) in heavy metal concentrations of each species between both locations. One-way analysis of variance was used to test for significant difference ($p \leq 0.05$) in the concentrations of heavy metals among the five species at each location. Cadmium (Cd) and Ni were absent in all the species at both locations. Lead (Pb) and Cu varied significantly among the species at each location, and also in each species between the two locations with higher concentrations recorded at Eleme Petro-Chemical environs in most species. The concentrations of heavy metals were higher in leaves than in barks. Concentrations of Pb and Cu in the species at both locations were found to be above the permissible limits set by the WHO/FAO except in the leaves of *A. indica* at Eleme and the leaves of *M. oleifera* and *M. indica* at Ogbogoro. However, heavy metal concentrations in the bark samples were within the permissible limits. The need to regulate anthropogenic activities responsible for the release of heavy metals at the study locations was emphasized.
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INTRODUCTION

Medicinal plants are plants associated with pharmaceutical values administered for specific conditions in an attempt to maintain health (Ahn, 2017). They may provide three main kinds of benefit to humans including health benefits to people who consume them as medicine; financial benefits to people who harvest, process and distribute them for sale; and society-wide benefits such as job opportunities, taxation income and healthier labour force (Smith-Hail, 2012).

These plants have been shown to have genuine ultimate benefits and about 80% of the rural population depends on them for primary health care (Akinyemi, 2000). In Africa, the use of medicinal plants is tagged an old tradition and has been used as a source of remedies for treatment of several diseases and over 25% of prescribed mediums in industrialized countries are derived directly or indirectly from plants (Newman *et al.*, 2000). In primary healthcare, about 70-80% of the world's population relies on unconventional medicine, mainly of herbal origin (WHO, 2002).

Heavy metals are metallic elements that have a relatively high density compared to water (Fergusson, 1990). They are natural components of the earth's crust present in all environmental matrices. The involution in anthropogenic activities has flared the concentration of heavy metals. Heavy metal pollution has remained a subject of global concern, owing to the toxicological threats that such metals pose to human health. (Ayodeji and Olorunsola, 2011). Although they are often essential for living organisms, they become toxic when bioaccumulation occurs (Elekes *et al*., 2010).

The main anthropogenic sources of heavy metals are various industrial processes such as mining, foundries and smelting, combustion of fossil fuel gasoline and waste of incinerators (Pacyna, 1982). Mercury (Hg), Caladium (Cd) and Lead (Pb) are the heavy metals of concern because they are the most toxic with known serious effect on humans and the environment (Llyin *et al.,* 2002).

World Health Organization in 2012 concluded that the magnitude of herbs used during recent decades for the cure of various ailments is evident. In some countries like China, Canada, Thailand, etc., quantitative and limit test has been carried out by World Health Organization, to determine the concentration of heavy metals in the form of impurities and contaminants in medicinal plants and an average permissible limit was drawn (As = 5ppm, Pb = 10pmm, Cd = 0.3pmm, Cr = 2pmm, Hg = 0.5pmm, Cu 150 pm) to determine the point where health hazards occur (WHO, 2012).

Many parts of Rivers State suffer from high level of pollution arising from the activities of several companies especially those involved in the oil and gas business. It is also a known fact that many of the people who reside in these areas (both indigenes and non-indigenes) rely on medicinal plants to cure different ailments. The use of medicinal plants is an old practice which has been encouraged and is termed economical even in rural and urban settlements. Human exposure to risks has risen dramatically as a result of an exponential increase of their use in several industrial, agricultural, domestic and technological applications (Bradl, 2002). The level of pollution and population keep increasing and so is the consumption level of these species either as food or medicine regardless of the negative effect of the pollution.

Considering the high level of pollution in many parts of Rivers State and given the fact that plants accumulate substances including toxins in their biomass, the significance of a study of this nature cannot be overemphasized as it aimed at evaluating the level of bioaccumulation of heavy metals in some widely consumed medicinal plant species in two localities (Ogbogoro and Eleme) reflecting low to high pollution gradient within the Greater Port Harcourt City and comparing them with permissible limits with a view to ascertaining the potential health implications of their consumption.

MATERIALS AND METHODS

Description of the Study Area

The study was carried out in two localities – Ogbogoro Community and Eleme Petro-Chemical environs, located in two local government areas (Obio/Akpor and Eleme, respectively) within the Greater Port Harcourt City, Rivers State, Nigeria. The two localities were chosen purposively to reflect a low (Ogbogoro) to high (Eleme Petro-chemical environs) pollution gradient.

Eleme Local Government Area was created in 1996. It is part of the metropolitan city. It covers an area of 138km^2 and at the 2006 census had a population of 190,884. Eleme is known for its high level of industrialization and with the discovery of oil in the Niger Delta in 1958, the Eleme territory has become home to both an oil refinery and a fertilizer industry. Ogbogoro is situated in Obio-Akpor LGA, Rivers State, Nigeria. Its geographical coordinates are $4^0$50'48" N and $6^0$55'50 E. This community is densely populated but has very low level of industrial activities, although residential buildings and settlements are rapidly expanding. Figure 1 is the map of Port Harcourt metropolis showing the locations of Obio/Akpor and Eleme Local Government Areas.

Identification, Documentation of Uses/Parts used, Prioritization and Selection of Major Medicinal Plant Species

Structured questionnaire was used in identifying the medicinal plants of importance in the study localities, their uses, parts used, methods of preparation and mode of administration. Thirty adults (15 male and 15 female) from 15 randomly selected compounds were used for the administration and completion of questionnaire in each of the two communities. The respondents were asked to list the 5 most important medicinal plant species to them in their decreasing order of importance and mention the ailments they use each of them to treat, their uses, the parts used and mode of preparation/administration.

The user-preference approach was used in ranking the medicinal plant species (Chima *et al.,* 2012). The species were scored on a scale of 1 -5 points such that the most important species identified by each individual scored 5points while the least important scored 1 point. Then the total score for each species was derived by adding the points from individual respondents in a community for that particular species. Subsequently, the total score of each species was used for ranking in each community. Five top-ranked medicinal tree species were then selected for the evaluation of heavy metal contents of their leaves and barks depending on the parts used as medicine.

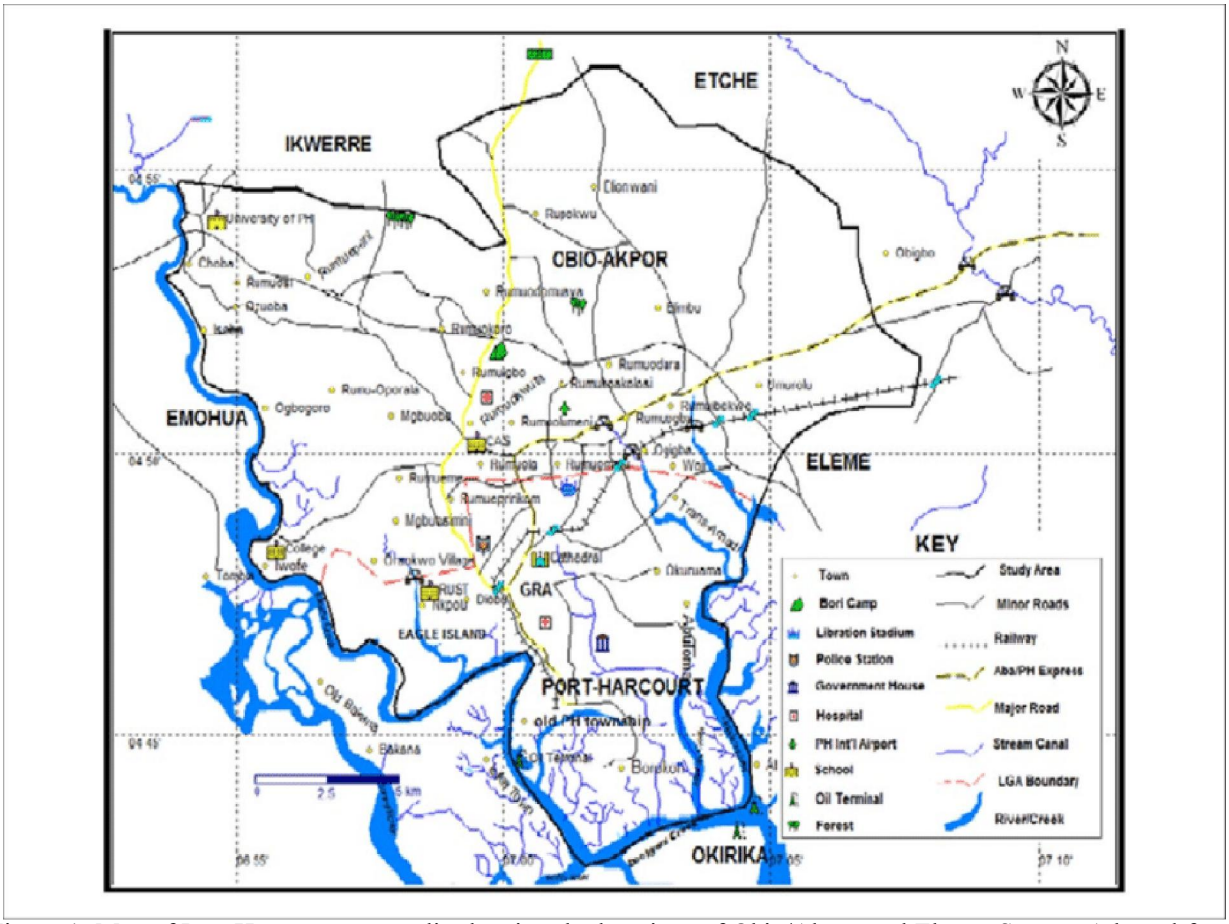

Figure 1: Map of Port Harcourt metropolis showing the locations of Obio/Akpor and Eleme. Source: Adapted from Google Earth (2012).

Collection of Specimen for Heavy Metal Analysis

Specimens were collected from the leaves and bark of each of the five most important medicinal plant species in each community. The samples were enclosed in separate well identified envelopes for each medicinal plant species, and immediately taken to the laboratory for analysis of their heavy metal contents.

Laboratory Analysis

The plant specimens were analyzed for Lead (Pb), Cadmium (Cd), Nickel (Ni) and Copper (Cu) using standard procedures as described by (Doran and Parkin, 1996).

Data Analysis

A one-way analysis of variance (ANOVA) was used to test for significant difference ($p \leq 0.05$) in heavy metal concentrations of different species at the same community. The Duncan Multiple Range Test (DRMT) was used for mean separation where significant difference existed. The ANOVA was performed using Statistical Package for Social Sciences (SPSS). Student t-test was used to test for the significant difference ($p \leq 0.05$) in heavy metal concentrations of each species between the two localities.

RESULTS

Demographic Characteristics of the Respondents

The gender, age and educational qualifications of respondents in the two communities are shown in Table 1. The gender classification shows that the same number of questionnaires was distributed to both male and female in each location in line with the design and scope of the study. In the age classification, respondents within the age class of 20-30 and 31-40 were highest in number at Ogbogoro, followed by 61 and above and 41-50 age classes respectively. In Eleme, respondents within the age class of 20-30 were highest in number, followed by 41-50, 31-40 and 61 & above age classes respectively. For educational qualifications, the majority of the respondents had the Secondary School Certificate (SSC) as their highest qualification in the two communities. In Ogbogoro, 50% of the respondents were married as against 63.33% in Eleme. Respondents at Ogbogoro came

from eight states of the Nigerian Federation while those at Eleme came from ten states.

Table 1: Demography of the respondents

	OGBOGORO		ELEME	
VARIABLES	**Frequency**	**%**	**Frequency**	**%**
Gender				
Male	15	50.00	15	50.00
Female	15	50.00	15	50.00
Total	**30**	**100.00**	**30**	**100.00**
Age				
20-30	12	40.00	13	43.33
31-40	12	40.00	7	23.33
41-50	1	3.33	8	26.67
61 and above	5	16.67	2	6.67
Total	**30**	**100**	**30**	**100**
Education				
Primary School Certificate	2	6.67	0	0.00
Modern School Certificate	2	6.67	0	0.00
Senior Secondary Certificate	12	40.00	14	46.67
Ordinary National Diploma	1	3.33	2	6.67
National Certificate in Education	7	23.33	0	0.00
Higher National Diploma	4	13.33	3	10.00
Postgraduate	2	6.67	5	16.67
Others	0	0.00	6	20.00
Total	**30**	**100**	**30**	**100**
Marital status				
Married	15	50.00	19	63.33
Single	15	50.00	9	30.00
Divorce	0	0.00	0	0.00
widow	0	0.00	2	6.67
Total	**30**	**100**	**30**	**100**
State of origin				
Rivers	15	50.00	16	53.33
Imo	4	13.33	1	3.33
Bayelsa	3	10.00	0	0.00
Anambara	2	6.67	2	6.67
Akawaibom	2	6.67	0	0.00
Osun	2	6.67	0	0.00
Delta	1	3.33	1	3.33
Lagos	1	3.33	0	0.00
Ogun	0	0.00	3	10.00
Cross rivers	0	0.00	2	6.67
Abia	0	0.00	2	6.67
Enugu	0	0.00	1	3.33
Oyo	0	0.00	1	3.33
Ondo	0	0.00	1	3.33
Total	**30**	**100**	**30**	**100**

Medicinal Plant Species used in Ogbogoro and their Ranking

The medicinal plant species used in Ogbogoro Community, their common names, families, habits and ranks, are shown in Table 2. A total of 17 medicinal plant species belonging 16 families were documented. The five top-ranked species were *Azadirachta indica, Mangifera indica, Moringa oleifera, Persea americana* and *Annona muricata,* in that order. The medicinal plant species comprised of trees, shrubs and herbs.

Table 2: Checklist of the medicinal plant species consumed in Ogbogoro and their ranking

S/N	Species	Common name	Family	Habit	Total Score	Rank
1	*Azadirachta indica**	Neem	Meliaceae	Tree	17	1st
2	*Mangifera indica**	Mango	Anacardiaceae	Tree	16	2nd
3	*Moringa oleifera**	Moringa	Moringaceae	Tree	13	3rd
4	*Persea americana**	Avocado	Lauraceae	Tree	9	4th
5	*Annona muricata**	Soursop	Annonaceae	Tree	9	4th
6	*Carica papaya*	PawPaw	Caricaceae	Tree-like herb	7	5th
7	*Psidium guajava*	Guava	Myrtaceae	Tree	7	5th
8	*Cymbopogon citrates*	Lemon grass	Poaceae	Herb	6	6th
9	*Citrus limon*	Lemon	Rutaceae	Tree	4	7th
10	*Citrus latifolia*	Lime	Rutaceae	Shrub/Tree	3	8th
11	*Terminalia catappa*	Almond	Combretaceae	Tree	3	8th
12	*Chromolaena odorata*	Awolowo leaves	Asteraceae	Shrub	3	8th
13	*Musa paradisiacal*	Plantain leaves	Musaceae	Tree-like herb	2	9th
14	*Irvingia gabonensis*	bush mango	Irvingiaceae	Tree	1	10th
15	*Jatropha tanjorensis*	Catholic vegetable	Euphobiaceae	Shrub/Tree	1	10th
16	*Ananas comosus*	Pineapple	Bromeliaceae	Herb	1	10th
17	*Costus lucanuscianus*	Monkey Sugarcane	Zingiberaceae	Herb	1	10th 10th

*Top five medicinal tree species selected for heavy metal analysis

Medicinal Plant Species used in Eleme and their Ranking

The medicinal plant species used in Eleme Community, their common names, families, habits, and ranks, are shown in Table 3. A total of 14 medicinal plant species belonging 13 families were documented. *Azadirachta indica,* ranked first, followed by *Cymbopogon citrates/Annona murincata* (second) and *Mangifera indica/ Moringa oleifera/ Carica papaya/ Persea americana* (third). The medicinal plant species comprised of trees, shrubs and herbs.

Table 3: Checklist of the medicinal plant species consumed in Eleme and their ranking

S/N	Species	Common name	Family	Habit	Total Score	Rank
1	*Azadirachta indica**	Neem	Meliaceae	Tree	24	1st
2	*Cymbopogon citrates*	Lemon grass	Poaceae	Herb	13	2nd
3	*Annon amurincata**	Soursop	Annonaceae	Tree	13	2nd
4	*Mangifera indica**	Mango	Anacardiacea	Tree	12	3rd
5	*Moringa oleifera**	Moringa	Moringaceae	Tree	12	3rd
6	*Carica papaya*	Paw-Paw	Caricaceae	Tree-like herb	12	3rd
7	*Persea americana**	Avocado	Lauraceae	Tree	12	3rd
8	*Psidium guajava*	Guava	Myrtaceae	Tree	5	4th
9	*Citrus latifolia*	Lime	Rutaceae	Shrub/Tree	4	5th
10	*Cocosnucifera*	Coconut	Arecaceae	Tree	1	6th
11	*Irvingia gabonensis*	Bush mango	Irvingiaceae	Tree	1	6th
12	*Elaeis guineensis*	Palm tree	Arecaceae	Tree	1	6th
13	*Citrus paradis*	Local Grapefruit	Rutaceae	Herb	1	6th
14	*Ananas comosus*	Pineapple	Bromeliaceae	Herb	1	6th

*Top five medicinal tree species selected for heavy metal analysis

Identified Uses of the Medicinal Plant Species, Parts Used, Methods of Preparation and Mode of Administration

The uses of the medicinal plant species, parts used, methods of preparation and mode of administration, are shown in Table 4. The plant species are used to treat various ailments including Malaria, typhoid, diabetes, high blood pressure, cancer, stomach ache, poison, cold, convulsion, infertility, blood shortage, toothache, among others. The parts of the plants used include leaves, fruits, bark, seed, seed oil, and root. They are administered in form of decoction, infusion, poultice, etc.

Table 4: Uses of the medicinal plant species in both communities

Species	Common name	Family	Ailment cured with	Parts used	Preparation	Administration
Ananas comosus	Pineapple	Bromeliaceae	Malaria and typhoid	Leaves	Wash, boil for 30 minutes, sieve, allow to cool and drink (Decoction)	A glass twice daily for 2 weeks (morning and night)
**Annon amuricata*	Soursop	Annonaceae	Diabetes, High blood pressure, Cancer.	Fruit (ripe) and leaves	Wash, boil for 30 minutes, sieve, allow to cool and drink (Decoction)	A glass twice daily (morning and night) Eat ripe fruits
**Azadirachta indica*	Neem	Meliaceae	Malaria and typhoid	Leaves, bark, seed	Wash, boil for 30 minutes, sieve, allow to cool and drink (Decoction)	A glass twice daily (morning and night)
Carica papaya	Paw-Paw	Caricaceae	Malaria and typhoid	Leaves, unripe fruits	wash, boil for 30 minutes, sieve, allow to cool and drink (Decoction)	A glass twice daily (morning and night) Eat unripe fruits
Chromolaena odorata	Awolowo leaves	Rutaceae	Malaria	Leaves	Wash, Boil with mango leaves for 30 minutes, allow to cool sieve and drink.	A glass twice daily (morning and night
Citrus latifolia	Lime	Asteraceae	Malaria, Diabetes, Typhoid	Bark and fruit	Boil with Neem and lemon grass. Squeeze fruit and take Lipton tea.	A glass twice daily for a week (morning and night)
Citrus limon	Lemon	Rutaceae	Stomach ache, high blood pressure, diabetes	Fruits	Wash and squeeze out juice. Boil with soursop leaves for HBP.	For poultice once daily. For decoction twice daily.
Citrus paradis	Local grapefruit	Rutaceae	Malaria, diabetes	Fruits	Used with lime and lemon via poultice(squeezing)	A glass daily for a week
Cocos nucifera	Coconut	Arecaceae	Neutralize Poison and alcohol.	Water and fruit	Break nut, collect water in a glass. Remove fruit from nut.	Drink water and chew fruit immediately
Costus lucanuscianus	Monkey sugarcane	Zingiberaceae	Malaria and typhoid. Antidote for poison	Whole plant	Wash and chew. Pound in mortar and squeeze out juice.	A glass daily.
Cymbopogon citrates	Lemon grass	Poaceae	Malaria and typhoid	Whole plant	wash, boil for 30 minutes, sieve, allow to cool and drink (Decoction)	A glass twice daily (morning and night)
Elaeis Guineensis	Palm tree	Arecaceae	Cold, convulsion	Oil from seed	Oil from seed should me Mixed with onion and rubbed.	Apply when cold or under convulsion attack.
Irvingia Gabonensis	Bush mango	Irvingiaceae	Infertility in men	Root	Soak root in alcohol (infusion)	A shot at night for 2 weeks

Jatropha Tanjorensis	Catholic vegetable	Euphobiaceae	Blood shortage	leaves	Wash and squeeze leaf (poultice)	Mix with liquid milk and take 3 times a day.
**Mangifera Indica*	Mango	Anacardiacea	Malaria and typhoid	Leaves and barks	Wash, boil for 30 minutes, sieve, allow to cool and drink (Decoction)	A glass twice daily (morning and night) Or bath with water.
**Moringa oleifera*	Moringa	Moringaceae	Diabetes, High blood pressure, Detoxification, Cancer	Leaves, seeds, bark	Gruel (porridge with leaves), decoction, chew seed	For decoction take a glass twice daily.
Musa paradisiacal	Plantain leaves	Musaceae	Malaria	Leaves	Wash, boil with lemon grass and lime sieve and drink	A glass twice daily
**Persea americana*	Avocado	Lauraceae	Diabetes, High blood pressure, Cancer.	Seeds, leaves, fruits	Dry and grind seed. Decoction (leaves)	A glass twice daily (morning and night). Eat ripe fruits. Add crushed seed to pap or tea
Psidium guajava	Guava	Myrtaceae	Toothache, typhoid, malaria, running stomach	Leaves, barks, stem, leaves	Decoction, poultice (squeezing leaves),	For decoction and poultice take a glass twice daily. Cut, wash and chew stem.
Terminalia catappa	Almond	Combretaceae	High blood pressure	Fruits and nuts	Wash and eat fruits. Dry and crack nuts	Eat available ripe fruits and nuts.

*Tree species for which the heavy metal contents were evaluated

Heavy Metal Concentration in Leaves of the Five Major Medicinal Plant Species in Ogbogoro

The extent of variation in the concentrations of heavy metals in leaves of the five major medicinal plant species in Ogbogoro is shown in Table 5. Lead was present only in *P. americana* and *M. indica* and their concentrations did not vary significantly although slightly higher in *P. Americana*. Cadmium and nickel were absent in the five species. Copper varied significantly among the five species with the highest and lowest concentrations found in *P. americana* and *M. indica*, respectively.

Table 5: Variation in the concentrations of heavy metals in leaves of the five major medicinal plant species at Ogbogoro

Treatments	Lead(mg/kg)	Cadmium(mg/kg)	Nickel(mg/kg)	Copper(mg/kg)
M. oleifera	0.00±0.00b	0.00±0.00	0.00±0.00	7.54±0.02c
P. americana	1.78±0.03a	0.00±0.00	0.00±0.00	12.42±0.09a
A. indica	0.00±0.00b	0.00±0.00	0.00±0.00	11.40±0.04b
M. indica	1.74±0.14a	0.00±0.00	0.00±0.00	7.18±0.02d
A. muricata	0.00±0.00b	0.00±0.00	0.00±0.00	11.32±0.00b
Total	0.70±0.29	0.00±0.00	0.00±0.00	9.92±0.72
P value	0.000			0.000

Means on the same column with the same alphabet for each metal concentration are not significantly different ($p > 0.05$)

Heavy Metal Concentration in Leaves of the Five Major Medicinal Plant Species in Eleme

The extent of variation in the concentrations of heavy metals in leaves of the five major medicinal plant species in Eleme Petrochemical Company Environs is shown in Table 6. The concentrations of lead varied significantly among the five species with the highest value recorded for *M. indica* while no trace of it was found in *A. muricata*. Cadmium and Nickel were also absent in the leaves of all the five species. Copper was detected in all the species with the concentrations varying significantly. The highest concentration of copper was found in *P. Americana* leaves followed by *A. muricata* leaves while the lowest concentration was found in *A. indica* leaves.

Table 6: Variation in the concentrations of heavy metals in leaves of the five major medicinal plant species at Eleme

Treatments	Lead(mg/kg)	Cadmium(mg/kg)	Nickel(mg/kg)	Copper(mg/kg)
M. oleifera	0.46±0.04c	0.00±0.00	0.00±0.00	9.95±0.09d
P. americana	0.22±0.01d	0.00±0.00	0.00±0.00	22.60±0.07a
A. indica	1.18±0.02b	0.00±0.00	0.00±0.00	8.21±0.03e
M. indica	2.01±0.04a	0.00±0.00	0.00±0.00	11.61±0.07c
A. muricata	0.00±0.00e	0.00±0.00	0.00±0.00	20.67±0.22b
Total	0.77±0.25	0.00±0.00	0.00±0.00	14.61±1.96
P value	0.000			0.000

Means on the same column with the same alphabet for each metal concentration are not significantly different ($p > 0.05$)

Comparative Evaluation of Concentrations of Heavy Metals in the Leaves of each of the Five Major Medicinal Plant Species between Ogbogoro and Eleme

The extent of variations in the concentrations of heavy metals in leaves of the five major medicinal plant species between Ogbogoro and Eleme Petrochemical Company Environs is shown in Table 7. The concentrations of lead in *M. oleifera, P. Americana, A. indica*, varied significantly between the two localities with Eleme having higher concentrations except in *P Americana*. There was no significant difference in the concentrations of lead in *M. indica* between the two localities, although the concentration was still higher in Eleme Petrochemical Company Environs. Lead was not detected in the leaves of *A. muricata* at the two localities. Cadmium and Nickel were totally absent in the five species at the two localities. Copper in the leaves of the five species varied significantly between the two localities with higher concentrations recorded at Eleme except in *A. indica* where a higher concentration was recorded at Ogbogoro.

Comparative Evaluation of Concentrations of Heavy Metals in the Barks of *A. indica* and *M. indica* between Ogbogoro and Eleme

The extent of variations in the concentrations of heavy metals in barks of *A. indica* and *M. indica* between Ogbogoro and Eleme Petrochemical Company Environs is shown in Table 8. Lead in the bark of *A. indica* varied significantly between the two locations with a higher concentration at Ogbogoro. However, lead was not detected in the bark of *M. indica* at the two localities. Cadmium and Nickel were also absent in the bark of the two species at the two localities. Copper in the barks of *A. indica* and *M. indica* varied significantly at the two localities with higher concentration in *A. indica* recorded at Ogbogoro while a higher concentration in *M. indica* was recorded at Eleme.

Table 7: Variation in heavy metal concentration of the five major medicinal plant species between the two localities

Heavy metals	*M. oleifera*		*P.americana*		*A. indica*		*M. indica*		*A. muricata*	
	Eleme	Ogbogoro	Eleme	Ogbogoro	Eleme	Ogbogoro	Eleme	Ogbogoro	Eleme	Ogbogoro
Lead(mg/kg)	0.46±0.04^{a}	0.00±0.00^{b}	0.22±0.01^{b}	1.76±0.03^{a}	1.18±0.02^{a}	0.00±0.00^{b}	2.01±0.04^{a}	1.74±0.14^{a}	0.00±0.00	0.00±0.00
Cadmium(mg/kg)	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Nickel(mg/kg)	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Copper(mg/kg)	9.95±0.09^{a}	7.54±0.02^{b}	22.60±0.07^{a}	12.42±0.12^{b}	8.21±0.03^{b}	11.40±0.04^{a}	11.61±0.07^{a}	7.18±0.02^{b}	20.67±0.22^{a}	11.32±0.00^{b}

Means on the same row with the same alphabet for each metal concentration are not significantly different ($p > 0.05$)

Table 8: Variations in heavy metal concentrations of *A. indica* and *M. indica* Barks between the two localities

	A. indica		*M. indica*	
Metals	Eleme	Ogbogoro	Eleme	Ogbogoro
Lead(mg/kg)	0.00±0.00b	0.47±0.05a	0.00±0.00	0.00±0.00
Cadmium(mg/kg)	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Nickel(mg/kg)	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Copper(mg/kg)	1.89±0.03b	8.80±0.06a	8.84±0.18a	5.82±0.02b

Means on the same row with same alphabet for each metal concentration are not significantly different ($p > 0.05$)

DISCUSSION

The various uses of plants in the study localities as revealed by this study confirm the importance of plants as sources of medication. Plants have been shown to have genuine ultimate benefits and about 80% of the rural population depends on them for primary health care (Akinyemi, 2000). In Africa, the use of medicinal plants is tagged an old tradition and has been used as a source of remedies for treatment of several diseases and over 25% of prescribed mediums in industrialized countries are derived directly or indirectly from plants (Newman *et al.*, 2000). In primary healthcare, about 70-80% of the world's population relies on unconventional medicine, mainly of herbal origin (WHO, 2002).

Bioaccumulation of metals at contaminated sites may result from a number of anthropogenic causes, such as metal mine tailings, the improper disposal of heavy metal wastes in landfills, leaded gasoline and lead-based paint, land applications of fertilizer, animal manure, biosolids (sewage sludge) compost, pesticides, coal combustion residues, petrochemicals and atmospheric decomposition. (Zhang *et al.,* 2010).

Thus, from the analyzed results at Ogbogoro, the sources of heavy metal concentration in the specimen of selected trees can be traced to domestic anthropogenic sources such as pesticides, application of fertilizers, fumigation, animal manure, improper disposal of household wastes such as plastics, tins, etc., due to the activities in this area. In Eleme-Petro-Chemical environs however, the observed significant higher level of heavy metal concentration was due to a combination of human activities and presence of numerous industries responsible for the production of toxic wastes capable of accumulating in the biomass of medicinal plants as they absorb them. The trend of the results obtained from this study also reflected a low to high pollution gradient from Ogbogoro to Eleme. The concentrations of the metals and pollution level were lower in Ogbogoro where anthropogenic activities were low compared to Eleme.

Lead (Pb) is a non-essential trace element that functions neither in plants nor human body. It causes chronic or acute poisoning that result in adverse effects on vital organs such as kidney, liver, vascular and body immune system (Jabeen *et al*., 2010; Moses *et al*., 2012). High level accumulation of Pb in the body causes anemia, colic, headache, brain damage, and central nervous system disorder (Rehman *et al.,* 2013). The World Health Organization's permissible limit of lead in medicinal plants is 10mg/kg while the dietary intake limit is 3mg/week (WHO, 2005), which is also the standard limit set by the Chinese, Malaysian, and Thai governments (Moses *et al.*, 2012). It was observed that all the major five medicinal tree specimens including leaves and bark in each location were below the permissible limit, and the concentration of lead in the species between the two locations were significantly different except in the leaves of *M. indica*.

Cadmium (Cd) is also a non-essential trace element and a by- product of zinc. Even at a minute quantity, Cd is extremely toxic and can cause disabilities, hyperactivity in children and also affect the vital organs of the body such as kidney, liver and the immune system (Hunt, 2003). The WHO/FAO have set a permissible limit of 0.3 mg/kg for cadmium. Results obtained revealed that Cd was totally not detected in all the specimens tested in both locations.

Nickel (Ni) is also an essential element for plants and animals. In minute quantity, nickel is required for the regulation of lipid contents in tissues and for the formation of red blood cells, but at high concentration it becomes toxic and results in loss of vision, loss of body weights, heart and liver failures as well as skin irritation (McGrath and Smith., 1990). WHO's permissible limit for nickel in medicinal plants is 1.5mg/kg (WHO, 2005), while its routine requirement for mankind is 1 mg/kg per day. From the results of this study, it was observed that Ni was totally undetected in all the selected medicinal plants specimen evaluated in the two locations.

Copper is an essential trace element required for many enzymes and aids in normal growth and development. Bioaccumulation of Cu can result in hair and skin discoloration, dermatitis, respiratory tract diseases and some other chronic diseases in humans (Khan *et al*., 2008). All the tested samples contained a significant amount of Cu. The world health organization's permissible limit of copper in medicinal

plants is 10 mg/kg while its uptake in food is 2-3mg/day (WHO, 2005). In Ogbogoro, the leaf specimen of *P. americana*, *A. indica* and *A. muricata* exceeded the permissible limit. *M. oleifera* and *M. indica* contained high concentration of this metal but were below the permissible limit as well as the bark of *A. indica*. The bark of *M. indica* had lower concentration and was below the permissible limit. In Eleme Petro-Chemical environs, the leaf specimen of *P. americana*, *A. muricata*, *M. indica* and approximately *M. oleifera* were above the permissible limits and are very likely to pose health risks if consumed. However, the concentration of Copper in leaves of *A. indica* was also high but below the permissible limit, as well as the bark of *M. indica.* The bark of *A. indica* had lower concentration and was below the permissible limit.

CONCLUSION

This study has revealed that plant species are sources of medicine and that they play an important role in improving the health standards of most individuals in both Ogbogoro and Eleme communities. From the results, the samples of leaves and barks of the selected medicinal plants (*A. indica, A. murincata, M. oleifera, M. indica*and *P. americana*) contained varying quantities of heavy metals across the two locations. In accordance with the WHO standards, it was found that only the leaves of *A. indica* were safe for consumption in Eleme, while the leaves of the other species were above the permissible limits and thus, pose great hazards to human health. They are therefore not safe for consumption. In Ogbogoro, the leaves of *M. oleifera* and *M. indica* were found to be safe for human consumption while *P. americana*, *A. indica* and *A. murincata* were above the prescribed limits and are therefore hazardous for consumption as food or medicine. However, concentrations of heavy metals in bark samples were below permissible limits and therefore safe for human consumption. The common sources of heavy metals in the study localities especially anthropogenic activities should be regulated. Proper disposal of household and industrial wastes (especially in Eleme Petro-Chemical environs) should be ensured to reduce the contamination of soils/air and the bioaccumulation of heavy metals in medicinal plants within the localities.

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