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Full Length Research Paper

Assessing concentrations of hazardous metals in medicinal plants from four selected districts in Ashanti region of Ghana

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Hazardous metals such as lead, cadmium and arsenic are potential biaccumulative toxins of medicinal plants. The hazardous metal amounts of medicinal plants, however, remains poorly documented in Ghana. The study was carried out to assess the amounts of lead (Pb), cadmium (Cd) and arsenic (As) in thirty-six (36) selected medicinal plant samples obtained from four (4) districts (Mampong, Sekyedumase, Ejisu and Oyoko) whose inhabitants are noted for extensive use of medicinal plants in the management of ailments. Dry Ashing method of digestion and analysis was adopted for the determination of amounts of hazardous metals and concentration per sample was expressed in μgg^{-1}. The study revealed that all the samples contained the assessed hazardous metals except the bark of *Ceiba pentandera* (B) which had no As. Pb was also not detected in the fruit of *Cola nitida* while the rhizome of *Zingiber officinale* contained no Pb and Cd. The highest concentrations of Pb, Cd and As were detected in the bark of *Mangifera indica* (12.96 μgg^{-1}) at Ejisu, the bark of *Pycnanthus angolensis* L (2.03 μgg^{-1}) at Mampong and the leaves of *Alchornea cordiforlia* (16.35 μgg^{-1}) at Sekyedumase, respectively. The observed amounts detected in these medicinal plant samples were all above the WHO maximum permissible limits (MPL) for the respective metals. The samples from Mampong, Sekyedumase and Oyoko all had Pb amounts below the WHO MPL of 10 μgg^{-1}, while those from Ejisu had thirty percent (30%) of its samples with Pb amounts above the WHO MPL. The range of levels of Pb were: Ejisu (2.50μgg^{-1}-12.96 μgg^{-1}), Mampong (0.04 μgg^{-1}-8.40 μgg^{-1}), Sekyedumase (0.375 μgg^{-1} - 1.415μgg^{-1}) and Oyoko (0-0.125 μgg^{-1}). All the samples from Sekyedumase recorded Cd amounts above the WHO MPL of 0.300 μgg^{-1}. Ejisu and Mampong had 60% and 70% of their samples, respectively recording Cd amounts above the WHO MPL. However, samples from Oyoko recorded Cd levels below the WHO MPL. The contents of As in the samples analyzed were all below the WHO MPL of 10 μgg^{-1} except *Alchornea cordiforlia* from Mampong, which recorded 16.35 μgg^{-1}.

Key Words: Hazardous metals, medicinal plants, Lead, Cadmium, Arsenic

INTRODUCTION

Since pre-historic times, medicinal plants continue to play a vital role in human health care delivery (Annan et al., 2010). The therapeutic properties of these plants are directly related to the vast array of phytoconstituent synthesized through various biochemical pathways. Globally, about eighty percent (80%) of people use medicinal plants for treatment of diseases (WHO, 2005). This is because of the availability of fewer health facilities and people have to travel long distances to access these facilities (Sarpong et al., 2000). There is also an increased lack of confidence in orthodox medicine because of huge pressure on drugs and the development of resistance to drugs,

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especially antibiotics, leading to treatment failures and re-emergence of diseases (Sarpong et al., 2000). In addition, there is the emergence of new diseases such as AIDS, which allopathic drugs are not able to cure and there still exist chronic diseases requiring prolonged and expensive orthodox medicines which patients cannot afford (Sarpong et al., 2000).

With recent technological advances, people are becoming more aware of the risks associated with the presence of hazardous metals in medicinal plants and their products (Wong, 1993). Hazardous metals are discharged into the environment through industrial activities, automobile exhaust, municipal wastes, burning of refuse and pesticides usage (Jarup, 2003). Arsenic is released into the environment by smelting of Cu, Zn and Pb (Hawkes, 1997). Agricultural land can be contaminated by Cd through the application of fertilizers and sewage sludge. Plants absorb hazardous metals such as Cd from surrounding soils or directly through the leaves and are accumulated in their tissues (Trueby, 2003). In minute amounts, certain hazardous metals are nutritionally essential for a healthy life. For example Fe, Cu, Zn and Mn are essential to the body. Zn is involved in numerous aspects of cellular metabolism and is also required for the catalytic activity of approximately hundred (100) enzymes (Young, 2005). The metal plays a role in immune function, proteins synthesis and wound healing. Zn supports normal growth and development during pregnancy, childhood and adolescence (WHO, 2005). Zn balances copper in the body, and is essential for male reproductive activity (Nolan, 2003). Deficiency of Zn causes anaemia and retardation of growth and development (McClugage, 1991).

Plants contaminated with higher concentrations of hazardous metals are toxic to consumers when ingested. They accumulate in organs such as kidneys and liver, causing damage to these organs (Taylor, 1997). The hazardous metals disrupt functions of vital organs such as heart, brain, kidney and liver. They also displace vital nutritional minerals from their original place, thereby hindering biological functions (Peplow, 1999). Cd poses a serious toxicological impacts on human health and ingestion via food, especially plant-based foodstuffs (Azhar et al., 2010). As is carcinogenic and exposure to high levels may lead to death (Ogwuegbu and Ijioma, 2003). Possible symptoms of toxic effects of As include hair loss, fatigue, dermatitis, kidney and liver failure, and muscle pains. Pb poisoning causes inhibition of the synthesis of haemoglobin, dysfunctions in the kidneys, joints and reproductive systems and chronic damage to the central nervous system (CNS) (Dartey et al., 2010; Ogwuegbu and Muhanga, 2005). Other effects include damage to gastrointestinal tract (GIT), urinary tract resulting in bloody urine and neurological disorder (McCluggage,1991).

The importance of medicinal plants in the health delivery system in Ghana cannot be over emphasized. Unfortunately, some herbal practitioners have inadequate scientific knowledge about the phytoconstituents and toxic effects of hazardous metals in plants they employ in their trade. Several cases of adverse effects of herbal drugs have been reported in many countries during the last few years, which are allegedly caused by taking herbal products or traditional medicines prescribed by the practitioners of indigenous systems of medicine (Rai and Mehrotra, 2005). Reports from two leading hospitals in Ghana indicates that herbal medicines are causing life–threatening medical complications, including kidney, heart failures, strokes, various cancers and sometimes, even death (The Herald, 2011). Higher amounts of hazardous metals (i.e. concentrations above the maximum permissible limits (MPL) set by the World Health Organization (WHO) can adversely affect the health of consumers. WHO indicates that about 70% of people in African countries rely on traditional or herbal medicine for their health–care needs, and Ghana is no exception (Sarpong, 2008). With a greater percentage of Ghanaians depending on medicinal plants, and the fact that both herbal practitioners and consumers are ignorant about the adverse effect of hazardous metals to the health of consumers, it is imperative to conduct an investigation into the concentrations of hazardous metals in medicinal plants which serve as raw materials for herbal drugs and other herbal products.

MATERIALS AND METHODS

Study Areas

The medicinal plant samples were selected based on the information gathered from traditional herbal practitioners with respect to their usage in treating and managing diseases. The samples were collected from Mampong (Mampong Municipality), Sekyedumase (Ejura-Sekyedumase District), Oyoko (Sekyere-Afram Plains District) and Ejisu (Ejisu - Juaben Municipality) in the Ashanti Region of Ghana. The medicinal plant samples were collected between March and July, 2010.

Ejisu lies in the transitional zone of Ghana and located on latitude 07^0 0'N and longitude 01^0 24'W with an altitude of 457m above sea level. The population of the district is 21,045. The Municipality shares common boundaries with Kwabre East, Bosomtwe-Atwima Kwannwoma , Asante-Akim North districts and Kumasi Metropolitan Assembly (Ghana districts, 2012).

Mampong is the capital of Mampong Municipality and lies 50km north of Kumasi. The Municipality is located within longitudes 0^0 05'N and $1^0$30'W and latitudes 6^0 55'N and $7^0$30'W covering a total land area

Table 1: Selected medicinal plant from Ejisu, Mampong, Sekyedumasi and Oyoko

Medical	**Ethnomedical**	**Family**	**Local**		**Area Sampled From**			
Plant	**Use**		**Name**	**PP**	**Ejisu**	**Mpg**	**Seko**	**Oyoko**
Portulaca oleracea	aphrodisiac,meningitis,	Portulacaceae	Pursulane	L	√			
Taraxacum officinale	high blood pressure	–		L	√			
Ceiba pentadera	diuretic, aphrodisac asthma	Bombacacae	Bombacacae	B	√			
Boerhahvia diffusa	asthma, lumbago, anaemia,	Nyctaginaceae	Hog Weed	L	√			
Moringa oleifera	arthritis, appetizer, rheumatism	Moringaceae	–	L	√			
Mangifera indica	stomach ulcer, jaundice,	Anarcadaceae	Mango	B	√			
Carica papya	skin ulcers, urinary retention	Caricaceae	Pawpaw	L	√			
Markhamia lutea	wounds, rheumatism	Bignoniaceae	Sisimia	L	√			
Alstonea congensis	Measles, cataract	Apocynaceae	–	B	√			
Solanum torvum	Coughs, diuretics, sedative	Solanaceae	–	F	√			
Kigelia Africana	hemorrhoids, otitis	Bignoniaceae	Sausage Tree	L		√		
Paullinia pinnata	gonorrhea, fracture	Sapindacea	–	L		√		
Gossypium arberenum Linn	dysentery, urine utention	Malvaceae	Cotton	L		√		
Pacnanthus angolensis	abortion, anaemia	Myristicaceae	–	B		√		
Spathodea campanulata	dyspepsia, hamorrhoids	Bigoniaceae	African Tulip	B		√		
Phyllanthus muellarianus	conjunctivitis, cough	Euphorbiaceae	–	L		√		
Thalia welwitschii	asthma	Marantaceae	_	R		√		
citrtus	diarrhea, rheumatism	Graminae	Lemon Grass	L		√		
Psidium guajava Linn	antimicrobial, cough	Myrtaceae	Guava	R		√		
Azadirachta indica	antidiabetic, antifatigue	Meliaceae	Neem tree	L		√		√
Mangifera indica	jaundice, dental caries	Anarcadaceae	Mango	B			√	
Alchoinea cordiforlia	abdominal pain, dysentry	Euphorbiaceae	Chrismas Bush	L			√	
Solanum incanum	conjunctivties	Solanaceae	-	R			√	
Parkia biglobosa	malaria, boils	leguminoceae	African Locust	B			√	
Jatropha curcas	convulsion , fever	Euphorbiaceae	Pig nut	R			√	
Cola nitrida	fracture,herps, dystocia	Stericuliaceae	-	F			√	√
Tectona grandis Khaya	skin diseases, leprosy	Verbanaceae	-	L			√	

of about 449 km^2 with a projected population of 43,469 (Ghana districts, 2012).

Sekyedumase is in Ejura-Sekyedumase District. The district shares boundaries with Sekyere-West district in Ashanti Region, Nkoranza South to the West, and Atebubu-Amanten to the East both in the Brong - Ahafo Region. The population of the district is 106,508 (Ghana districts, 2012).

Oyoko is located in the Sekyere Afram Plains District of Ashanti Region. The district is located between latitude

Table 1 continues

Senegalensis	helmininthaiasis, arthritis	Meliaceae	Mahogany	B			√	
Milletia thonningii	Anthelmintics, blood purifier	Leguminaceae	Iron tree	R			√	
Ageratum conyzodes	conjunctivties, convulsion	Asteraceae	Goat weed	L				√
Carica payaya	uninary retention, amoebiasis	Caricaceae	Pawpaw	R				√
Sida acuta	dystocia, diabetes mellitus	Malvaceae	Horn Bean	L				√
Zingiber officinale	Fibriod (uterine)	Zingiberaceae	Ginger	Rh				√
Ficus asperifolia	headache, cancer(unspecified)	Moraceae	Sandpaper	L				√
Alternanthera pungens	rheumatism, dysentery	Amaranthaceae	Khaki bur	R				√
Hiliotropium Indicum	abdnominal pain,	Boraginaceae	Indian heliotrope	L				√
Gossypium arboretum	dysentery, malaria,	Malvaceae	Cotton	R			√	√
PP = PLANT PART, R = ROOTS, L = LEAF, B = BARK, F = FRUIT , Rhizome = Rh								

Table 2: Concentration of Hazardous Metals in $\mu g g^{-1}$ of selected thirty six (36) medicinal plant samples

Medicinal Plant	Plant part	Lead	Cadmium	Arsenic
			Ejisu	
Portulaca oleracra	L	4.750 ± 0.353	0.18 ±0.035	0.015±0.007
Taraxacum officinale	L	2.500 ± 0.707	0.215 ± 0.035	0.025 ± 0.007
Ceibapentandera	B	3.750 ±0.353	0.375± 0.035	nd
Boerhavia diffusa	L	11.780± 0.106	0.380± 0.028	0.030± 0.000
Moringa oleifera	L	5.930± 0.035	0.350± 0.07	0.030± 0.014
Mangifera indica	B	12.960± 0.07	0.375± 0.035	0.025± 0.007
Carica papaya	L	2.980± 0.07	0.875 ± 0.035	0.020 ±0.0 14
Markhamia mica	L	10.860 ± 0.21	1.275±0.035	0.025 ±0.007
Alsionea congensis	B	9.765± 0.33	0.085± 0.021	0.045± 0.007
Solanum torvum	F	5.930 ± 0.106	0.115 ± 0.007	0.015 + 0.007

0^{0}20'N and 1^{0}20'W and longitudes 6^{0}52'N and 7^{0}32'W. The district shares common boundaries with Sekyere Central to the west, Sekyere East and Asante-Akim North Districts to the south, Kwahu North district in the Eastern Region to the east and the Sene District in the Brong-Ahafo Region to the north. The population of the district as at 2008 was 92,857 (Ghana districts, 2012).

Collection and Preparation of Selected Medicinal Plant Samples

The medicinal plant sample parts were collected from their natural habitats. Table 1 indicates the selected medicinal plants, their families, ethno medical use and parts of plant collected. Specimens were authenticated at CSIR-FORIG and vouchers kept at the University of Education, Winneba, College of Agriculture Education, Asante-Mampong. The medicinal plant samples were washed thoroughly with distilled water to remove any soil contaminants and possible parasites. The medicinal plant samples were dried at room temperature and later oven-dried at a temperature of 40^{0}C for forty eight (48) hours. They were pulverized using roller miller and their weights noted.

Digestion and Analysis of Medicinal Plant Samples

Digestion and analysis were carried out at Council for Scientific and Industrial Research–Soil Research Institute (CSIR-SRI) at Kwadaso, Kumasi, Ghana. Dry

Table2 continues				
		Mampong		
Kigelia Africana	L	2.600 ±0.141	0.475 ± 0.035	0.02 5±0.007
Paullinia pinnala	L	2.950 ± 0.106	2.020± 0.208	0.03 5±0.007
Gossypiurn arbereum Linn	L	6.775 ± 0318	2.03 0± 042	0.05 5±0.007
Pycnanlhus angolensis	B	2.825 ± 0.247	1.125± 0.177	0.040 ±0.014
Spaihodea campanulata	B	8.200± 0.424	0.060± 0.014	0 .070±0.0 14
Phyllanihus muellarianus	L	8.400 ± 0. 141	0.055± 0.007	0. 075±0 .007
Thulia welwitschii	R	0.795 ± 0.063	0.070 ± 0.014	0.040±0.014
Cyenbopogon	R	3.485 ± 0.049	0.865± 0.078	0 .03 0±0.0 14
Psidium guajava Linn	L	3.485 ± 0.049	1:140±0.028	0.090±0.007
Azadirachia indica	L	0.040 ± 0.014	2.075±0.106	0.015±0.099
		Sekyedumase		
Mangifera indica	B	0.775±0.035	0.785+0.021	0.0035±0.0007
Alchornea cordiforlia	L	0.725±0.106	1.035±0.007	16.350 ± 0.071
Solanum incanurn	R	0.375±0035	0.410+0.021	0.0105 ±0.0007
Gossypium arborerum	R	0.790+0.014	0.545±0.021	0.0055± 0.0021
Parkia biglobosa	B	1.415+0.092	0.635±0.007	0.0025±0.0007
Jatropha curcas	R	0.545±0.021	0.545+0.021	0.005±0.001
Cola nitida	F	1.720±0.028	0.750+0.014	0.004±0.001
Tectonagrandis	L	0.945±0.021	1.305±0.035	0.0045±0.0007
Khayasenegalensis	B	0.775±0.035	0.830±0.071	0.003±0.001
Milletia thonningii	R	0.380±0.028	0.310±0.041	0.020±0.01
		Oyoko		
Ageratum conyzodes	L	0.017± 0.001	0.025 ± 0.007	1.170±0.014
Carica papaya	R	0.017± 0.001	0.015± 0.007	2.070± 0.014
Sida acuta	L	0.080± 0.01	0.030± 0.01	0.675± 0.106
Azadirachia Indica	L	0.125 ± 0.035	0.015± 0.007	4.100 ± 0.14
Cola nitida	F	nd	0.030±0.01	2.175± 0.092
Zingiber officinale	Rh	nd	nd	1.895 0.064
Ficus asperifolia	L	0.080± 0.01	0.015± 0.0 17	3.085± 0.035
Alternantherapungens	R	0.060± 0.01	nd	1.1 50± 0.014
Hiliotropium Indica	L	0.065 ± 0.007	0.020± 0.01	3.235± 0.064
Gossypium arboretum Linn	R	0.055± 0.007	0.025 ±0.007	1.215±0.021

ashing method of digestion was adopted from the protocol of Perkin Elmer manual for Atomic Absorption Spectrometry. A known weight of each of the selected medicinal plant samples was placed into crucibles made of porcelain. The contents of crucibles were dried at 110 ^{0}C and moistened with magnesium nitrate (50% w/v). Ashing started immediately in a controlled muffle carbolated furnace at a temperature of 450 ^{0}C and left overnight to ensure complete oxidation of organic components of the sample. The ash of each sample was dissolved in 20ml of concentrated nitric (HNO_3) and perchloric ($HClO_4$) acids in a ratio of 9:4 in a 200 ml

Table 3: WHO Maximum Permissible Limit (MPL) values for Pb, Cd and As in medicinal plant samples

Element	Lead	Cadmium	Arsenic
Maximum Permissible Limit (MPL) (μgg^{-1})	10	0.3	1

digestion tube. It was then heated in a block digester to allow thorough dissolution of ash in acid. Heating continued until the brown fume of nitric acid ceased and the sample turned clear. The digestion was stopped and distilled water added to obtain a total volume of 20 ml. The final solution was filtered through a 0.45 µm pore size membrane filter paper (Whatman filter paper No. 41) to obtain a particle-free solution. The analyte was poured into a beaker and the capillary dipped into it, the analyte was aspirated on the VARIAN SPECTRA AA 220 Zeeman Atomic Absorption Spectrometer (AAS) (Varian Canada Inc). Determinations of the various metals (triplicates) in each sample were then performed and the mean values of samples were recorded (Sarpong et al**.,** 2012).

Statistical Analysis

The data were based on three replicates and were expressed as mean ± standard deviation.

RESULTS AND DISCUSSION

The concentrations of the hazardous metals (Pb, Cd and As) in selected medicinal plants from the districts are as indicated in Table 2.

Pb

The medicinal plant samples with the highest concentration of Pb was in *Mangifera indica* (B), (12.960 μgg^{-1}) collected from Ejisu in the Ejisu Municipality (Table 2). Thirty percent (30%) of medicinal plants from the Municipality contained Pb amounts greater than the WHO maximum permissible limits (MPL) of 10 μgg^{-1}. These were *Markhamea lutea* (L) 10.860 μgg^{-1}, *Boerhavia diffusa* (L) 11.78 μgg^{-1}, and *Mangifera indica* (B) 12.960 μgg^{-1}. *Alstonea congensis* (B) possessed a concentration of 10 μgg^{-1} which was equal to the WHO MPL of 10 μgg^{-1}. The remaining sixty percent (60%) (*Taraxacum officinale* (L) 2 μgg^{-1}, *Carica papaya* (L) 2 μgg^{-1}, *Ceiba pentandera* (B) 3.750 μgg^{-1}, *Portulaca oleracea* (L) 4.750 μgg^{-1}, *Moringa oleifera* (L) 5.930 μgg^{-1} and *Solanum torvum* (F) 6 μgg^{-1} contained Pb amounts below the WHO MPL (Table 2 and 3).

All the samples collected from the Mampong Municipality showed concentrations below the WHO maximum permissible limits of 10 μgg^{-1}. The maximum amount of Pb in the medicinal plant samples was in the leaves of *Phyllanthus muellarianus* (L) and the roots of *Thalia welwitschii* (R) with a concentration of 8.400 μgg^{-1} each. *Azadirachta indica* leaves recorded the lowest concentration of 0.04 μgg^{-1}.The concentration of Pb in the samples are as shown: *Thalia welwitschii* (R), 8.400 μgg^{-1}>*Phyllanthus muellarianus* (L) 8.20 μgg^{-1}> *Pycnanthus angolensis* (B) 6.775 μgg^{-1} > *Psidium guajava* Linn (L), 3.485 μgg^{-1}, > *Spathodea campanulata* (R), 2.825 μgg^{-1}*Gossypium arbereum* Linn (L) , 2.925 μgg^{-1} > *Paullinia pinnata* (L), 2.600 μgg^{-1} > *Cymbopogon* (L) 0.795 μgg^{-1} (Table 2).

From the Ejura- Sekyedumase district *Cola nitida* (F) recorded the highest concentration of 1.720 μgg^{-1}, while the lowest concentration was 0.380 μgg^{-1} in *Milletia thonningii* and *Solanum incanum* (R). All the samples analyzed from Sekyedumase exhibited Pb concentrations below the WHO maximum permissible limits of 10 μgg^{-1}. The Pb concentrations were in the decreasing order: *Parkia biglobosa* (B), 1.415 μgg^{-1} > *Tectona grandis* (L), 0.945 μgg^{-1} > *Gossypium arborereum* (R), 0.790 μgg^{-1} >*Khaya senegalensis* (B), *Mangifera indica* (B), 0.775 μgg^{-1}> *Alchornia cordiforlia* (L), 0.725 μgg^{-1} > *Jatropha curcas* (R), 0.545 μgg^{-1} (Table 2).

The samples from Oyoko had Pb concentrations below the WHO MPL of 10 μgg^{-1}. *Cola nitida* (F) and *Zingiber officinale* (Rh) contained no Pb, while *Hiliotropium indica* (L), Gossypium *arborereum* (R), *Ficus asperifolia* (L), *Sida acuta* (L) , *Azadirachta indica* (L) and *Alternanthera pungens* (R) contained lower concentrations of 0.060 – 0.100 μgg^{-1} . The highest concentration of 0.18 μgg^{-1} was in *Carica papaya* (R) and *Ageratum conyzoides* (L). Khan et al., (2008) in their study about amounts of Pb in medicinal plant samples obtained concentrations below the detection limit of the AAS instrument employed. In the case of Azhar et al. (2010) studies on levels of Pb in medicinal plants, Pb concentrations varied between 0.700 - 0.960 μgg^{-1}, similar to the levels of 0.00 - 0.100 μgg^{-1} obtained in the present study.

The highest mean concentration (12.960 μgg^{-1}) of Pb obtained in *Mangifera indica* in the current study was less than that revealed in an earlier study (Sarpong et al., 2012) and that of Abou-Arab (2000) with mean Pb concentration 14.400 μgg^{-1}.

Pb can be found in all parts of our environment. The principal sources of Pb contamination of the ecosystem are from internal combustion of gasoline engines, metal smelting plants, agrochemicals such as Pb arsenate ($Pb_3(ASO_4)_2$) pesticides, phosphate fertilizers, Pb based paints and spent Pb shots from hunting activities. Also human activities such as mining, manufacturing and burning of fossils fuels release Pb to the environment. Plants absorb them from the soil when particles fall on the soil and are stored in plant tissues. Once ingested by humans, Pb affects the red blood cells and causes damage to organs such as the liver, kidneys, heart and male gonads. Unborn children can be exposed to Pb through their mothers. Harmful effects include premature birth, smaller babies and decreased mental ability in the infant, learning difficulties and reduced growth in young children. The continuous use of these medicinal plants could be harmful (Ahmed et al., 2008; Gasanal et al., 2006).

Cd

At Ejisu, *Markhamea lutea* (L) contained the highest Cd concentration of 1.275 μgg^{-1} highly above the WHO MPL of 0.300 μgg^{-1} (Table 2). The lowest amount of 0.085 μgg^{-1} was in *Alstonea congensis* (B). Forty percent (40%) of the samples (*Portulaca oleracea*, 0.18 μgg^{-1} (L), *Alstonea congensis* (B) 0.085 μgg^{-1}, *Solanum torvum* (F), 0.115μgg^{-1} and *Taraxacum officinale* (L),0.215 μgg^{-1}) contained Cd amounts below the WHO maximum permissible limits . However, fifty percent (*Ceiba pentandera* (B), 0.375 μgg^{-1}, *Boerhavia diffusa* (L) ,0.380 μgg^{-1}, *Mangifera indica* (B), 0.375 μgg^{-1}, *Carica papaya* (L), 0.875 μgg^{-1} and *Markhamia lutea* (L), 1.275 μgg^{-1} contained Cd concentrations above the WHO maximum permissible limits (MPL). Only *Moringa oleifera* (L), showed a level equal to the WHO MPL (0.300 μgg^{-1}) (Table 3).

Seventy percent (70%) of the medicinal plants selected at Mampong (*Kigelia Africana* (L), 0.475 μgg^{-1}, *Paullinia pinnata* (L), 2.020 μgg^{-1}, *Gossypium arbereum Linn* (L), 2.030 μgg^{-1}, *Pycnanthus* angolensis (B) , 1.125 μgg^{-1}, *Cymbopogon* (L), 0.865 μgg^{-1} , *Psidium guajava* Linn (L),1.140 μgg^{-1} *and Azadirachta indica* (L), 2.075 μgg^{-1}) showed amounts above the WHO maximum permissible limits (MPL) (Table 3). Thirty percent (30%) of the plants (*Phyllanthus muellarianus* (L), 0.055 μgg^{-1}, *Spathodea campanulata*, 0.060 μgg^{-1} and *Thalia welwitschii* (R), 0.070 μgg^{-1}) had Cd concentrations below WHO maximum permissible limits. The lowest Cd concentration was in *Phyllanthus* muellarianus (L), 0.055 μgg^{-1} while the highest concentration of 2.030 μgg^{-1} was in *Gossypium arbereum Linn* (L) (Table 2) .

All the medicinal plant samples from Sekyedumase contained Cd levels greater than the WHO MPL of 0.300 μgg^{-1}(Table 3) The levels of Cd concentrations ranged from 0.310- 1.305 μgg^{-1}. *Alchornea cordiforlia* (L) contained the highest concentration of 1.035 μgg^{-1}, while the lowest amount of 0.310 μgg^{-1} was contained in *Milletia thonngii* (R) (Table 2).

The concentrations of Cd in all the medicinal plant samples were below the WHO maximum permissible limits (MPL). The highest concentration of 0.200 μgg^{-1} was recorded in *Ageratum conyzoides* (L), *Sida acuta* (L) *and Gossypium arbereum* Linn (R). *Zingiber officinale* (Rh) and *Althernanthera pungens* (R) contained trace amounts (Tables 2 and 3).

Azhar et al. (2010) study showed highest mean Cd level of 12.060 μgg^{-1}, while the highest mean Cd concentration of 1.275 μgg^{-1} was reported in the present study. The previous study conducted by Sarpong et al. (2012) revealed highest mean Cd concentration of 2.500 μgg^{-1}, higher than the mean Cd for the current study. No Cd was detected in the study conducted by Khan et al. (2008).

Cd enters the air from mining industry and burning of coal. The particles in air can travel long distances before falling on the ground or in water where it is taken up by plants from the environment. Cd can stay for longer periods in the human body and can build up to harmful levels after many years of exposure. Acute effects of high concentrations of Cd may include throat dryness, cough, headache, vomiting, chest pain, extreme restlessness and irritability, pneumotitis, bronchopneumonia and death due to severe lung damage. Long term exposure to lower levels of Cd can lead to build up of Cd in the kidneys and possible kidney disease (Jarup et al., 1998).

As

The medicinal plant samples showed the highest As level of 0.045 μgg^{-1} in *Alstonea congensis* (B), but this was below the World Health Organization (WHO) maximum permissible limits (MPL) of 1 μgg^{-1}. As was not detected in *Ceiba pentandera* (B). The rest of the medicinal plant samples analyzed contained lower As levels which ranged from 0.015 to 0.300 μgg^{-1} (Table 2)

All the medicinal plant samples from Mampong exhibited lower As amounts in comparison to the WHO maximum permissible limits (MPL) of 1 μgg^{-1}. *Psidium guajava* Linn (L) contained the highest amount of 0.090 μgg^{-1} while *Azadirachta indica* (L) contained the lowest amount of 0.015 μgg^{-1} (Table 2). The amounts of As were in ascending order: *Kigelia Africana* (L) 0.025 μgg^{-1} < *Cymbopogon* (L) 0.030 μgg^{-1} < *Paullinia pinnata* (L) 0.035 μgg^{-1} < *Pycnanthus angolensis* (B), *Thalia welwitschii* (R) 0.040 μgg^{-1} < *Gossypium arberium* Linn (L) 0.055 μgg^{-1} < *Spathodea campanulata* (B) 0.070 μgg^{-1} < *Psidium guajava* (L) 0.090 μgg^{-1} (Table 2)

At Sekyedumase, *Alchornia cordiforlia* (L) recorded the highest As concentration of 16.40 μgg^{-1} ,which was about sixteen times higher than the maximum permissible limit of the World Health Organization

(WHO) (Table 2 and 3). The rest of the medicinal plants (*Khaya senegalensis* (B), 0.003 μgg^{-1}, *Mangifera indica* (B), 0.0035 μgg^{-1}, *Parkia biglobosa* (B), 0.0025 μgg^{-1}, *Tectona grandis* (L), 0.0045 μgg^{-1}, *Gossypium arborereum* (R), 0.0055 μgg^{-1}, *Jatropha curcas* (R) 0.005 μgg^{-1}, *Cola nitida* (F), 0.004 μgg^{-1}, *Solanum incanum* (R) 0.0105 μgg^{-1}, *Milletia thonningia* (R), 0.020 μgg^{-1} (Table 2) recorded concentrations below WHO maximum permissible limits (MPL) of 1 μgg^{-1}.

The levels of As in all the medicinal plant samples except *Sida acuta* at Oyoko were higher than WHO MPL for As. The highest concentration of As was in *Azachdirachta indica* (L), 4.00 μgg^{-1}, while the lowest was in *Sida acuta* (L), 0.745 μgg^{-1} . The concentration of As in the medicinal plant samples in descending order were : *Azadirachta indica* (L), 4.100 μgg^{-1} > *Hiliotropium indica* (L), 3.235 μgg^{-1} > *Ficus asperifolia* (L), 3.085 μgg^{-1} > *Cola nitida* (F), 2.1750 μgg^{-1} > *Carica papaya* (R), 2.070 μgg^{-1} > *Zingiber officinale* (R), 1.895 μgg^{-1} > *Gossypium arborereum* (R), 1.215 μgg^{-1} > *Ageratum conyzoides* (L), 1.170 μgg^{-1} > *Altenanthera pungens* (R), 1.150 μgg^{-1} > *Sida acuta* (L), 0.675 μgg^{-1}.

Medicinal plant samples collected from Oyoko (Sekyere -Afram Plains District) showed highest levels of As than all the three remaining districts. These As amounts were greater than the World Health Organization (WHO) maximum permissible limits (MPL) of 1 μgg^{-1}. The current findings are contrary to the previous study where As amounts were below the WHO maximum permissible limits (MPL) (Sarpong et al., 2012). *Azadirachta indica* (L) is extensively employed by many households to treat malaria. The maximum As concentration detected was also below the highest concentration detected in fifty medicinally important leafy samples that were analyzed for arsenic concentration (Reddy and Reddy, 1997). Higher As concentration may affect consumers on a continuous use as bioaccumulation of As becomes toxic to the organs of the body. For example it has been demonstrated that there is a relation between exposure to As and increased incidence of *Diabetes mellitus* (Lai et al., 1994).

Conclusion

The selected medicinal plants are highly employed traditionally for the treatment and management of numerous ailments and as food supplements. They are also used to manufacture other herbal products. However, not much has been done to ascertain the levels of hazardous metals in these medicinal plants. The current study was an effort in doing so. There were differences in the levels of hazardous metals in the medicinal plants. The highest concentration of Pb was in *Mangifera indica* (B), 12.960 μgg^{-1} and that of Cd was 2.075 μgg^{-1} in *Azadirachta indica* (L). *Mangifera indica* (B) is used to treat varieties of diseases including *Diabetes mellitus*, jaundice, and so on. With Pb levels above the WHO maximum permissible limits (MPL) of 10 μgg^{-1} caution must be taken when using the sample. The highest As concentration was in *Azadirachta indica* Linn (L) with concentration 4.100 μgg^{-1}. The medicinal plant sample, *Khaya senegalensis* (B) is employed extensively to manufacture herbal drugs and other herbal products. The levels of Pb, Cd and As were 0.380 μgg^{-1}, 0.830 μgg^{-1} and 0.003 μgg^{-1} . These amounts were within the World Health Organization maximum permissible limits for the hazardous metals. Since hazardous metals bioaccumulate with continuous use, care must be taken when these plants are to be used for a longer period.

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