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Full Length Research Paper

Assessment of hazardous metal load in soils and medicinal plants samples from Suame Magazine, Kumasi

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The presence of non-essential hazardous metals lead (Pb), cadmium (Cd) and arsenic (As) deleterious to biota were analyzed in samples (soil and medicinal plants) obtained from Suame Magazine by employing atomic absorption spectrometry. Soil samples were contaminated and their geo-accumulation indices were: Zone 1, Pb (I_{geo}=1.67, moderate), Cd (I_{geo}=2.30, moderate to strong) and As (I_{geo}=2.05, moderate to strong); Zone 2, Pb (I_{geo}=2.91, moderate to strong), Cd (I_{geo}=2.33, moderate to strong) and As (I_{geo}=2.11, moderate to strong) and Zone 3, Pb (I_{geo}=0.782, uncontaminated to moderate), Cd (I_{geo}=1.92, moderate) and As (I_{geo}=2.01, moderate to strong). Soil Pb, Cd and As levels ranged (2.02 - 480.05), (0.16- 1.51) and (0.05-0.85) µgg^{-1} respectively. The range of toxic metal concentrations recorded for medicinal plants (roots and barks) were: Pb (2.04 - 93.48), Cd (0.16 -3.76) and As (0.01 - 1.12) µgg^{-1}. Medicinal plants tendency to accumulate and translocate Pb, Cd and As were estimated by employing Bioconcentration Factor (BCF), Translocation Factor (TF) and Bioaccumulation Coefficient (BAC). Range of values recorded for BAC, TF and BCF respectively were: Pb (0.02 - 13.33), Cd (0.80 - 17.26) and As (0.03 - 19.60); Pb (0.15 - 8.72), Cd (0.23 - 7) and As (0.02-19.60); and Pb (0.02-46.28), Cd (0.39-14.25) and As (0.03-20.60). The hazardous metal content in some medicinal plants from the zones studied were found to be above WHO MPL, thus, regular screening is a must to check the levels of these pollutants in the plant parts and extracts before consumption.

Key words: Bioconcentration Factor, Translocation Factor, Bioaccumulation Coefficient, Geo-accumulation index, Medicinal plant.

INTRODUCTION

Medicinal plants have contributed immensely to the health care of communities and have also served as a source for the discovery of novel phytoconstituents with therapeutic properties isolated for the pharmaceutical industries. Most of the uses and isolated phytoconstituents have been documented. For example, *A.boonei* De Wild (stem-bark) is employed to treat placental retention, malaria and rheumatism. The root-bark for treating hypertension whiles the bark for cataract (Mshana et al., 2001). *Azadirachta indica* contains phytoconstituents nimbolin, tannin and glycosides and decoction of stem-bark has antipyretic and antimalarial properties (Ayitey-Smith, 1989). Ethno-pharmacologically, *M. Indica can* be employed to manage asthma, dermatitis and other allergic ailments (Garcia et. al., 2006). According to Madunag (1990), *M. indica* possess alkaloids and glycosides with known pharmacological benefits. Secondary metabolites mangostin, 29- hydroxyl mangiferonic acid was isolated from stem bark (Shankar Narayanan et al., 1979). Milky sap from stalk of *C. papaya* for ascaris, whipworms and enterobius vermicularis (pin worm) while roots are used as diuretic (Ghana Herbal Pharmacopoeia, 1992). The roots of *J. curcas* are utilized to treat jaundice and management of sexual impotence. *Moringa oleifera* is believed to have a potential to treat asthma, antidiabetic, antibacterial, cholesterol-lowering and

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Table 1. Geo-accumulation Index Classification (Forstner et al., 1993).

Geo-accumulation Index(I_{geo})	I_{geo}	Contamination Intensity
>5	6	Very strong
>4-5	5	Strong to very strong
>3-4	4	Strong
>2-3	3	Moderate to strong
>1-2	2	Moderate
>0-1	1	Uncontaminated to moderate
<0	0	Practically uncontaminated

antihypertensive. Used to treat and manage both simple and complex diseases, medicinal plants must be free from hazardous metals and other toxins (Agarwal and Mehta, 2008; Jaiswal et al., 2009; Nikkon et al., 2003). The World Health Organization (WHO) endorses analyzing medicinal plants and other herbal products for the hazardous metal contents (WHO, 1998).

The existence of hazardous metals in ecosystems are of great concern to environmentalist and well-meaning inhabitants since they pose health threat to humankind and are toxic to other living organisms (Turkdogan et al., 2003). For example Cd is harmful to the kidneys while Pb also has adverse effects on the brain, reproductive and immune systems (Toxicology Factsheet, 2009). Adriano (1986) and Rodriguez et al. (2008) reported that human activities emit more hazardous metals to the environment than natural activities such as weathering and volcanic eruptions. Weathering and volcanic eruptions account for 80% of natural emissions of hazardous metals into the surroundings while forest fires and biogenic sources are responsible for 10% each (Nriagu,1990). Once these toxic chemicals are in the area, medicinal plants may absorb them through the roots by evapotranspiration and later translocate to the aerial parts for storage. The extent of contamination of the environment by hazardous metals can be evaluated by geo-accumulation indices while their presence in medicinal plants can be accessed through Bioconcentration Factor (BCF), Translocation Factor (TF) and Bioaccumulation Coefficient (BAC). Potential contributors of hazardous metals are through the application of fertilizers and pesticides, combustion of fossil fuels, use of waste water in irrigation, industrial production of metals and indiscriminate disposal of lead accumulator cells (Hussain and Khan, 2010). According to Luo et al. (2009), the amount of Cd in agriculture soils in China increased by 0.004 mg/kg/year in the plough layer. Increased concentrations of hazardous metals in agriculture soils adversely affect crop yield (Gupta and Gupta, 1998). Also studies had revealed that auto-mechanic workshops account for increased amounts of hazardous metals in the vicinity (Iwegbwe et al., 2006).

Auto-mechanic workshops are found in many parts of Ghana. At these locations auto- electricians, auto mechanics and auto sprayers apply their trade. Through their activities hazardous metals such as Cd, Pb from spent oil, paint and Pb-acid battery, Zn from wear and tear of tyres, etc. are released to the surroundings (Pam et al., 2013). Many useful plants with claimed therapeutic properties are sited in these areas where residents employ the leaves, stem - bark and roots for the management of both simple and chronic ailments. According to Calixto (2005) about 80% of indigenous people in developing world employ medicinal plants to treat diseases. These people still hold on to the belief that medicinal plants are free from toxic chemicals and cannot cause adverse reactions. Medicinal plants are composed of essential micronutrients and trace metals needed for the proper growth of humans. Insufficient and excess amounts of these have adverse effects on human health (Underwood, 1997).

The current economic hardships facing Ghanaians are making it difficult for people to access health care at the hospitals and other standard health-care facilities. Inadequate medical facilities at impoverished communities make patients find solace in medicinal/herbal plants which are easy to obtain and apply (Abbasi et al., 2013). The tendency that hazardous metals can be transferred to humans through medicinal plant use is a concern for consumers and scientists. The study sought to assess the levels of contamination of Pb, Cd and As in soil and also medicinal plants employed by inhabitants at Suame Magazine in Kumasi.

MATERIALS AND METHODS

Study Area

The study was conducted at Suame Magazine, an industrial slum in Kumasi ($6^0$35'N-40'N, 1^o30'W) situated at about 250-300 m above sea level (Ghana Districts, 2012). Suame Magazine is made up of a cluster of Micro-, Small- and Medium- Scale enterprises with specialty mainly in vehicular repairs and metal works. It occupies an area of 20 square miles. It has an estimated income earning population of about 200,000. Besides the sale of vehicular spare-parts, repair of lead accumulator cells, engineering materials, welding and other artisanal work are many women who sell food at these sites (Dartey et al., 2014).

Sample Collection, Pretreatment and Analysis

The area of study was divided into three (3) zones (i.e. zones 1, 2 and 3). Soil samples were collected at (0 to

Table 2. Concentration Ranges of Metals (μgg^{-1}) in Soils and Plants and Critical Concentration in Plants.

Hazardous Metals	Normal Range in Plants	Critical Plant Concentration	Normal Range in Soils
Lead	0.2 - 20	30 - 300	2-300
Arsenic	0.02 - 7	5 - 20	0.1- 40
Cadmium	0.1- 2.4	5 -30	0.01-2

Radojevic and Bashkin (2006).

Table 3. Hazardous Metal Contents of Auto-Mechanic Workshop Soils and Background Soils (μgg^{-1}).

Auto-Mechanic Workshop Soil, Zone 1			Auto-Mechanic Workshop Soil, Zone 2			Auto-Mechanic Workshop Soil, Zone 3			Background Soil		
Pb	**Cd**	**As**	**Pb**	**Cd**	**As**	**Pb**	**Cd**	**As**	**Pb**	**Cd**	**As**
53.00	0.49	0.93	182.65	0.42	0.87	21.72	0.27	0.78	6.62	0.03	0.07

15) cm depth at the selected auto-mechanic sites since according to Krishna and Grovil (2007), hazardous metals contaminate top layer of soils at a depth of (0 to 40) cm. Representative soil cores and medicinal plant samples (stem-bark and roots) were collected (Agyarko et al., 2010). This process was repeated at background sites (1000 m) away. Soil samples were obtained from sites where medicinal plants were rooted. The medicinal plants gathered were those dominantly employed by inhabitants in the vicinity. Medicinal plants samples were washed with distilled water to free them from contaminants, solar dried for 72 hours, crushed with a wooden mortar and pestle and sieved using a 2 mm mesh. Collected soil samples were solar dried for 48 hours and crushed down with pestle and mortar. They were sieved using 2 mm mesh. Soil and medicinal plant samples were kept in polyethene bags. Samples were placed in well labeled plastic bottles and transported to Center for Scientific and Industrial Research (CSIR) - Soil Research Institute (SRI), Kwadaso, Kumasi for analysis.

Digestion and analysis were carried out at Council for Scientific and Industrial Research –Soil Research (CSIR-SRI) at Kwadaso, Kumasi, Ghana. Dry Ashing Method of digestion was adopted from the protocol of Perkin –Elmer manual for atomic absorption spectrophotometry. This involved weighing 8g each of the selected medicinal plant samples into crucibles made of porcelain. The contents of crucibles were dried at 110^0C and moistened with magnesium nitrate (50% w/v). Ashing started immediately in a controlled muffle carbolated furnace at a temperature of 450 ^0C and left overnight to ensure complete oxidation of organic components of the sample. The ash of each sample was dissolved in 20 ml of concentrated nitric (HNO_3) and perchloric ($HClO_4$) acids in a ratio of 9:4 in a 200 ml 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. Heavy metal concentration were determined (in triplicates) using VARIAN SPECTRA AA220 Zeeman Atomic Absorption Spectrometer (AAS) (Varian Canada Inc). The instrument setting and operational conditions were in accordance with the manufacturers specifications.

Data Analysis

The Bioconcentration Factor (BCF), Translocation Factor (TF) and Bioaccumulation Coefficient (BAC) were evaluated by the following relations:

Bioconcentration Factor (BCF) = $[Metals]_{roots} / [Metals]_{soil}$ (Yoon et al., 2006)

The Translocation Factor (TF) = $[Metals]_{shoot} / [Metals]_{roots}$ (Cui et al., 2007; Li et al., 2007)

Bioaccumulation Coefficient (BAC) = $[Metals]_{shoots} / [Metals]_{soil}$ (Cui et al., 2007; Li et al., 2007)

The geo-accumulation index, (I_{geo}) was employed to evaluate the extent of pollution of hazardous metals in soil samples. The geo-accumulation index relation employed was:

$I_{geo} = \ln (C_n Sample / 1.5 \times B_n)$ Forstner et al. (1993).

Where:

C_n = measured concentration of metal in the soil (μgg^{-1})

B_n= background value of heavy metal in μgg^{-1}; and 1.5 = background matrix correction factor.

RESULTS AND DISCUSSION

The hazardous metal concentrations in soil, roots and bark of medicinal plants in the three zones studied are represented in Tables 3-9.

Metal Levels in Soils

A wide range of hazardous metal concentrations in the soil samples were observed in tables 5, 6 and 7 as follows:

Table 4. Geo-accumulation Index (I_{geo}) and Classification.

Areas of Study	Pb	Cd	As
Zone 1	1.67 Moderate	2.30 Moderate to Strong	2.05 Moderate to Strong
Zone 2	2.91 Moderate to Strong	2.33 Moderate to Strong	2.11 Moderate to Strong
Zone 3	0.782 Uncontaminated to moderate	1.92 Moderate	2.01 Moderate to Strong

Table 5. Concentration of Hazardous Metals in µgg^{-1} in Medicinal Plants (Roots and Barks) and Soils, from Zone 1.

Medicinal Plants	Soil			Roots			Barks		
	Pb	**Cd**	**As**	**Pb**	**Cd**	**As**	**Pb**	**Cd**	**As**
Jatropha curcas	18.13	0.36	0.25	5.68	1.12	0.04	12.60	3.20	0.03
Magnifera indica	55.60	0.54	0.10	6.84	1.56	0.05	8.88	2.88	0.03
Alstonia boonei De Wild	57.96	0.58	0.25	3.36	1.00	0.03	16.84	1.60	0.01
Azadirachta indica	192.00	0.61	0.35	9.36	2.40	0.09	20.04	3.20	0.06
Blighia sapida	17.30	0.34	0.35	12.64	1.04	0.03	3.60	0.48	0.01
Carica papaya	19.26	0.40	0.25	4.20	0.56	0.02	11.20	3.92	0.01
Moringa oleifera	35.50	0.46	0.10	63.84	0.88	0.02	22.76	2.88	0.01

Pb (2.02- 480.05), Cd (0.16-1.51) and As (0.05-0.85) µgg^{-1}. Soil Cd and As levels were found within the normal range for the respective metals. Soil Pb levels found at *M.indica (*480.05µgg^{-1}), Zone 2 was above the normal range (Table 2). Cadmium levels recorded in the soils might be due to indiscriminate disposal of polyvinyl plastics, Ni-Cd batteries and motor oil (Jarup, 2003; Ebong et al., 2008). Lead and Cd soil levels observed in the present study were below that recorded at automobile mechanic villages in Ibadan, Nigeria ranging (18.25 - 15100) mg/kg for Pb while Cd was (0.41-17.23) mg/kg (Adelekan and Abegunde, 2011). Studies undertaken at Iree, Osun State, Nigeria revealed higher Pb (2460 ± 16) and Cd (2.02 ±1.01) levels in comparison to the present study (Abidemi, 2011).

The extent of pollution of the soils in the zones by the metals (Table 3) were determined employing the geo-accumulation index (I_{geo}) classification by Forstner et al. (1993) (Table 1). The hazardous metal load in the medicinal plant samples from the zones were found to differ. The highest Pb load recorded was 93.48 µgg^{-1}[*B.sapida* (roots), Zone 3] (Table 7) and the lowest 2.04 µgg^{-1} [*A. indica* (bark), Zone 2] (Table 6).

The highest (3.92 µgg^{-1}) and lowest (0.16 µgg^{-1})Cd levels were recorded in [*C. papaya* (bark), Zone1](Table 5) and [*B. sapida* (roots), Zone 2] (Table 6) respectively. Arsenic load was highest in [*J. curcas* (roots) (1.12) µgg^{-1}, Zone 2] and the lowest in [*A. boonei* (bark), *B. sapida* (bark), *C. papaya* (bark) and *M. oleifera* (bark) (0.01 µgg^{-1}) Zone 1].

Levels of Pb recorded in Zone 1 exceeded the WHO maximum permissible limits (WHO MPL) of 10 µgg^{-1}. With the exception of *B. sapida* (roots) (0.16 µgg^{-1}) Zone 2, all Cd levels in the medicinal plant samples were higher than WHO MPL for Cd of 0.3 µgg^{-1}. Arsenic levels recorded were lower than WHO MPL for As of 1 µgg^{-1} except *J. curcas* (1.12 µgg^{-1}) (roots) and *A. indica* (roots) (1.03 µgg^{-1}) all in Zone 2.

Lead levels found in [*C. papaya* (roots) (14.48), (bark)(24.04) Zone 3; (roots)(19.36) Zone 2 and bark (11.20 µgg^{-1}) Zone 1]; [*A. indica* (bark)(20.04) Zone 1, (roots)(13.60µgg^{-1}) Zone 2]; [*J. curcas* (bark) (12.60) Zone 1, (roots) (32.20 and 19.08µgg^{-1}) Zone 2 and Zone 3 respectively] in the current study was above the previous study [*C.papaya* (0.43 µgg^{-1}) (leaves) , *A. indica* (leaves) (0.36 µgg^{-1}) and *J. curcas* (leaves) (0.20 µgg^{-1})] (Sarpong et al., 2012)**.** Lead is a non-essential toxic metal and a neurotoxin. Sources of Pb contamination might have originated from indiscriminate disposal of Pb-acid battery waste and welding operations. Disposal of spent engine oils rich in hazardous metals content arising from wear and tear of old engines and gear boxes might be accountable for high metal load at the auto-mechanic shop (Nwachukwu et al., 2010).

Table 6. Concentration of Hazardous Metals in µgg^{-1} in Medicinal Plants (Roots and Barks) and Soils from Zone 2.

Medicinal Plants	**Soil**			**Roots**			**Barks**		
	Pb	**Cd**	**As**	**Pb**	**Cd**	**As**	**Pb**	**Cd**	**As**
Jatropha curcas	65.30	0.42	0.35	32.20	3.76	1.12	6.96	0.72	0.05
Magnifera indica	480.05	1.51	0.05	10.20	0.64	0.06	88.92	1.84	0.05
Alstonia boonei	180.88	0.85	0.85	12.16	1.04	0.08	14.48	0.68	0.03
Azadirachta Indica	126.07	0.25	0.05	13.60	2.93	1.03	2.04	0.68	0.03
Blighia sapida	221.62	0.41	0.10	15.80	0.16	0.03	10.08	0.44	0.02
Carica papaya	159.74	0.32	0.05	19.36	1.48	0.05	8.64	2.76	0.98
Moringa oleifera	184.24	0.35	0.35	4.68	2.12	0.10	15.28	1.12	0.6

Table 7. Concentration of Hazardous Metals in µgg^{-1} in Medicinal Plants (Roots and Barks) and Soils from Zone 3.

Medicinal Plants	**Soil**			**Roots**			**Barks**		
	Pb	**Cd**	**As**	**Pb**	**Cd**	**As**	**Pb**	**Cd**	**As**
Jatropha curcas	18.88	0.16	0.10	19.08	2.28	0.95	9.96	2.12	0.46
Magnifera indica	6.85	0.19	0.10	14.48	2.28	0.92	10.72	2.40	0.35
Alstonia boonei	10.31	0.19	0.10	4.00	0.96	0.32	14.56	3.28	0.101
Azadirachta Indica	24.56	0.23	0.35	7.24	1.04	0.41	7.24	1.40	0.11
Blighia sapida	2.02	0.18	0.35	93.48	0.84	0.24	26.92	3.04	0.10
Carica papaya	65.18	0.31	0.10	14.48	0.64	0.20	24.04	1.28	0.04
Moringa oleifera	52.65	0.34	0.35	7.80	1.32	0.47	11.72	1.84	0.30

Table 8. Bioaccumulation Coefficient (BAC) of Medicinal Plant of Selected Metals.

Medicinal Plant	**Pb_{zone1}**	**Cd_{zone1}**	**As_{zone1}**	**Pb_{zone2}**	**Cd_{zone2}**	**As_{zone2}**	**Pb_{zone3}**	**Cd_{zone3}**	**As_{zone3}**
Jatropha curcas	0.70	8.89	0.12	0.11	1.71	0.14	0.53	13.25	4.60
Magnifera indica	0.16	5.33	3.00	0.19	1.22	1.00	1.53	12.63	3.50
Alstonia boonei	0.29	2.76	0.04	0.08	0.80	0.62	1.41	17.26	10.10
Azadirachta Indica	0.10	5.25	0.17	0.02	2.72	0.60	0.30	4.00	0.31
Blighia sapida	0.21	1.41	0.03	0.05	1.07	2.00	13.33	16.89	0.29
Carica papaya	0.58	9.80	0.04	0.05	8.63	19.60	0.37	4.13	0.04
Moringa oleifera	0.64	6.26	0.10	0.84	3.20	0.17	0.22	5.41	0.86

The existence of Cd in the vicinity could be attributed to disposal of metallic Cd employed as anti-corrosion agent and other products of Cd not recycled (Jarup, 2003). Cadmium concentrates in organs such as liver and kidneys.

Table 9. Translocation Factor (TF) of Medicinal Plant of Selected Metals.

Medicinal Plant	Pb_{zone1}	Cd_{zone1}	As_{zone1}	Pb_{zone2}	Cd_{zone2}	As_{zone2}	Pb_{zone3}	Cd_{zone3}	As_{zone3}
Jatropha curcas	2.22	2.86	0.75	0.22	0.19	0.05	0.52	0.93	0.48
Magnifera indica	1.30	1.85	0.60	8.72	2.88	0.83	0.74	1.05	0.38
Alstonia boonei	5.01	1.60	0.33	1.19	0.65	0.38	3.64	3.42	3.16
Azadirachta Indica	2.14	1.33	0.67	0.15	0.23	0.02	1.00	1.35	0.27
Blighia sapida	0.29	0.46	0.33	0.64	2.75	0.67	0.29	3.62	0.42
Carica papaya	2.67	7.00	0.50	0.45	1.87	19.60	1.67	2.00	0.22
Moringa oleifera	0.36	3.27	0.50	3.27	0.53	0.60	1.50	1.39	0.64

Table 10. Bioconcentration Factor (BCF) of Medicinal Plant of Selected Metals.

Medicinal Plant	Pb_{zone1}	Cd_{zone1}	As_{zone1}	Pb_{zone2}	Cd_{zone2}	As_{zone2}	Pb_{zone3}	Cd_{zone3}	As_{zone3}
Jatropha curcas	0.31	3.11	0.16	0.49	8.95	3.20	1.01	14.25	9.50
Magnifera indica	0.12	2.89	0.50	0.02	0.42	1.20	2.11	12.00	9.20
Alstonia boonei	0.06	1.72	0.12	0.07	1.22	0.09	0.39	5.05	3.20
Azadirachta Indica	0.05	3.93	0.26	0.11	11.72	20.60	0.29	4.52	1.17
Blighia sapida	0.15	3.06	0.09	0.07	0.39	0.03	46.28	4.67	0.69
Carica papaya	0.22	1.40	0.08	0.12	4.63	1.00	0.22	2.07	2.00
Moringa oleifera	1.80	1.91	0.20	0.03	6.06	0.29	0.15	3.88	1.34

Research has proved that Cd is a human carcinogen, impairs kidney and cause much ailments (Adams et al., 2011). Plant-animal Bioconcentration factors for cows and sheep are (2.99 - 2.08), (0.554 -1.85) and (3.3×10^{-3} - 2.9×10^{-3}) in kidney, liver and meat respectively (de Vries et al., 2002). Ingestion of products contaminated with Cd may adversely affect the health of humans.The BCF values recorded varied (Table 10). *M. indica* (2.11) and *B. sapida* (46.28) Zone 3 had BCF values greater than 1. The general BCF values in the zones for Pb was Zone 3 > Zone 1 > Zone 2. BCF values for Cd in the studied Zones were greater than 1. *J. curcas* (14.25) Zone 3 and *M. indica* (0.43) Zone 2 recorded the highest and lowest BCF values respectively. The BCF value for Cd in the Zones was in the order: Zone 3 > Zone 2 > Zone 1. Zone 2 registered the highest BCF value in *A. indica* (20.60) while the lowest was in *B. sapida* (0.03)**.** BCF values for Zone 1 was less than 1.BCF for As in Zone 3 was above 1 except *B. sapida* (0.69). BCF content for As in the Zones were: Zone 3 > Zone 2 > Zone 1.

Translocation Factor (TF) of Pb for the medicinal plants samples in the three (3) zones recorded highest value in *M. indica* (8.72), Zone 2 and the lowest *A. indica* (0.15) Zone 2. Range for Zone 1, (0.29 - 5.01), Zone 2 (0.15 - 8.72) and Zone 3 (1.00 - 3.64). The TF for Pb in the samples in the studied zones were Zone 2 > Zone 1 > Zone 3. Maximum (7.00) and minimum (0.19) TF content for Cd were recorded in *C. papaya* and *J. curcas* (Zone 1) .Translocation Factor for Cd, ranged (0.46 - 7.00) Zone 1, (0.19 - 2.75) Zone 2 and (0.93 - 3.62) Zone 3. Translocation Factor amounts for Cd in the zones were Zone 1> Zone 3 > Zone 2. Arsenic TF ranges in the zones were: (0.33 - 0.75) Zone 1, (0.02 - 19.60) Zone 2 and (0.27- 3.16) Zone 3.

The BAC of the analyzed medicinal plants exhibited differences in magnitude (Table 8). BAC values for Pb, Cd and As in Zone 1 ranged: Pb (0.10 - 0.70), Cd (1.41 - 9.80) and As (0.04 - 3.00). BAC for hazardous metals in Zones 2 and 3 were: Pb (0.02 - 0.84), Cd (0.80 - 8.63), As (0.14 - 19.60); and Pb (0.22 - 13.33), Cd (4 - 17.26) and As (0.04 - 10.10) respectively. The maximum and minimum BAC for Pb was recorded in *B. sapida* (13.33) Zone 3 and *A. indica* (0.02) Zone 2 respectively. Highest BAC for Cd was *A. boonei* (17.26) Zone 3 while the lowest was in *A. boonei* (0.80) Zone 2. Highest and lowest BAC for As were recorded in *C. papaya* (19.60) Zone 2 and *A. boonei* (0.04) Zone 1, *C. papaya* (0.04) Zone 3. The analysis revealed that the medicinal plant samples might be considered for application as excluder for Pb (Ma et al., 2001).

Bioconcentration Factor (BCF), BAC and TF are employed as indicators for plant metal translocation from soil to roots, soil to shoots and roots to shoots. Translocation Factor, BCF and BAC magnitude > 1 had been employed to assess the ability of medicinal plant for phyto-extraction and phyto-stabilization (Yoon et al., 2006; Li et al., 2007). High amount of TF (high root to shoot translocation) is an indication of the species tendency to transfer metals and possess needed properties to be utilized in phyto-extraction. Phyto-extraction is the means whereby toxic metals are eliminated from soils and preserving soil structure and fertility (Ghosh and Singh, 2005; La'zaro et al., 2006; Malik et al., 2010). *Alstonei boonei* with TF>1 for all the zones [Zone1 (5.01), Zone 2 (1.87) and Zone 3 (3.64)] had potential for phyto-extraction for Pb polluted soil. *Carica papaya*, TF > 1 for the study zones [Zones 1 (7.00), Zone 2 (1.87) and Zone 3 (2.00)] and *M. indica,* TF>1 for zones [Zone 1 (1.85), Zone 2 (2.88) and Zone 3 (1.05)] for Cd had ability to act as phyto-extraction agent.

Phyto-stabilization is dependent on roots tendency to prevent contaminants motion and bioavailability in the soils. Medicinal plants with high BCF and low TF qualifies to be used for phyto-stabilization of toxic chemicals in soils (La'zaro et al., 2006). High BCF contents imply that a plant keep metals in their roots and restricts metal movement from roots to shoots after absorption by roots (Cui et al., 2007). *Magnifera oleifera* (Zone 1) with BCF (1.80); TF (0.36) and *M. indica* (Zone 3) BCF (46.28); TF (0.74) for Pb may be considered for phyto-stabilization of Pb contaminated soil. Almost all the medicinal plant samples had BCF for Cd > 1 except [*M. indica* (0.42) and *B. sapida* (0.39), Zone 2][Table 10]. As indicated in Table 9 TF values > 1 except [*J. curcas* (0.19), *A. indica* (0.23) and *M. oleifera* (0.53), Zone 2] for Cd was observed. *Jatropha curcas*, *A. indica* and *M. oleifera* had phyto-stabilization properties. Translocation Factor < 1 for all the medicinal plant samples except *C. papaya* (19.60), Zone 2 and *A. boonei* (3.16), Zone 3 (Table 9) for As but BCF values from Table 10 showed values which are inconsistent with properties for phyto-stabilized samples.

CONCLUSION

The present investigation clearly demonstrated variation in hazardous metal concentration at the respective zones soil and medicinal plant parts. Hazardous metal content in some medicinal plants from the zones were found to be above WHO MPL for respective metals (Pb, Cd and As). The Ghanaian people have a great passion for medicinal plants and use them for a wide range of health related applications from common cold to treatment of cancers. However, continuous increase in environmental pollution is leading to build up of pollutants including heavy metals in the plant parts which eventually enter the human food chain. Therefore, regular screening of raw material is a must to check the levels of these pollutants in the plant parts and extracts before consumption.

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