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Full Length Research Paper

Analysis of Toxic Metal Contamination in Selected Medicinal Plants Available in Kumasi, Ghana

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Twenty (20) medicinal plant samples purchased from the Kumasi Central Market, Ashanti Region, Ghana, were studied in order to ascertain the concentration of arsenic, cadmium, lead, and zinc in them. These plant samples are medicinal plants commonly employed in the treatment and management of diseases by the inhabitants. Dry Ashing method of digestion and analysis was adopted from the protocol of Perkin-Elmer manual for atomic absorption spectrophotometry and content of metals per sample was expressed in µg/g. The study revealed that all the samples contained arsenic and zinc. The range of concentration of arsenic in the medicinal plant samples was 0.001µg/g to 0.051µg/g. The highest concentration of arsenic was found in the bark of *P. biglobosa* roots, and the lowest was recorded in the fruits of *X. aethiopica*. The levels of arsenic in the samples were lower than the WHO maximum permissible limits (MPL) of 10 µg/g. Forty percent (40%) of the samples contained trace amounts of lead, while sixty percent (60%) contained lead with concentration ranging from 0.090 µg/g to 6.280 µg/g. These concentrations were higher than the WHO maximum permissible limits (MPL) of 0.01 µg/g. Forty – five percent (45%) of the medicinal plant samples contained trace amounts of cadmium. The remaining fifty-five percent (55%) contained varying concentrations of cadmium ranging from 0.010µg/g to 2.500 µg/g. Three of the samples had cadmium concentrations above the WHO permissible limit (MPL) of 0.300 µ/g. The levels of zinc in the samples ranged from 0.020 µg/g to 32.50 µg/g. The concentration, 0.020 µg/g was in *F. asperifolia* (Leaves) and *A. conyzoides,* and 32.50 µ/g in *Z. Officinale* (Rhizome).Though high, the zinc concentration was lower than the WHO recommended level of 100 µg/g. Although the levels of the hazardous metals were not high, continuous use of these medicinal plants can lead to bioaccumulation, which can be harmful to consumers.

Keywords: Hazardous metals, concentration, medicinal plants

INTRODUCTION

The symbiotic relationship between man and plants has given the world many invaluable benefits. Besides the major contribution as food for mankind, plants are raw materials for products such as essential oils, dyes and medicines (Sofowora, 1996). Medicinal plants have been employed for the treatment of diseases such as headaches, stomachache, *Diabetes mellitus*, hypertension, malaria, and herpes and for the management of HIV-AIDS. According to the World Health Organization (WHO), most of the world's population residing in rural areas depends on medicinal plants for treatment of their ailments (Ayitey-Smith, 1989).

Many people especially the poor and vulnerable rely on medicinal plants because of the high prices of allopathic drugs (Ghana Herbal Pharmacopoeia, 1992). Besides, many believe that medicinal plants are natural and thus safer than allopathic drugs (Ayitey-Smith, 1989). This assertion is not wholly true as there have been a number of reports of people experiencing side effects caused by the use of medicinal plants (Drew, 1997).

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Humans require varying amounts of hazardous metals such as iron, cobalt, copper, manganese, molybdenum and zinc (Young, 2005). For example, copper is essential to the human body because it is a component of many enzyme systems such as cytochrome, oxidase and ceruloplasmin, an iron-oxidizing enzyme in blood. The observation of anaemia associated with copper deficiency may be probably related to its role in facilitating iron absorption and in the incorporation of iron in haemoglobin. Selenium and zinc are essential to maintaining metabolism of the human body. These useful heavy metals can be supplied to the body when medicinal plants containing them are consumed by humans. However, higher levels of hazardous metals accumulated overtime in the body can be damaging to humans (Khan et al. 2008).

Studies have shown the presence of high levels of lead (Pb), cadmium (Cd), chromium (Cr), cobalt (Co), manganese (Mn), copper(Cu) and zinc (Zn) in some medicinal plants samples. The hazardous metal levels were beyond World Health Organization (WHO) permissible limits (Rai, 2005). Several cases of adverse health effects allegedly caused by taking herbal products have been reported in developed countries (The Herald, 2011). These products might have been contaminated with hazardous metals (Drew, 1997). Higher levels of hazardous metals in these medicinal plant samples were probably due to the contaminated sites from which they were obtained. Higher levels of hazardous metals such as lead (Pb) in medicinal plants can have adverse effects on the blood, the central nervous system (CNS), the blood pressure, the kidneys, the reproductive system and vitamin D metabolism (Ling, 2001). Exposure to chromium (Cr) can cause lung cancer, irritation of the lung resulting in asthma, liver and kidney damage (Abbot, 1996). Arsenic (As) impairs cellular respiration by inhibiting mitochondrial enzymes and uncoupling oxidative phosphorylation. Arsenic also acts on the Krebs cycle by blocking pyruvate dehydrogenase (Ling, 2001). It also damages many tissues including nerves (peripheral polyneuropathy, axonal degeneration), stomach and intestines, and skin (Ling, 2001). When cadmium (Cd) enters the body, it severely irritates the stomach, leading to vomiting and diarrhea. Cadmium can also cause severe lung damage leading to death. Acute toxicity of zinc may cause throat dryness, cough, general weakness, fever, nausea, anaemia and pancreas damage.

Interactions with the sellers of medicinal plants at Kumasi Central Market indicated that most medicinal plants being sold had been brought in by ‘middlemen’, traders who did not actually know the sites from where these medicinal plants were harvested. Medicinal plants harvested from mine sites and farmlands where agrochemicals have been used continuously could become contaminated with high levels of hazardous metals. Arsenic compounds applied to prevent wood rot could also leach out to contaminate the soil. Medicinal plants can absorb hazardous metals from surrounding soils or directly through the leaves. These hazardous metals taken up by the plants are accumulated in their tissues (Truby, 2003). For example, Lerger Werf (1967) noted that zinc containing aerosol particles settle with dust and precipitate. Deposited on vegetation or soils, zinc enters the food chain uptake through the roots or foliar absorption.

Contaminated raw materials could lead to unwholesome herbal products which can adversely affect the health of consumers. Even though some studies on phytochemical and bioactivity in medicinal plants have been done in Ghana, very little or limited work has been done on hazardous metal contents of many medicinal plants (Annan *et al*, 2010).

This work was carried out to ascertain the levels of hazardous metals such as lead (Pb), zinc (Zn), copper (Cu) and cadmium (Cd) in twenty (20) selected medicinal plant samples sold at the Kumasi Central Market, Ashanti Region, Ghana.

MATERIALS AND METHODS

Study Area

Kumasi (6^{o}35’N-40’N, 1 ^{o}30’W) is the capital town of Ashanti Region of Ghana and is located 250-300m above sea level. It is the second most populous city after the nation’s capital, Accra. It is estimated to have a population of two million, twenty-two thousand nine hundred and nineteen (2,022,919) and covers an area of two hundred and fifty-four square kilometers (254 km^2). Because of its relatively central location in the country, people from other regions of the country trade there. The products traded include medicinal plants, foodstuffs and many others.

Collection and Preparation of Medicinal Plants Samples

Twenty (20) medicinal plant samples were purchased from the Kumasi Central Market, Ashanti Region. The medicinal plants are as listed in Table 1. Specimen vouchers have been kept at University of Education, Winneba, College of Agriculture Education, in Asante-Mampong.

The medicinal plant samples were washed thoroughly with distilled water to remove any soil contaminants, dried at room temperature and later oven-dried at a temperature of 40^{0}C for forty-eight (48) hours. They were

Table 1. Medicinal Plants Selected for the Study

Medicinal Plants	Ethno-medical uses	Family	Part collected
Xylopia aethiopica	Malaria, hemorrhoids	Annonaceae	Fruits
Tetrapleura tetraptera	Diabetes	Leguminosae-Mimosoideae	Fruits
Allium sativum	Fevers, worms, diabetes	Amaryllidaceae	Bulb
Parkia biglobosa	Constipation	Leguminosae-Mimosoideae	Bark
Zingiber officinale	Coughs, boils, vomiting	Zingiberaceae	Rhizome
Garcinia kola	Mastitis	Guttiferae	Bark
Parkia biglobosa	Constipation,	Leguminosae-Mimosoideae	Root
Moringa oleifera	Gonorrhoea	Moringaceae	Leaves
Ananas comusus	Venereal disease	Bromeliaceous	Fruits
Jatropha curcas	Wound, fever, jaundice	Euphorbiaceae	Leaves
Asimina triloba	Malaria	Annonaceae	Leaves
Alstonia congensis	Malaria, gonorrhea	Apocynaceae	Bark
Azadirachta indica	Fever ,chicken pox	Meliaceae	Leaves
Psidium guajava	Sore throat, analgesic	Myrtaceae	Leaves
Carica papaya	Amoebiasis, jaundice	Caricaceae	Leaves
Khaya senegalensis	Malaria	Meliaceae	Bark
Sida acuta	Diabetes, abdominal pain	Melvaceae	Leaves
Ceiba pentandera	Headache, asthma	Bombacaceae	Bark
Ficus asperifolia	Headache	Moraceae	Leaves
Ageratum conyzoides	Dysentery, intestinal worm	Asteraceae	Leaves

pulverized, using roller miller, and their weights noted.

Digestion and Analysis of Medicinal Plants Samples

The medicinal plants samples were sent to Council for Scientific and Industrial Research –Soil Research Institute (CSIR-SRI) at Kwadaso, Kumasi, for digestion and analysis. 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 and putting it into a crucible made of porcelain. The contents of the 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 20ml of concentrated nitric (HNO_3) and perchloric ($HClO_4$) acids in a ratio of 9:4 in a 200ml 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 20ml.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 AA220 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.

RESULTS AND DISCUSSION

The concentrations of the hazardous metals (lead, cadmium , zinc and arsenic) in selected medicinal plants are as indicated in Table 2.

Lead

Forty percent (40%) of the twenty selected medicinal plant samples analyzed contained trace amounts of lead (Pb).The highest amount of lead was recorded in *A. Comusus* (fruits) with a value of 6.280 µg/g while the lowest concentration of 0.090 µg/g was in *F. asperifolia* (leaves) and *S. acuta* (leaves) as indicated by Table 2 above. The concentrations of lead in the selected samples were in the descending order:
A. comusus (fruits), 6.280 µg/g > *C. pentandera* (bark), 4.000 µg/g > *K. senega lensis* (bark), 0.490 µg/g > *P.guajava* (leaves), 0.450µg/g > *C. papaya,* 0.430 µg/g > *A. indica* (leaves), 0.360 µg/g > *A.* congensis (bark), 0.300 µg/g > *J. curcas* (leaves), 0.200 µg/g > *A. conyzoides* (leaves), 0.180 µg/g and *F. asperifolia* and *S.*

Table 2. Concentration of Hazardous Metals in µg/g of Selected Twenty (20) Medicinal Plant Samples

Medicinal Plants	Lead (Pb)	Cadmium (Cd)	Zinc (Zn)	Arsenic (As)
*Xylopia aethiopica (*Fruits)	Trace	Trace	17.750	0.001
*Tetrapleura tetraptera (*Fruits)	-	-	9.750	0.004
Allium sativum (Bulb)	-	-	15.500	0.003
Parkia biglobosa (Bark)	-	-	17.000	0.011
Zingiber officinale (Rhizome)	-	-	32.500	0.021
Garcinia kola (Bark)	-	2.500	2.550	0.002
Parkia biglobosa (Root)	-	Trace	2.500	0.051
Moringa oleifera (Leaves)	-	Trace	2.750	0.003
Ananas comusus (Fruits)	6.280	0.350	6.300	0.005
Jatropha curcas (Leaves)	0.200	0.020	6.660	0.006
Asimina triloba (Leaves)	0.270	Trace	7.300	0.003
Alstonia congensis (Bark)	0.300	Trace	3.360	0.004
Azadirachta indica (Leaves)	0.360	0.010	1.600	0.004
Psidium guajava (Leaves)	0.450	0.250	1.500	0.005
Carica papaya (Leaves)	0.430	0.020	3.900	0.007
Khaya senegalensis (Bark)	0.490	0.150	5.670	0.003
Sida acuta (Leaves)	0.090	0.020	0.020	0.010
Ceiba pentandera (Bark)	4.000	0.400	0.560	0.005
Ficus asperifolia(Leaves)	0.090	0.010	0.020	0.020
Ageratum conyzoides (Leaves)	0.180	0.020	0.020	0.011

acuta,0.090 µg/g.

Abou Arab and Abou Donia (2000) and Sumayya et al. (2010) recorded mean lead (Pb) levels of 14.4 and 1.30 µg/g respectively in some commonly used medicinal plants. The mean levels of lead (Pb) recorded by Abou Arab and Abou Donia were higher than the highest mean value of 6.28 µg/g recorded in the present study. On the other hand the mean lead (Pb) levels recorded by Sumayya et al. were lower than those recorded in this study. However, in the case of Khan et al.(2008) levels of lead (Pb) in the medicinal plants studied were below the detection limit of the AAS instrument used.

All the medicinal plant samples showed levels lower than the World Health Organization (WHO) maximum permissible limits (MPL) of 10 µg/g. The presence of lead in the samples indicated the general availability of the metal in the environment. According to Chow (1996), the combustion by motor vehicles of lead tetra alkyl derivatives in gasoline has resulted in massive contamination near roadways. The transport and distribution of lead from fixed, mobile and natural sources are primarily via the air, and most lead emissions are deposited near the source, although some particulate matter might be carried over long distances, thousands of kilometers. Lead is a non-essential trace element which does not have any function in humans' body or in plants. Studies have shown that it induces various toxic effects in humans even at low doses. The typical symptoms of lead poisoning are colic, anaemia, headache, convulsions and chronic nephritis of the kidneys, brain damage and central nervous system disorders (Connel, 1994). Products from such medicinal plants, consumed over a period of time, could build up and become harmful to humans.

Cadmium

Fifty percent (50%) of the medicinal plants analyzed contained cadmium (see table 2). These were *G. kola* (bark), 2.500 µg/g; *A. comusus* (fruits), 0.350 µg/g; *J. curcas* (leaves), 0.020 µg/g; *A. indica* (leaves), 0.010 µg/g; *P. guajava* (leaves), 0.250 µg/g; *C. papaya* (leaves), 0.020 µg/g; *K. senegalensis* (bark), 0.150 µg/g; *S. acuta* (leaves), 0.020 µg/g*; C. pentandera* (bark), 0.400 µg/g; *F. asperifolia* (leaves), 0.010 µg/g and *A. conyzoides* leaves), 0.020 µg/g.

X. aethiopica (fruits), *T. tetraptera* (fruits), *A. sativum* (bulb), *P. biglobosa* (bark), *P. biglobosa* (root), *M. oleifera* (leaves), *Z. officinale* (rhizome), *A. triloba* (leaves) and *A. congensis* (bark) contained trace amounts. Twenty percent (20%) of the medicinal plant samples analyzed contained cadmium levels greater than maximum permissible levels (MPL) of 0.3µg/g (WHO, 2004).

The highest mean level of 12.06 µg/g for cadmium (Cd) recorded by Sumayya et al. (2010) far exceeded the highest mean value of 2.5 µg/g recorded in this study. The mean cadmium level of 2.44 µg/g recorded by Abou Arab and Abou Donia (2000) was similar to that recorded in the current study. The present study however indicated a lower cadmium (Cd) level to that reported by Annan et al. (2010) which was in the range 22.5 – 59.0 µg/g.

Cadmium may be taken up and accumulate in the leafy tissue of plants. Subsequent ingestion of those plants by humans and animals may then result in accumulation in the liver and kidneys, which can result in kidney damage (Taylor, 1997). Cadmium strongly adsorbs to organic matter, soil and reduces its availability to the medicinal plants. The low cadmium values might be due to its strong adsorption to organic matter making it less available to the plants (Shannon, 1998).

Zinc

Zinc concentrations in the twenty (20) medicinal plant samples analyzed exhibited the highest degree of variability as compared to all the other metals assayed and concentration ranged from 0.020 µg/g to 32.500 µg/g. The highest concentration was in *Z. officinale* (rhizome), 32.500 µg/g while the lowest was in *S. acuta* (leaves), *F. asperifolia* (leaves) and *A. conyzoides* (leaves) with a concentration of 0.020 µg/g (leaves) each.

Sumayya et al. recorded Zinc (Zn) levels in the range of 17.54 – 77.15 µg/g which were higher than the 0.02 – 32.5 µg/g recorded in this study. The highest mean value of 68.80 µg/g recorded by Abou Arab and Abou Donia (2000) also exceeded the highest mean value of 32.5 µg/g recorded for the current study. Studies by Annan et al. (2010) and Khan et al. showed levels of Zinc (Zn) within the ranges of 43.5 – 495.0 µg/g and 17.34 and 47.18 µg/g respectively.

Though the contents of zinc were high, they were lower than the World Health Organization (WHO) maximum permissible limits (MPL) of 100 µg/g. Zinc is an essential trace element for plant growth and also plays an important role in various cell processes including normal growth, brain development and wound healing (Khan *et al*. 2008). The contamination might be due to the fact that the samples were collected from sites where agrochemicals such as herbicides, phosphates fertilizers and animal feed had been employed.

Arsenic

Arsenic is mostly found in industrial effluents, as impurity in some detergents, wood preservatives, pharmaceutical products, herbicides and pesticides (Glass, 2003). The fact that the medicinal plants contained amounts of arsenic indicated that they might have been exposed. Possibly they might have been collected from sites which had been contaminated with arsenic. It was observed that the concentration of arsenic in *P. biglobosa* (root), 0.051µg/g was higher than that of the stem. The concentration of arsenic in all the medicinal plants analyzed were below 10µg/g, the maximum permissible limit (MPL) of the World Health Organization (WHO).

CONCLUSION

The selected medicinal plants are employed locally for the treatment and management of many diseases and as food supplements, example, *M. oleifera*. They are also used to manufacture other herbal products. However, little have been done to ascertain the concentration of hazardous metals in some of these medicinal plants. The present study was an effort in doing so. There were variations in the hazardous metal levels in the medicinal plants. The highest concentration of lead was in *A. comusus* (fruits), 6.280 µg/g and that of cadmium was 2.5 µg/g in *G.kola* (bark). *Z. officinale* (rhizome), 32.500µg/g and *P. biglobosa* (root), 0.051 µg/g, contained the highest amounts of zinc and arsenic respectively. Some selected medicinal plants such as *X. aethiopica, T. tetraptera (*Fruits) *A. sativum* (Bulb) , *P. biglobosa (*Stem bark), *Z. officinale* (Rhizome), *G. kola (Bark), P. biglobosa (Root) and M. oleifera (Leaves)* contained traces of lead. *X. aethiopica, T. tetraptera (*fruits) *A. sativum (Bulb), P. biglobosa (*Bark), *Z. officinale* (Rhizome) also contained trace amounts of cadmium. Though the contents of hazardous metals in the selected medicinal plants were below the WHO maximum permissible limits (MPL) except that of lead in *A. comusus*, 6.2 µg/g; continuous use of these selected medicinal plants can lead to bioaccumulation which can be harmful to consumers.

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