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Heavy Metal Contamination of Herbal Drugs: Implication for Human Health-A Review

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Authors' contributions

This work was carried out in collaboration between all authors. Author CAE initiated and designed the study. All authors participated in the literature searches, wrote, read and approved the final manuscript.

Review Article

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ABSTRACT

Interest in the use of medicinal plants in treatment of diseases in Africa has increased tremendously over the past decade. Ingestion of contaminated medicinal plants and herbal medicinal products is regarded as potential source of heavy metal toxicity to both man and animals. Heavy metals are often not well defined in medicine, but include all toxic metals. They are released into the environment by both natural and a variety of anthropogenic sources. The presence of heavy metals in plant tissues is primarily dependent upon their availability and concentration in the soil. They can also be deposited directly on plant surfaces from the atmosphere. Heavy metals are persistent in nature due to their long biological half-life. The major heavy metals of health concern are arsenic, cadmium, lead and mercury. They are the redox inactive metals and show their toxic effects via bonding to sulphydryl groups of proteins and depletion of glutathione - an antioxidant. In order to ensure quality and safety of herbal drugs, cultivation and collection of medicinal plants in the immediate vicinity of industrial sites which utilize these metals and their compounds, and sites where these metals have been improperly disposed is highly discouraged; because plants from these areas are prone to high concentration of heavy metals, hence, increases human risk of contamination when taken. In addition,

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screening of plant extracts, herbal medicinal products and medicinal plants at large, for heavy metal contamination is of highly medical importance and must be given maximum attention in phytotherapy.

Keywords: *Heavy metal poisoning; herbal drug contaminants; herbal medicine; human health hazards; medicinal plants contamination; plant accumulation of heavy metals.*

1. INTRODUCTION

There is no clear definition of what a heavy metal is, density is in most cases taken to be the defining factor; heavy metals are thus commonly defined as those having a specific density of more than $5g/cm^3$ [1-3]. In medicine, heavy metals are often not well defined and include all toxic metals (including lighter ones); "heavy metal poisoning" can possibly include excessive amounts of iron, manganese, aluminum, mercury, or beryllium (the fourth lightest element) or such a semimetal as arsenic [4]. Furthermore, this definition excludes bismuth, the heaviest of approximately stable elements, because of its low toxicity. Heavy metals are among the most important sorts of contaminant in the environment [5]. They are released into the environment by both natural and anthropogenic sources [6]. Some metals are redox active, that is, they undergo redox cycling reactions whilst others are redox inactive. Metal concentrations in soil range from less than 1mg/kg(ppm) to high as 100,000mg/kg, whether due to the geological origin of the soil or as a result of human activity [7,8]. Medicinal plants can be contaminated by heavy metals via roots uptake or by direct deposition of contaminants from the atmosphere onto plant surfaces [9].

The adverse health effects of several chemical elements have been documented throughout history: Greeks and Roman physicians were able to recognize symptoms of acute lead and arsenic poisoning long before toxicology became a science [10]. Exposure to metals has risen dramatically in the last fifty years as a result of an exponential increase in the use of heavy metals in industrial processes and products [11]. In the last decade, the desire for food safety and security has stimulated research on the danger associated with the consumption of food contaminated with heavy metal and toxins [12].

In the developing countries, heavy metal pollution becomes serious due to mining, mineral, smelting and tannery industry [13]. The heavy metals pollution is one of the problems that arise due to the increased uses of fertilizers and other chemicals to meet the higher demands of food production for human consumption [10]. Moreover, contamination of heavy metals represents one of the most pressing threats to water and soil resources as well as human health [14]. Transition metals cause oxidative injury in plant tissue [15]. Toxicity of phytochemicals, plant-based extracts and dietary supplements, and medicinal plants in general, is of medical importance and must be considered in phytotherapy and other plant uses [16]. Take, for instance, there is increasing evidence that the permanent exposure of human beings to small doses of substances such as aluminum, cadmium, mercury or lead could be one of the co-determinants of certain neurological, cardiovascular or autoimmune illnesses [11]. There are three main mechanisms that have been proposed to account for heavy metal contamination in medical herbal products; contamination during cultivation [17,18], accidental cross contamination occurring during processing and/or the deliberate introduction of heavy metals as a therapeutic ingredient [13].

In the world over, the presence of heavy metals continues to generate a lot of concern to environmentalists, government agencies and health practitioners in the environment; which is due to the health implications of their presence since they are non-essential metals that are not required for any function either by plants or animals [19]. Intake of heavy metals through the food chain by human populations has been widely reported throughout the world [20,21]. Due to the non-biodegradable and persistent nature, heavy metals are accumulated in vital organs in the human body such as the kidneys, bones and liver and are associated with numerous serious health disorders [21,22]. Although heavy metals are considered as the oldest known toxins harmful to humans, heavy metal toxicity remains a very general subject due to the variety of symptoms caused by heavy metal poisoning [23]. Heavy metal pollution of the environment has become a growing ecological crisis and concern and therefore the subject of many research [12,24,25]. Medicinal plants have been cited as a potential source of heavy metal toxicity to both man and animals [18,26]. Therefore, the world health organization recommends that medicinal plants, which form the raw materials for most herbal remedies, should be checked for the presence of heavy metals [18]. In addition, it becomes necessary to improve quality standards for herbal medicines by examining and revising the maximum allowable values of heavy metals in medicinal plants, using research based on medicinal plants [13,27]. Medicinal herbs can present health risks due to toxic metal content and there is possibility that some people might be ignorant of this. Thus, it is absolutely necessary to sensitive medicinal plant growers and harvesters, food and pharmaceutical industries, herbal drug administrators, final consumers and public in general, on the risk of heavy metal contamination; in order to improve the quality, safety, and efficacy of herbal drugs. The objective of this study, therefore, was to ascertain the source, availability and health implication of heavy metals in medicinal plants and herbal drugs, which has over the past decade become predominant in the treatment of diseases in Africa; thereby creating the awareness and thus, the need to screen plant materials for heavy metal contamination.

2. SOURCES OF CONTAMINATION

Heavy metal pollution is released into the environment by various anthropogenic activities, such as industrial manufacturing processes, domestic refuse and waste materials [28]. Mining, smelting, and the associated activities are one of important sources by which soils, plants, and surface waters are contaminated [6]. Heavy metal contamination and acid mine drainage are very important concerns where waste materials containing metal rich sulphides from mining activity have been stored or abandoned [29-31]. Human activities all over the earth have increased environmental pollution by heavy metals in agricultural soil [13]. Cadmium emissions have increased dramatically during the 20th century, one reason being that cadmium-containing products are rarely re-cycled, but often dumped together with household waste [2]. At high concentrations, all heavy metals have strong toxic effects and are regarded as environmental pollutants [32,33]. Excess concentrations of heavy metals in soils have caused the disruption of natural terrestrial ecosystems [28,34,35]. The main source of heavy metal exposure to human adult in Nigeria are: food, accounting for over 60% of blood levels, air inhalation, accounting for approximately 30% and water, 10% [19,36].

3. FACTORS INFLUENCING THE BIOAVAILABILITY OF METALS IN THE SOIL AND THEIR OCCURRENCES IN PLANTS

The plant uptake of heavy metals is dependent upon a number of factors. These include: physical processes such as root intrusion, water, and ion fluxes and their relationship to the kinetics of metal solubilization in soils; biological parameters, including kinetics of membrane transport, ion interactions, and metabolic fate of absorbed ions, the ability of plants to adapt metabolically to changing metal stresses in the environment [37], soil acidity (pH), organic matter content, soil texture and interaction among the target elements [6,38]; the higher the acidity, the more soluble and mobile the metals become, and the more likely they are to be taken up and accumulated in plants [38]. The mobility and availability of heavy metals in the soil are generally low, especially when the soil is high in pH, clay and organic matter [14,39,40]. The accumulation of heavy metals in medicinal plants have also been reported to depend on climatic factors, plant species, air pollution and other environmental factors [41,42]. In addition, deficiencies in the plant (like a low level of zinc) can also influence a plant's likelihood to accumulate metals [6].

4. TRANSFER OF HEAVY METALS FROM SOIL TO PLANTS

The bioavailability of metals in soil is a dynamic process that depends on specific combinations of chemical, biological, and environmental parameters [28,43-45]. The heavy metals accumulation in plants highly depends on the availability in the soil [18,46]. The greater the amount of heavy metals in the soil the increased chance of the metal to accumulate in plant tissues [9,47]. Heavy metals are generally not removed even after the treatment of wastewater at sewage treatment plants, and thus cause risk of heavy metal contamination of the soil, interfere with the plant roots and subsequently to the food chain when eaten by animals or humans [21,31,48].

Plants absorb metals from soil and they predominantly accumulate in the roots, then some portions are transferred to other parts of the plant [49]. Plants can immobilize heavy metals through absorption and accumulation by roots, adsorption onto roots, or precipitation within rhizosphere [14]. A convenient way for quantifying the relative differences of bioavailability of metals to plants is the transfer quotient [10]. Therefore, soil-to-plant transfer quotient is the main source of human exposure and follows a pattern that root>leaf>shoot (stem)>fruit; and lateral root>main root, old leaf>young leaf [49-51]. Metal concentrations in leaves are usually much higher than those in grain [6]. Take, for instance, in compound pollution of As, Cd, Cu, Pb and Zn, the contents of heavy metals in roots were 55-61% of the total in paddy plants [49,52,53].

5. EFFECTS OF HEAVY METALS ON PLANTS

Heavy metals are persistent in nature, therefore get accumulated in soils and plants [54].Exposure of plants to non redox reactive metals result in oxidative stress as in indicated by lipid peroxidation, H_2O_2 accumulation and an oxidative burst [15]. Heavy metals interfere with physiological activities of plants such as photosynthesis, chlorosis, gaseous exchange and nutrient absorption, reductions in plant growth, dry matter accumulation and yield, disorders in plant metabolism and, in leguminous plants, a reduced ability to fixate molecular nitrogen [54-58]. Doses of 1000ppm and 2000ppm of lead, copper, cadmium and vanadium impaired the chloroplast content of *Barbula lambarenensis* thereby resulted in reduced chlorophyll content as the bright green colours changed to light green, yellow and brown [59].

Generally, plants show signs of stress when they accumulate high level of heavy metals. Thus, stressed plants may be a sign of metal contamination [38]. In addition, it is advised to look for unusual changes in the colouring or growth pattern of plants as an indicator of a stressful growth environment (like drought) combined with high metals concentrations in the soil. These kinds of conditions make it more likely that the plants are bioaccumulating (or uptaking) metals. In heavy-metal-polluted soils, plant growth can be inhibited by metal absorption [28]. Root crops (like potatoes and carrots), leafy vegetables (like spinach and lettuce), and parts of plants that grow near the soil (like strawberries) are a higher risk for exposure to metal contamination than the higher portions of plants, like fruits or berries [38]. Heavy metals were reported toxic to the growth of maize by causing noticeable and gradual stunted growth on the shoots of the plants [60]. The dry weights of shoot and root of the maize plant, respectively, were reduced 63.4 and 70.5% by Cd; 58.5 and 55.8% by Co; 51.2 and 46.1% by Hg; 26.3 and 29.1% by Pb; 31.7 and 39.7% by Mn; 17.0 and 13.8% by Cr at 0.5× concentration. In addition, the treatment of the maize plants with Mn, Pb, Cd, Cr and Co lead to reduction in the seed yield.

However, some plant species are able to accumulate fairly large amounts of heavy metals without showing stress, which represents a potential risk for animals and humans [28][61].These plants that easily absorb high levels of metals from the surrounding soil are called hyperaccumulators [38]. Take, for instance, dose of 5-ppm of Cd(II), Cr(VI), Cu(II), Ni(II), and Zn(II) has been reported to promote the root growth of alfalfa plants (*Medicago sativa*) by 22.0%, 166.0%, 156.0%, 63.0%, and 105.0% respectively [8]. In addition, a dose of 5ppm of Cr(VI), Cu(II), Ni(II), and Zn(II) increased the shoot length in 14.0%, 60.0%, 36.0%, and 7.7%, respectively.

6. HEALTH EFFECTS OF ACCUMULATION OF HEAVY METALS IN HUMANS

Metal-mediated formation of free radicals causes various modifications to DNA bases, enhanced lipid peroxidation, and alter calcium and sulphydryl homeostasis [62]. Moreover, lipid peroxides, formed by the attack of radicals on polyunsaturated fatty acid residues of phospholipids, can further react with redox metals finally producing mutagenic and carcinogenic malondialdehyde, 4-hydroxynonenal and other exocyclic DNA adducts (etheno and /or propane adducts). The redox active ones such as iron, copper, chromium, vanadium and cobalt possess the ability to produce reactive radicals such as superoxide anion radical and nitric oxide in biological systems, whereas the redox inactive ones such as arsenic, cadmium, lead, mercury, nickel show their toxic effects via bonding to sulphydryl groups of proteins and depletion of glutathione [62,63]. Despite many years of research we are still far away from effective treatment against toxicity caused due to exposure to heavy metals/metalloids [64].

Dietary intake of many heavy metals through consumption of plants has long term detrimental effects on human health [54]. Heavy metal-polluted food can severely reduce some vital nutrients in the body that are accountable for declining immunological defenses, growth delay, reduced psychosocial abilities, incapacities related with malnutrition and greater occurrence of upper gastrointestinal cancer degrees [31,65-67]. In addition to their roles in health and disease, dietary metal ions have been the focus of discussions on the mechanism of ageing [65]. Redox active metal ions such as Cu (I)/(II) and Fe(II)/(III) are especially implicated in the free radical theory of ageing as they are credited with enhancing oxidative stress [68,69]. Contaminants possessing very long half-lives can be accumulated in the body and chronic effects are most often observed when critical concentrations are reached in target tissues [69]. In addition, it was reported that in biological fluids and tissues, most metals and metalloids are not present as free cations; in blood they are usually bound to red cells or to plasma proteins; lead and cadmium are almost completely bound to red blood cells; the chemical elements bound to plasma proteins constitute the fraction available for transport into and out of the tissues; albumin, a plasma protein, has a great capacity to bind several metals and some metals binds with proteins having a specific transport function such as transferring or ceruloplasmin.

The four major heavy metals of health concern are arsenic, cadmium, mercury and lead [2][4][38].They are biologically non essential and toxic [70,71]. The permissible limits for arsenic, cadmium, lead and mercury in herbal medicines and products are 10.0(μg/g), 0.3(μg/g), 10.0(μg/g) and 0.1(μg/g) respectively [72-74]. In addition, the toxic limits of arsenic, cadmium, lead and zinc were presented in (Table 1). Available literatures have shown that there is current concern in these heavy metals, probably because they are regarded as human carcinogens. The unifying factor in determining toxicity and carcinogenicity for arsenic, cadmium, lead and mercury is the generation of reactive oxygen and nitrogen species [64]. Moreover, they have high affinity for thiol groups containing enzymes and proteins, which are responsible for normal cellular defense. This indicated that consumption of plant materials and/or herbal drugs that contained these heavy metals, above the safe intake doses would most likely intoxicate and thus, be detrimental to human health. However, even when not in high concentration, they tend to accumulate in the body over time due to their non-biodegradable and persistent nature which will eventually be detrimental to health.

Heavy metal uptake by crops growing in contaminated soil is a potential hazard to human health because of transmission in the food chain [28,75-77]. Arsenic, cadmium, copper, iron, lead, manganese, selenium and zinc were reported present in some herbal medicines in varied levels (Tables 2, 3, 4 and 5). Some were within permissible levels whereas some were not. Some of the herbal products that were above permissible limits are believed to be currently sold in the market, thus, there is need to strongly advice people to desist from taking these herbal formulations. Heavy metals accumulate in vital organs and glands in the human body such as the brains, kidneys, bones and liver and are associated with numerous serious health disorders, due to the non-biodegradable and persistent nature [21,22,78]. Moreover, although these metals are known to produce their toxic effects on a variety of body systems, much emphasis has been placed on their effects on the nervous system owing to apparent association of relatively low or "subclinical" levels of metallic exposure with behavioural and psychological disorders [79].

Accumulation of cadmium in human bodies creates the problems like cardiovascular, kidney, nervous and bone diseases [10,19]. Ingesting very high levels severely irritates the stomach, leading to vomiting and diarrhoea; whereas long-term exposure to lower levels leads to a buildup in the kidneys and possible kidney disease, obstructive lung disease and has been likened to lung cancer, and fragile bones, osteomalaria, osteoporosis in humans and animals [19,36,38]. Lead is considered a potential carcinogen and is associated with pathology of many diseases which includes cardiovascular, kidney, blood, nervous, and bone diseases [2,80]. Lead can affect every organ and system in the body [38]. Clinical and animal data on environmental exposure show that while lead and manganese are most toxic to the nervous system, cadmium exerts profound adverse effects on kidney and the male reproductive system [79]. Except for a few reports, hyperactivity has indeed been observed in animals exposed to any of the three metals: lead, cadmium and manganese. In a research conducted by [18], lead (Pb) was reported to be present in all plant species examined, except *Ocimum gratissimum*; one plant exceeded the maximum safety limit for lead. In addition, cadmium was also detected in some of the medicinal plant species (44%) whilst majority were below the detection limit (0.002) representing 56%; 40% of the plant species exceeded the limit for cadmium [18]. Mercury and arsenic in all the plant species were below the detection limit. Mercury is a neurodevelopment poison; it can cause problems in neuronal cell migration and division, and can ultimately cause cell degeneration and death [4]. This indicated that there is always a possibility of heavy metal content in medicinal plants, though some may still be below detection limit; which might accumulate over time thereby making the plant material detrimental to human health when taken as drugs. Natural arsenic contamination is a cause for concern in many countries of the world including Argentina, Bangladesh, Chile, China, India, Mexico, Thailand and the United States of America [4,81]. Arsenic undergoes transformation in the body from the pentavalent ($As5+$), less toxic form, which is well absorbed, to the trivalent ($As3+$), more toxic form [4,82]. Consequently, arsenicosis is the effect of arsenic poisoning, usually over a long period such as from 5 to 20 years [4]. Lower level exposure to arsenic can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of “pins and needles” in hands and feet; whereas long-term low level exposure can cause a darkening of the skin and the appearance of small “corns” or “warts” on the palms, soles, and torso [38]. In addition, arsenic has been reported to be associated with hypertension; serious impacts on the cardiovascular system; and even hepatic damage at high doses [83,84]; suppressive effect on spermatogenesis and gonadotrophin and testosterone release in rats [85]; and there is correlation between arsenic exposure and diabetes mellitus (type II) [69,86]. Ingestion of very high levels can possibly result in death [38]. Excess amount of selenium is found as pro-oxidant and can be toxic for all animal species and man depending on the dose and duration of intake [69].Short term exposure of barium can cause vomiting, abdominal cramps, diarrhoea, difficulties in breathing, increased or decreased blood pressure, numbness around the face, and muscle weakness whereas large amounts of barium intake can cause, high blood pressure, changes in heart rhythm or paralysis and possibly death [38].

Table 1. Toxic limit and recommended/safe intake of heavy metal

Heavy metal	Toxic limit	Recommended intake/safe intake
Arsenic	3mg/day for 2-3 weeks	15-25µg/day(adults)
Cadmium	200µg/kg of fresh weight	15-50µg/day adults 2-25µg/day children
Lead	$\geq$500µg/L (Blood)	20-280µg/day adults 10-275µg/day children
Zinc	150µg/day	15µg/day

Source:[3]

Table 2. Distribution levels (Mg/l),±SD, n=3) of heavy trace metal contents in the analysed herbal plants

Herbal Plants	Zinc (Zn)	Lead (Pd)	Copper (Cu)	Manganese (Mn)	Iron (Fe)
Bateri diver	36.75±0.20	15.21±0.01	102.20±0.01	33.75±0.01	0.33±0 .02
Belinia confusa (stem)	28.75±0.01	0.15±0.01	35.50±0.90	80.90±0.04	0.35±0. 03
B. confusa (root)	47.5±0.01	10.09±0.02	85.40±0.05	27.50±0.03	0.20±0.0 1
B. grandiflora	2.25±0.03	5.03±0.01	46.30±0.01	17.12±0.03	0.36±0.0 1
Kigelia africana	36.25±0.01	11.23±0.01	175±0.06	72.30±0.06	0.30±0.02
Malantha alnifolia	4.03±0.01	5.21±0.02	208.1±0.08	23.10±0.02	0.25±0. 02
Dracaena fragrans	45.00±0.01	13.14±0.01	112.20±0.02	12.30±0.01	0.36±0 .01
Altanenthera pungens	3.25±0.01	24.4±0.01	132.20±0.12	39.30±0.05	0.28±0 .01

Source: [42]

Table 3. Mean heavy metal concentration (mg kg-1) DW of raw medicinal plant material, (n=5,±SD)

Sample ID	Pb±SD	Zn±SD	Fe±SD	Ni±SD	Cu±SD	As±SD
Combretum imberbe leaves	0.56±0.05*	0.30±0.01	1.42±0.09	0.01±0.00	24±0.00	0. 04±0.00
C. imberbe stems	0.45±0.02	0.30±0.00	1.41±0.02	0.01±0.00	0.20±0.00	0 .01±0.00
C. imberbe roots	0.23±0.01	0.25±0.01	1.42±0.01	0.02±0.00	0.20±0.03	0 .02±0.00
Ocimum americanum leaves	0.37±0.07	1.30±0.00	33.61±0.07	0.14±0.03	0.17±0.06	0.06±0.00
O. americanum stems	0.32±0.09	1.30±0.02	30.84±0.02	0.10±0.03	0.16±0.04	0.03±0.00
Uapaca kirkiana bark	19.01±0.01	0.61±0.08	12.25±0.01	0.12±0.03	0.39±0.00	0.32±0.00
U. kirkiana roots	19.01±0.05	0.46±0.00	12.11±0.00	0.09±0.01	0.32±0.00	0.32±0.02
Pseudolachnostylis aprouneifolia bark	19.01±0.05	0.33±0.01	2.10±0.03	0.06±0.00	0.22±0.05	0.46±0.02
Lannea discolor leaves	0.60±0.05	0.83±0.09	4.65±0.06	0.05±0.00	0.19±0.00	0 .12±0.01
L. discolor roots	0.55±0.00*	0.73±0.01	3.44±0.01	0.01±0.00	0.12±0.01	0.11±0.00

Source: [9]

Table 4. Concentrations of mineral elements of the selected medicinal plants products

Product name	Fe (ppm)	Cu (ppm)	Pb (ppm)	Cd (ppm)	Zn (ppm)
Ibhubezi	3.47±0.01	0.19±0.01	0.56±0.22	0.81±0.33	1. 51±0.43
Wonder cure	0.28±0.01	0.19±0.01	0.58±0.30	0.81±0.31	2.71±0.30
Ingwe	0.06±0.03	0.20±0.06	0.61±0.19	0.80±0.31	0.20± 0.34
Stametta	0.007±0.03	0.19±0.04	0.66±0.21	0.80±0.31	0 .24±0.10
Tonic life	0.17±0.01	0.16±0.03	0.58±0.28	0.80±0.32	0.40±0.03
Aloe Vera Gel	0.019±0.01	0.13±0.05	0.55±0.34	0.80±0 .33	0.40±0.03

Source: [87]

Table 5. Mean concentration (µg/g) of cadmium and lead in herbal formulations

Herbal formulation (samples analysis)	Cadmium mean cons. (µg/g)±SD	Lead mean cons. (µg/g)±SD	Origin of the samples
C-lax	1.3011±0.0015	19.915±0.001	Iran
Carvil	0.4533±0.0002	12.681±0.001	Iran
Garlet	0.3038±0.0001	52.741±0.003	Iran
Slim-quick	0.2775±0.0003	19.735±0.001	Iran
Galega	1.7531±0.0031	18.875±0.001	Iran
Valiflore	0.6871±0.0002	15.809±0.001	Iran
Garcine	1.2533±0.0045	16.586±0.001	Iran
Green teadin	0.4038±0.0028	14.787±0.001	Iran
Aphrodit	0.2373±0.0008	16.826±0.001	Iran
Anethum	0.1916±0.0007	11.024±0.001	Iran

Source: [88]

7. CONCLUSION AND RECOMMENDATIONS

The common sources of heavy metal are anthropogenic activities mainly as result of industrial activities and improper disposal of refuse as well as runoff from applied fertilizers and pesticides. Take, for instance, lead-acid batteries are usually disposed off indiscriminately in ignorance that they are non-biodegradable as a result of their long biological half-life. Proper disposal of household and industrial waste is thus, a necessity; because primary source of heavy metals in herbal plants was mainly as a result of the availability of these metals in the soil where these plants are grown. Besides, this has corrected the impression that some medicinal plants produce heavy metals which consequently led to recommendation that people should desist from using such plants. Medicinal plants do not produce heavy metals rather they absorb them from the soil containing high concentrations of heavy metals. Thus, presence of heavy metals in plant materials is usually as a result of contamination from where they were cultivated and collected; which suggested that contamination is primarily linked to the source of the materials.

Considering the health hazards of the accumulation of these heavy metals to human health, the need to screen medicinal plants used in traditional medicine; as raw materials and the finished herbal products for heavy metals content and concentration, is highly desirable. In addition, giving the basic information such as the product name, batch number, batch size, date of production and the manufacturer of the analyzed herbal products is indispensable; to enable the consumers identify them accurately. However, there is deficient literature on the content of heavy metals in traditional medicinal products currently in the market. This implied that they are not adequately screened for presence of heavy metal contaminants; therefore, proper, regular and reliable determination, monitoring and regulations of heavy metal concentrations in herbal drugs are requisite. Although the accumulations in the plant parts were reported to be greater in the roots, there was evidence that they also accumulate in other parts of plants. It therefore becomes paramount importance to examine all parts of plants for presence of heavy metals before they could be used as medicine or raw materials for herbal formulations.

In addition, collection of medicinal plants from areas close to industrial sites which utilize these metals and their compounds, and sites where these metals have been improperly disposed is highly discouraged; because plants from these areas are prone to high concentration of heavy metals, hence, increases human risk of contamination when taken. Moreover, the accumulation of heavy metals in plants is a stress factor which causes a number of health defects in plants. Therefore, care has to be taken not to harvest medicinal plants which show any sign of stress because it might be as a result of accumulation of heavy metals. The major aim of using medicinal plants in treatment of diseases is to get cure with little or no side effects but presence of heavy metals in these plants would pose serious health hazards to the consumers when ingested. Even when they are below harmful limits, there is tendency that those with long biological half-life would accumulate in the body over time and consequently, long-term ingestion of very high levels can possibly result in death.

CONSENT

Not applicable.

ETHICAL APPROVAL

Not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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