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Research Article

Exposure to Trace Elements Through *Rauwolfia vomitoria* and *Argemone Mexicana,* Two Medicinal Plants at Hahotoé-Kpogamé, a Polluted Area in Southern Togo

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Abstract

Background: Herbal drugs and mineral elements are well established for their therapeutic benefits against diseases and nutritional importance in human health. Medicinal plants contain toxic metabolites which, once consumed, become a formidable source of disease. Accumulation of toxic industrial effluents in soil, air and water is continuously increasing due to fast urbanization and intensive environmental pollution. Elements like lead (Pb), cadmium (Cd), uranium (U), arsenic (As) which are not used by the plants directly but accumulate in the plants are detrimental to human health when consumed. This study aims to investigate the level of trace elements through the use of two medicinal plants in a polluted area in southern Togo. The trace elements analysis in the powder of the *Rauwolfia vomitoria* and *Argemone Mexicana* leaves, was carried out by the method and protocol described by Acme Laboratory using PerkinElmer ELAN 9000 Inductively Coupled Plasma Mass Spectrometry (ICP- MS). The result of trace elements concentrations (ppm) ranges revealed, as follows: Cadmium (0.8-1.5), Antimony (0.17-0.9), Arsenic (10.85-15.25), Lead (11.31-13.33), Iron (21.02-25.13), Manganese (84.5-140), Calcium (22.39-31.81), Zinc (73.1-82.6), Uranium (0.01-0.04) and Thorium (0.15-1.05) are significantly higher than the World Health Organization maximum permissible limit. These results suggested that the leaves of the two medicinal plants have contaminated by the trace elements. More toxicological activities need to be conduct in the area to find out the toxicity level of contaminants in herbal raw materials in the area.

Keywords

Rauwolfia vomitoria and *Argemone Mexicana,* Pharmacological Uses, Hahotoé-Kpogamé (Togo) Polluted Area, Exposure to ETM, Sanitary Risk

1. Introduction

Numerous medicinal plants are used to alleviate illness, particularly in traditional systems of medicine [21]. Plants are the source of natural products which act as models for new pharmacologically active compounds. Therefore, there has been considerable increase in the usage of herbal products and drugs in recent years [36]. Attraction towards herbal medi-

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cines may be due to the erroneous perception of low recorded incidences of serious adverse effects or absence of proper documentation of adverse effects of traditional herbal medicines amongst other factors [19]. It is clear that medicinal plants contain toxic metabolites which, once consumed, become a formidable source of disease. More, safety of herbal medicines does not only depend on the presence of relatively inherent toxic metabolites of medicinal plants but on the overall quality of the plants [19]. For instance, accumulation of toxic industrial effluents in soil, air and water is continuously increasing due to fast urbanization and intensive environmental pollution [6]. Consumption of medicinal plant products contaminated with toxic substances like trace elements have been reported to elicit deleterious effect on living organisms [14]. Elements like lead (Pb), cadmium (Cd), uranium (U), arsenic (As) which are not used by the plants directly but accumulate in the plants are detrimental to human health when consumed [8]. The most trace elements are implicated in toxicity in humans, because of this, it is essential that the quality of plant-based drugs must be assured safe prior to their use. Pharmacological evaluation of the medicinal plants was recommended for purity and quality of the drugs coming from the botanicals. Therefore, the medicinal plants, which form the raw materials for most herbal remedies, should be checked for the presence of trace elements [3]. Several works have been reported on the phytochemical and biological activities of two medicinal plants, although there are few reports in regard to the trace elements concentrations in the two medicinal plants commonly used by the traditional practitioners of Hahotoé-Kpogamé in the management of different illness. Hahotoé-Kpogamé is an area in southern part of Togo, where Société des Nouvelles Phosphates du Togo (SNPT) Company exploite the phosphate. The train, trucks, cars, machines and vehicles used by the SNPT emit a lot of smoke and produce dust that pollutes the environment of the area. However, the traditional practitioners of this area are dependent on the use of the medicinal plants that they collect to treat the patients. Seeing the risk faced by the people of Hahotoé-Kpogamé by using plants for their health needs, it is necessary to conduct a scientific study in the area to find out if the medicinal plants that the traditional practitioners of Hahotoé-Kpogamé use are safe. According to West Africa Pharmacopoeia, *Rauwolfia vomitoria* and *Argemone mexicana* are known and locally used by the herbal practitioners in the management of malaria, hemorrhoids and hypertension [15]. This study aims to determine the level of some trace elements contamination in *Rauwolfia vomitoria* and *Argemone mexicana* used by the traditional practitioners at Hahotoé-Kpogamé, to assess their relative safety based on the World Health Organization (WHO) standard limits of these trace elements.

2. Material and Methods

2.1. Material

Collection of the Plant Material

The leaves of *Rauwolfia vomitoria and Argemone mexicana* were selected on the basis of their ethno medicinal uses in the management of malaria, hemorrhoids and hypertension in Togo. The plants were collected from Hahotoé-Kpogamé, and were identified and authenticated in Botanic Department/Faculty of Sciences/University of Lomé, Togo (Table 1). Table 1 shows the profile of plants used in this study.

Table 1. *Profile of the Medicinal Plants Used in this Study.*

Voucher N°	Botanical name	Family	Plant parts	Collection place
TG02117	*Rauwolfia vomitoria*	Apocynaceae	Leaf	Hahotoé-Kpogamé
TG20176	*Argemone mexicana*	Papaveraceae	Leaf	Hahotoé-Kpogamé

2.2. Methods

2.2.1. Preparation of the Plant Material

The collected plant materials were washed and dried at room temperature for two weeks. All samples were powdered mechanically, sieved, and 25 g of each plant powder were stored in plastic bags for metal analysis.

2.2.2. Digestion of the Plant Samples

All prepared or pulverized plant samples were cold leached with nitric acid and then digested in a hot water bath.

2.2.3. Measurement of Heavy Metals

The traces metallic elements in the digested samples were determined according to the manual of each instrument. The concentrations of the target heavy/trace metals in plant samples were determined using PerkinElmer ELAN 9000 Inductively Coupled Plasma Mass Spectrometry (ICP- MS) in Acme Laboratory.

Appropriate quality assurance procedures and precautions were carried out to ensure reliability of the results. Deionized water was used throughout the study. Glassware was properly cleaned, and the reagents used were of analytical grade.

Reagents blank determinations were used to correct the instrument readings. For validation of the analytical procedure, the samples were analyzed with Certified Reference Material (CRM) (STD V16 and STD CDV-1). The results of the CRMs and their percentage recoveries are presented along with the respective samples.

2.2.4. Statistical Analysis

The data collected was exported to Microsoft excel spreadsheet where descriptive statistics were carried out. The data was analyzed using Statistical Package for Social Scientist (SPSS) version 23.0 [5]. Data are presented as mean ± SD (Standard Deviation) of three independent experiments.

3. Results and Discussion

3.1. Results

3.1.1. Toxic Trace Elements Concentration in *Rauwolfia Vomitoria* and *Argemone mexicana* Leaves Samples

Table 2 summarizes the mean concentration of toxic trace elements in the leaves of *Rauwolfia vomitoria* and *Argemone mexicana* samples collected from Hahotoé-Kpogamé area. The mean ± SEM concentration of toxic trace elements in the leaves of two medicinal plants were highest in the order Pb (14.33 ± 0.16) > As (15.25 ± 0.00) > Cd (1.5 ± 0.01) > Sb (0.17 ± 0.03) for *Rauwolfia vomitoria* and Pb (11.31 ± 0.08) > As (10.85 ± 0.00) > Sb (0.9 ±0.00) > Cd (0.8 ±0.01) for *Argemone mexicana* respectively. The level of Pb, Sb and As were higher in *Rauwolfia vomitoria* when compared to *Argemone mexicana*. The mean concentration of Pb, Cd, As and Sb in the leaves of two medicinal plants were higher than maximum permissible limit set by WHO.

Table 2. *Toxic trace Elements Concentration in Rauwolfia vomitoria, and Argemone mexicana Leaves Samples.*

Plant species	Mean of ETM concentration in plant leaves samples (ppm)			
	Pb	Cd	As	Sb
R. vomitoria	16.33 ±0.16	1.5 ±0.01	15.25 ±0.00	0.17 ±0.03
A. mexicana	11.31 ±0.08	0.8 ±0.01	10.85 ±0.00	0.9 ±0.00
WHO REF STD (ppm)	10	0.3	10	0.1

Values are expressed as mean ± ESM (n = 3); Reference standard (Ref Std) were based on FAO/WHO [17, 18].

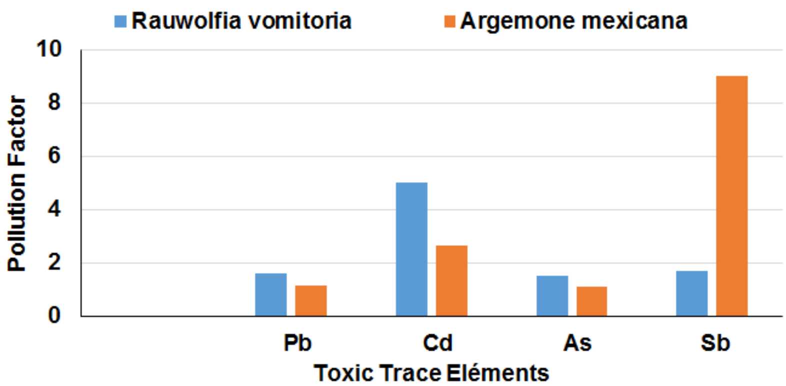

Figure 1. *Pollution factor of toxic trace elements in the leaves samples of two medicinal plants collected from Hahotoé – Kpogamé*

Figure 1 summarizes the pollution factor of toxic trace elements of *Rauwolfia vomitoria* and *Argemone mexicana* leaves samples collected at Hahotoé-Kpogamé area. The pollution fator (PF) of toxic trace elements in the leaves of two medicinal plants were highest in the order Cd (5) > Sb (1.7) > Pb (1.6) > As (1.53) for *Rauwolfia vomitoria* and Sb (9) > Cd (2.66) > Pb (1.13) > As (1.09) for *Argemone mexicana* respectively. The level of pollution factor of Pb, Cd and

As were higher in *Rauwolfia vomitoria* than in *Argemone mexicana*. The pollution factor of Pb, Cd, As and Sb in the leaves of two medicinal plants were above 1.

3.1.2. Radio-active Trace Elements Concentration in *Rauwolfia vomitoria* and *Argemone mexicana* Leaves Samples

Table 3 summarizes the mean concentration of radio - active trace elements in the leaves of *Rauwolfia vomitoria* and *Argemone mexicana* samples collected from Hahotoé-Kpogamé area. The mean ± SEM concentration of radio - active trace elements in the leaves of two medicinal plants were highest in the order Th (0.2±0.00) > U (0.04±0.01) for *Rauwolfia vomitoria* and Th (0.15±0.07) > U (0.01±0.01) for *Argemone mexicana* respectively. The level of Th was higher in the leaves of two medicinal plants when compared to the level of U in the leaves of two medicinal plants. Except of U in the leaf of *Argemone mexicana*, the mean concentration of U and Th in the leaves of two medicinal plants were higher than maximum permissible limit set by WHO [17, 18].

Table 3. *Radio-active Heavy Metals Concentrations in Rauwolfia vomitoria and Argemone mexicana Leaves Samples.*

Plant species	Mean of radio-active trace elements concentration (ppm) in plant leaves samples	
	U	Th
R. vomitoria	0.04 ±0.00	0.2 ±0.00
A. mexicana	0.01 ±0.01	0.15 ±0.07
WHO REF STD (ppm)	0.03	0.01

Values are expressed as mean ±ESM (n = 3); Refence standard (Ref Std) were based on FAO/WHO [17, 18]

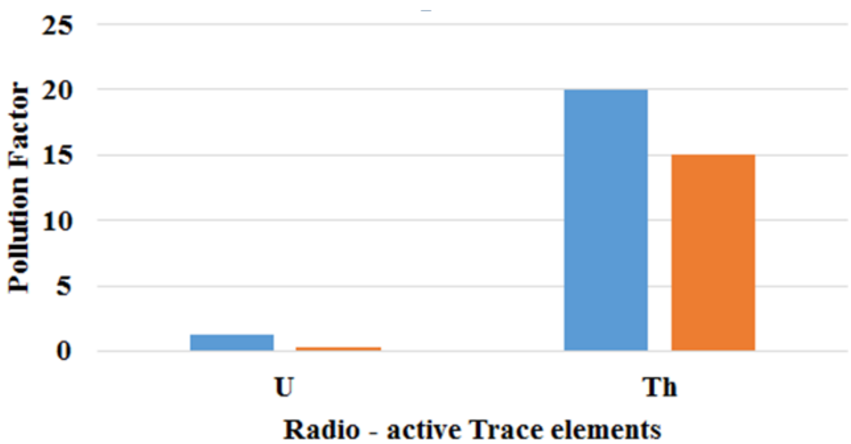

Figure 2. *Pollution factor of radio - active trace elements in the leaves samples of two medicinal plants collected from Hahotoé– Kpogamé*

Figure 2 summarizes the pollution factor of radio-active trace elements of *Rauwolfia vomitoria* and *Argemone mexicana* leaves samples collected from Hahotoé-Kpogamé area. The pollution factor of radio-active trace elements in the leaves of two medicinal plants were highest in the order Th (20) > U (1.33) for *Rauwolfia vomitoria* and Th (15) > U (0. 33) for *Argemone mexicana* respectively. The pollution factor of U and Th were higher in *Rauwolfia vomitoria* when compared to *Argemone mexicana*. The pollution factor of U in *Rauwolfia vomitoria* and the pollution factor of Th in the leaves of two medicinal plants were above 1.

3.1.3. Essential Trace Elements Concentration in Rauwolfia Vomitoria and *Argemone mexicana* Leaves Samples

Table 4 summarizes the mean concentration of essential trace elements in the leaves of *Rauwolfia vomitoria* and *Argemone mexicana* samples collected from Hahotoé-Kpogamé area. The mean ± SEM concentration of essential trace elements in the leaves of two medicinal plants were highest in the order Mn (140±1.41) > Zn (73.1±0.14) > Ca (31.39±0.01) > Fe (25.13±0.0.00) for *Rauwolfia vomitoria* and Mn (84.5±6.36) > Zn (82.6±22) > Ca (22.81±0.21) > Fe

(21.03±0.00) for *Argemone mexicana* respectively. The level of Mn and Fe was higher in *Rauwolfia vomitoria* than in to *Argemone mexicana*. The mean concentration of Ca, Fe, Mn and Zn in the leaves of two medicinal plants was higher than maximum permissible limit set by WHO [17, 18].

Table 4. *Essential Trace Elements Concentration in Rauwolfia vomitoria and Argemone mexicana Leaves Samples.*

Plant species	Mean of essential trace elements concentration in plant leaves samples (ppm)			
	Ca	**Fe**	**Mn**	**Zn**
Rauwolfia vomitoria	31.39 ±0.01	25.13 ±0.00	109 ±1.41	73.1 ±0.14
Argemone mexicana	22.81 ±0.21	21.03 ±0.00	84.5 ±6.36	82.6 ±2.26
WHO REF STD (ppm)	10	20	0.1	60

Values are expressed as mean ±ESM (n = 3); Refence standard (Ref Std) were based on FAO/WHO [17, 18]

Figure 3 summarizes the pollution factor of essential trace elements of *Rauwolfia vomitoria* and *Argemone mexicana* leaves samples collected from Hahotoé-Kpogamé area. The pollution factor of essential trace elements in the leaves of two medicinal plants was highest in the order Mn (1090) > Ca (3.13) > Fe (1.3) > Zn (1.22) for *Rauwolfia vomitoria* and Mn (845) > Ca (2.3) > Zn (1.38) > Fe (1.05) for *Argemone mexicana* respectively. The pollution factor of Fe, Ca and Mn was higher in *Rauwolfia vomitoria* than *Argemone mexicana*. The pollution factor of Ca, Fe, Mn and Zn in the leaves of two medicinal plants was above 1.

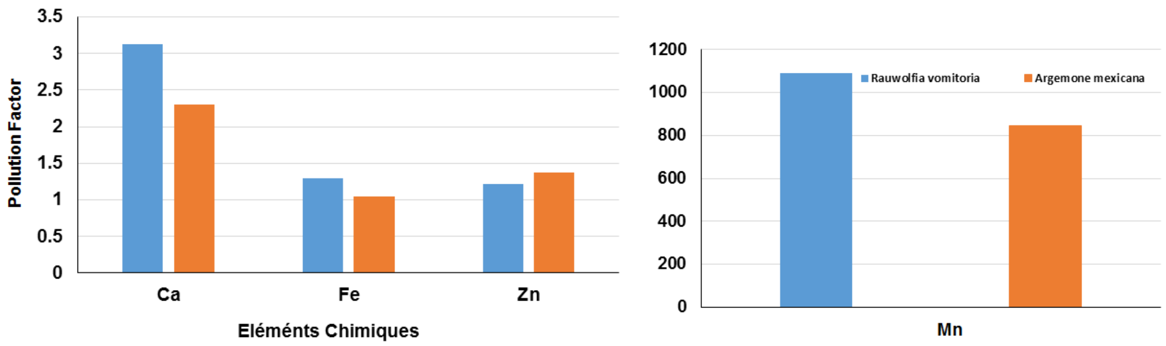

Figure 3. *Pollution Factor of Essential Trace Elements in the Leaves Samples of two Medicinal Plants Collected from Hahotoé– Kpogamé*

3.2. Discussion

3.2.1. Toxic Trace Elements Concentrations

The plant samples investigated revealed varying concentrations of the selected toxic trace elements as reported in Table 2. The mean concentrations of toxic trace elements (cadmium, lead, arsenic and antimony) found in *Rauwolfia vomitoria* and lead, cadmium and arsenic found in *Argemone mexicana* were above the maximum residual limit (MRL) set by WHO for raw medicinal plants [17] (table 2). While the mean concentration of antimony in *Argemone mexicana* was below the limit set by WHO for raw medicinal plants [17] (Table 2). However, due to their cumulative effect as reported by Jabeen et al. [7], the low level of the toxic trace elements does not make what it contained to be safe for consumption. The Pollution caused by toxic trace elements is a worldwide phenomenon. Among the many toxic trace elements, lead (Pb), antimony (Sb) cadmium (Cd) and arsenic (As) are the most concern. They are very toxic because, as ions or in compound forms, they are soluble in water and may be readily absorbed into living organisms [14]. After absorption, these metals can bind to vital cellular components, such as structural proteins, enzymes, and nucleic acids, and interfere with their functioning [14]. These metals are quintessential to maintain various biochemical and physiological functions in living organisms when in very low concentrations; however, they become noxious when they exceed certain threshold concentrations [22]. In human body, these metals, even in small amounts, can cause severe physiological and health effects. Lead (Pb) is one of the systemic poisons in that, once absorbed into the circulation, it is distributed throughout the body, where it causes serious health effects [14]. Manifested effects of Pb poisoning include nausea, anorexia, severe abdominal pain, neurological toxicity, hematological toxicity, hallucination anemia, renal tubular dysfunction and cardiovascular [23]. Lead can also pass the placental barrier and may reach the fetus, resulting fetal hemorrhage, abortions, and birth malformation [23]. High concentration of lead above permissible limits in medicinal plants and herbs has been reported in United Arab Emirates. This is in agreement with our studies. The similar results were reported in most commonly and commonly used medicinal herbs in Jordan (22.40 for Pb; 1.79 for Cd; 18.54 for As and 1.13 for Sb), in Nigeria (48.1 for Pb; 4.42 for Cd; 65.65 for As and 2.09 for Sb) and Iranian (32.25 for Pb; 6.04 for Cd; 59.03 for As and 8.13 for Sb) spices and medicinal plants, respectively [3]. Cadmium is toxic in small amounts, and there is no evidence that Cd has any useful biological function [14]. Although dietary intake is the means by which humans are most highly exposed to Cd, inhalation of Cd is more dangerous than ingestion. This because through inhalation, the body's organs are directly and intimately exposed to the metal. Inhaled Cd may cause emphysema and pneumonitis, while ingested Cd may result in disturbances in the gastrointestinal tract, liver dysfunction, kidney damage manifested, neuronal damage, risk of cancer and cardiovascular disorders [24]. Similar results of high levels of cadmium in Iranian medicinal herbs drugs have been reported [25]. Also, residual values reported in foliar part for *Ocimum gratissimum* and sampled from Road Side and Physique Garden in Kwame Nkrumah University of Science and Technology and natural habitat respectively in Ghana [3], were significantly higher (49.25 for Pb; 13.7 for Cd, 61,78 for As and 2,12 for Sb) than level found in the plant samples involved in this study. Placental transfer of inorganic arsenic has been demonstrated in both experimental animal (rat and hamster) and human studies. In a study on rats, dimethyl arsenic acid was shown to pass through the placental barrier, the blood values in the fetus being comparable with those of the mother [26]. Acute and sub-acute effects of arsenic may involve many organ systems including the respiratory, gastrointestinal, cardiovascular, nervous, and hematopoietic systems [27]. Lesions of the upper respiratory tract including perforation of the nasal septum, laryngitis, pharyngitis, and bronchitis have frequently been encountered in workers in the smelting industry exposed to high levels of arsenic [14]. Inorganic arsenic in the trivalent state can give rise to skin lesions in man, especially palmo-plantar hyperkeratosis which has a characteristic appearance [35]. Disturbances of liver function have been observed in both man and animals after chronic exposure to inorganic arsenic [29]. Evidence of effects on the heart has been found in human subjects after exposure to comparatively high doses of arsenic, which produced other symptoms and signs of intoxication [28]. Peripheral vascular disturbances, hypertension and lung cancers have been reported in Chine where toxic trace elements exposure due to ingestion of inorganic arsenic has occurred [30]. On the other hand, the effects of antimony and its compounds on human and environmental health differ widely. Chronic exposure to antimony in the air at levels of 9 ppm may exacerbate irritation of the eyes, skin, and lungs [12]. Long-term inhalation of antimony can potentiate pneumoconiosis, altered electrocardiograms, stomach pain, diarrhea, vomiting, and stomach ulcers, results which were confirmed in laboratory animals [12]. Long-term exposure in experimental animals has shown an increase in the hepatic malfunction and blood changes [1]. The limitation existing in the study of antimony includes the lack of studies of the influence of the metal on lung cancer in human subjects [2]. Metals measured in casual (spot) urine specimens by ICP-MS demonstrated that peripheral arterial disease (PAD) risk increased sharply at low levels of antimony and remained elevated beyond 0.1ppm. The role of antimony compounds in sudden infant death syndrome (SIDS) was determined via hepatic biopsies, although there was no difference between the two categories of cause of death, SIDS or those who had died of an identified disease [10]. Antimony is a non-essential element relatively hardly soluble in the soil solution; however, it can be taken up by plants. High concentration of Sb was found in the shoot of various plants growing in the vicinity of old mining sites and industrial areas in Nigeria [4]. However, the high concentration of toxic trace elements above the maximum residual limit (MRL) stipulated by the WHO [17, 18] found in the selected medicinal plants revealed that the herbal formulations studied were not safe for consumption.

3.2.2. Radioactive Trace Elements

The medicinal plant samples investigated revealed varying concentrations of the selected radioactive trace elements as reported in Table 3. The mean concentrations of radioactive elements (uranium and thorium) found in *Rauwolfia vomitoria* and the mean concentration of Th found in *Argemone mexicana* were above the maximum residual limit (MRL) set by WHO for raw medicinal plants [17]. While the mean concentration of U in the leaf of *Rauwolfia vomitoria* was below the maximum residual limit (MRL) set by WHO for raw medicinal plants [17] (Table 3). U and Th are radioactive elements, their exposure can lead to severe biological effect: uranium exposure can lead to the cardiovascular, musculoskeletal, skin damage, bone, hepatic, respiratory, renal and gastrointestinal effects [31]. While acute, high-level exposure to uranium compounds can clearly cause nephrotoxicity in humans [32]. The primary health effects of high doses of thorium are blood disorders and liver tumors [33]. Some evidence of increased incidence of liver and kidney cancers was found in workers occupationally exposed to thorium via inhalation [34].

3.2.3. Essential Trace Elements

The plant sample under investigation revealed varying concentrations of the selected essential trace elements as reported in Table 4. The mean concentration of Ca, Fe, Mn and Zn in the two medicinal plants were above the maximum permissible limit set by WHO for medicinal plants. Ca, Fe, Mn and Zn are an essential trace elements and relatively non-toxic especially if taken orally. However, high amount can cause system dysfunction. Calcium is an integral component of the skeleton, and the skeleton provides a reservoir of calcium for other essential calcium-dependent functions throughout the body. A main physiological function of calcium apart from its role in maintaining the skeleton, is an essential intracellular messenger in cells and tissues throughout the body [13]. Due to its properties, iron (Fe) excess is closely related to oxidative stress. The excessive accumulation of Fe has been linked to oxidative damage to proteins and lipids [16], causing oxidative stress. In another hand Mn is an essential element for humans and other animals. Adverse effects can result from both deficiency and overexposure. Mn is known to cause neurological effects following inhalation exposure, particularly in occupational settings, and there have been epidemiological studies that reported adverse neurological effects following extended exposure to very high levels in drinking-water [8]. Adverse effects have been reported in populations, in areas associated with manganese-processing plants. In 1939, increased morbidity and mortality due to lobar pneumonia were reported from Sauda in Norway, where a ferro and silicomanganese plant was operating [20]. The mortality rate was positively correlated with the amount of manganese alloy produced. In laboratory animals, histopathological lesions found in intoxicated animals included degenerative changes, primarily in the striatum and pallidum, but lesions in the sub thalamic nucleus, cortex, cerebrum, cerebellum, and the brain stem have also been observed [8]. Furthermore, Zinc toxicity can occur in both acute and chronic forms. Acute adverse effects of high zinc intake include nausea, vomiting, loss of appetite, abdominal cramps, diarrhea, and headaches [11]. Intakes of 150–450 mg of zinc per day have been associated with such chronic effects as low copper status, altered iron function, reduced immune function, and reduced levels of high-density lipoproteins [9].

4. Conclusion

Togo people have a tremendous passion for medicinal plants and use them for a wide range of health related applications. The results of this study indicate a potential health risk of trace elements to consumers over long-term consumption of contaminated herbs. In order to protect the population of Hahotoé - Kpogamé from the toxic effects of transmetallic elements, further research is needed in the area.

Abbreviations

DI H_2O: Deionized Water
HCL: Chlorydric Acid
HNO_3: Nitric Acid (HNO_3)
ICP- MS: Inductively Coupled Plasma Mass Spectrometry
SNPT : Société des Nouvelles Phosphates du Togo
WHO: World Health Organization
CRM: Certified Reference Material
SPSS: Statistical Package for Social Scientist

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Conflict of Interest

The authors declare no conflicts of interest.

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