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Determination of the Level of Toxic Heavy Metals in Selected Traditional Medicinal Plants in Sheka Zone, Southwest Ethiopia

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Abstract: Although medicinal plants may be produced in polluted soil or water settings, their extracts have long been utilized to treat illnesses affecting the general populace. Many of these herbs are collected and prepared in an unsanitary way by untrained local natural healers and other sellers. As a result, there is a chance that potentially harmful elements from the environment will contaminate the area. In this study, the five most prevalent poisonous heavy metals (arsenic, cadmium, chromium, lead, and mercury) were measured in five medicinal plants used extensively in southwest Ethiopia's Sheka Zone., including *Bersama abyssinica, Calpurnia aurea, Croton macrostachyus, Eucalyptus globules,* and *Solanum incanum.* The Tepi district in southwest Ethiopia provided the plant samples, which were then cleaned, dried, disinfected with 0.1% HgCl, digested with 69% HNO_3 and 35% H_2O_2, and then subjected to AAS analysis. According to the study's findings, neither cadmium nor mercury was found in *Solanum incanum*. Additionally, *Bersama abyssinica* and *Croton macrostachyus* also do not contain mercury. Cd (below detection limit (BDL) to 0.6012 ppm), As (below detection limit (BDL) to 0.032 ppm), Hg (below detection limit (BDL) to 0.020 ppm), Cr (0.75 0.18 to 1.32 0.21), and Pb (below detection limit (BDL) to 0.0200 ppm) were the harmful heavy metals with the widest concentration ranges (0.01013 ppm to 0.4012 ppm). The findings demonstrate that while these plant species were below the WHO permitted limits for consumed therapeutic herbs; their usage for disease prevention will not cause heavy metal toxicity and may even be advantageous to users who are deficient in micronutrients.

Keywords: Spectrophotometer, Heavy Metals, Medicinal Plants

1. Introduction

Many people in developing nations still use herbal treatments as their first line of defense. Traditional medicine is commonly utilized to prevent and treat a variety of diseases, as well as to increase energy and strengthen the immune system [1]. In Africa, up to 80% of the population in rural areas depends on traditional medicine (TM) for primary health care. Ethiopia, like the majority of African countries, contains around 2600 plant species, with roughly 700 of them having known medical use [2, 3].

Research has revealed that in addition to having harmful secondary metabolites, plants are frequently contaminated with other environmental toxins, particularly heavy toxic metals, which are dangerous to all living things when ingested. Climate, atmosphere, pollution, soil, harvesting, and handling, among other factors, may all have a role in trace metal poisoning of medicinal plants. Even when hazardous metals including arsenic, cadmium, chromium, lead, and mercury accumulate above the allowed level, they can still cause harm to the blood's composition, the lungs, kidneys, liver, and other important organs, as well as impaired or diminished mental and central nerve function. According to the World Health Organization, some medicinal plants used as raw materials for different medicines should be checked for pollutants such as heavy/toxic metals, pesticides, fungi, and microbes [4, 5].

This study was designed to determine the concentrations of five toxic heavy metals (arsenic, cadmium, chromium, lead, and mercury) in the root, leaf, and stem samples from five commonly used medicinal plants (*Bersama abyssinica, Calpurnia aurea, Croton macrostachyus, Eucalyptus globules, and Solanum incanum*) in southwest Ethiopia Sheko Zone to compare the levels with International Organization standard and to provide a scientific data baseline for traditional practitioners as well as for pharmaceutical industries. The medicinal plants were chosen based on their varied medicinal qualities, frequent use in developing new pharmaceutical preparations, preparation of traditional medicine formulations, and substantial importance in the medical value. Table 1 provides a general overview and economic significance of the medicinal herbs used in this investigation.

Table 1. *A list of medicinal plants whose heavy metal content and historical uses have been examined.*

No	Botanical name	Local name	Utilized parts	The use of medicine	Ref
1	*Bersama abyssinica* Fresen	Azamir	Leaves or steam	for applying cream to a wound after pressing the leaves	[6, 7]
2	*Calpurnia aurea*	Digita	Leaves \Roots\Seed	Boiling the leaves and drinking the resulting tea with honey will help prevent dangerous snake bites.	[7, 8]
3	*Croton macrostachyus*	Bisana	Bark	for treating gonorrhea and splenomegaly	[8, 9]
4	*Eucalyptus globules Labill*	Nech-bahirzaf	Leaves	utilized to treat allergy and influenza	[10]
5	*Solanum incanum*	Tikur awud	Leaves/Root	used to treat amebiasis, bleeding, and menstruation	[9, 11]

2. Materials and Methods

2.1. Collection of Plant Material

The fresh five selected different medicinal plant species, such as *Bersama abyssinica Fresen, Calpurnia aurea*, *Croton macrostachyus*, *Euca lyptus globule*, and *Solanum incanum* were collected from Sheka zone, Tepi district, South West Ethiopia. The collected plats were botanically identified and authenticated using the standard morphological characteristic features and processed for Analysis.

2.2. Instruments and Chemicals

A flame atomic absorption spectrophotometer (210VGP, Buck Scientific, USA) with an air-acetylene flame, standard solutions (1000 mg L^{-1}) of Cr, As, Hg, Pb, and Cd (Merck, Germany), and HNO_3 (69%), HCl (37%), and H_2O_2 (30%) were used in the study.

2.3. Sample Preparation

The plant leaves were cleaned with distilled water to first get rid of any contaminants on their surface. After that, the leaves were dried at 100°C and kept in a clean polyethylene plastic bag until digestion, powdered using an electronic grinder (Bsch, Germany), and sieved through a sieve with a pore size of 100 m. All plastic and glassware were cleaned before use by soaking in an aqueous 10% HNO_3 solution and rinsing with clean water.

2.3.1. Sample Digestion

Plant leaf samples were digested using the acid digestion method after optimization concerning the proportions of HNO_3 (69%), HCl (37%), and H_2O_2 (30%) in mixes, digestion time, and digestion temperature. Under optimal conditions, 0.5 g of the powdered leaves for each plant species were filled in three flasks. Then, 7, 8, 9, 8, and 7 mL of HNO_3:HCl:H_2O_2 acid solutions were added to *Bersama abyssinica Fresen, Calpurnia aurea, Croton macrostachyus, Eucalyptus globule, and Solanum incanum,* respectively, in the following ratios by volume: 4:2:1, 6:1, 7, 1, 6, 1, and 2:1. The samples were placed on a heated plate and digested for 2:30 hours at 150°C for *Bersama abyssinica Fresen*, 2:00 hours at 180°C for *Calpurnia aurea*, 1:50 hours at 210°C for *Croton macrostachyus*, 2:00 hours at 190°C for *Eucalyptus globule*, and 2:10 hours at 180°C for *Solanum incanum*. After passing the solution through Whatman filter paper, distilled water was added to a 50 mL volumetric flask. Following the steps employed for the digestion of each plant species, reagent blank solutions were made [12, 13].

2.3.2. FAAS Determination of Elements

The concentrations of trace elements in the digested leaf samples were estimated using air acetylene arc AAS equipped with a deuterium arc background corrector and an air-acetylene flame under various working conditions (Table 2). The atomic absorption spectrometer was calibrated using five-point standard solutions for each element.

Table 2. *Standard operationg condition of AAS for the analysis of most common heavy metals in plant materials.*

Elements	λ_{max} (nm)	Slit siz (nm)	Flame type
As	193.7	0.8	Air/Acetylene
Cd	228.9	0.7	Air/Acetylene
Cr	357.9	0.5	Air/Acetylene
Hg	253.7	0.7	Air/Acetylene
Pb	283.3	1.3	Air/Acetylene

2.4. Statistical Analysis

Results were provided as mean values standard deviation after three replications of each determination.

3. Results and Discussion

The profiles of medicinal plants used in the analysis were determined and the results showed that the samples had variable compositions of each analyte metal with varying concentration ranges among various plant species. Cadmium below the detection limit and mercury was not found in

Solanum incanum, as shown in Table 3 and Figure 1 below. Mercury was also not found in *Bersama abyssinica and Croton macrostachyus*.

Arsenic is a hazardous non-essential metal that is primarily found in therapeutic plants. The WHO suggested 10 ppm as the maximum amount of arsenic in medicinal plants [14]. Minor exposure to arsenic can cause symptoms like tingling in the hands and feet, a loss of red and white blood cells, disturbances in heart rhythm, and nausea and vomiting. Long-term exposure to arsenic can result in skin blackening and the development of small corns on the soles, hands, and torso. Arsenic is also one of the main contributors to hypertension. At larger doses, severe side effects involving the hepatic and cardiovascular systems were also noted [14]. According to Table 3 and Figure 1a of the current investigation, the concentration of arsenic in chosen herbal samples ranged from 0.00 pm or below the detectable limit (BDL) to 0.316 ppm. *Eucalyptus globules* had the highest content (0.032 ppm), whereas *Croton macrostachyus and Solanum incanum* had the lowest concentration (BDL). The WHO-recommended range was found to be below in every sample, indicating that the plants are safe for use as food and medicine.

Even at low concentrations, cadmium is one of the poisonous heavy metals to human tissue and serves no biological purpose [15]. It has both immediate and long-term effects on the human body [16]. The primary causes of cadmium accumulation in soil and plants are the use of agricultural inputs such as fertilizers, herbicides, and biosolids (sewage sludge), as well as the disposal of industrial waste or air deposition [17]. Concentrations of cadmium were measured to give 0.02 ± 0.08, 0.23 ± 0.02, 0.6 ± 0.04, 0.28 ± 0.01 mg/kg, and BDL in *Bersama abyssinica Fresen, Calpurnia aurea, Croton macrostachyus, Eucalyptus globules, and Solanum incanum* respectably as shown in Table 3 and Figure 1b. The WHO established 0.3 mg/kg in the finished medicinal plant as the allowable limit for cadmium in medicinal plants in 2005. The level of cadmium in this study was quite equivalent to the values and standards mentioned in the aforementioned literature.

Another popular heavy metal that is hazardous to the environment is chromium. Tanneries, the steel industry, the use of sewage sludge, and fly ash are the main sources of chromium contamination. In high quantities, it might be dangerous for both plants and animals. The problems associated with chromium exposure include skin rashes, stomach distress, ulcers, respiratory problems, weakened immune systems, kidney and liver damage, genetic material alteration, lung cancer, and ultimately mortality [18]. The present study revealed that the maximum level of chromium was discovered to be 1.321 ppm in *Calpurnia aurea*, while the lowest concentration (0.7518) was seen in *Croton macrostachyus*, as indicated in Table 3 and Figure 1c. The tolerated limit stated by FAO (1984) for Cr in medicinal plants is 0.02 g g-1. All plants accumulated Cr below this level when the metal limit in the researched medicinal plants was compared to those suggested by FAO (1984).

Increased lead levels are thought to be extremely detrimental to microbes, plants, and animals [19]. It harms the renal, liver, vascular, and immunological systems in addition to causing acute and chronic poisoning [20]. Due to the study site's proximity to a busy road, fuel exhausts are the most likely cause of the lead contamination of the environment. For medicinal herbs, the FAO/WHO defined an acceptable limit of 10 ppm. According to Table 3 and Figure 1d, the concentration of lead (Pb) in the current investigation ranged from 0.01 to 0.4 ppm. The maximum concentration was detected in *Croton macrostachyus* while the minimum was detected in *Solanum incanum.* Lead concentrations were barely below the permissible limit in all of the samples, raising the possibility of harm from continued usage of these plants.

Mercury poses serious threats to both plants and animals. Metal, inorganic, or organic mercury exposure at high amounts can permanently damage the developing fetus's kidneys and brain. The impacts on brain function include irritability, shyness, tremors, abnormalities in vision or hearing, and memory problems. The FAO/WHO determined a permitted level of 0.1 ppm for medicinal plants. According to the current study's findings, *Calpurnia aurea and Eucalyptus globules* had the greatest concentrations of mercury (0.02 ppm and 0.01 ppm, respectively), while *Bersama abyssinica, Croton macrostachyus, and Solanum incanum* had no mercury at all, as indicated in Table 3 and Figure 1d. After comparing the metal limits in the investigated medicinal plants with those suggested by the FAO/WHO, it was discovered that the mercury concentration in five specific plants was below the allowable range.

Table 3. *Samples of medicinal plants' heavy metal content.*

No	Medical plant	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Lead (Pb)	Mercury (Hg)
1	B.a	0.032 ± 0.003	0.02 ± 0.008	1.14 ± 0.16	0.36 ± 0.012	BDL
2	C.a	0.035±0.008	0.23 ± 0.02	1.32 ± 0.21	0.2 ± 0.018	0.02 ± 0.00
3	*C*.m	BDL	0.6 ± 0.04	0.75 ± 0.18	0.4 ± 0.009	BDL
4	E.g	0.031 ± 0.004	0.28 ± 0.01	0.98 ± 0.15	± 0.011	0.01 ± 0.00
5	S.i	BDL	BDL	0.89 ± 0.24	0.01 ± 0.013	BDL

BDL = Below Detectable Level, B.a = Bersama abyssinica Fresen, C.a = Calpurnia aurea, C.m = Croton macrostachyus, E.g = Eucalyptus globules, S.i = Solanum incanum.

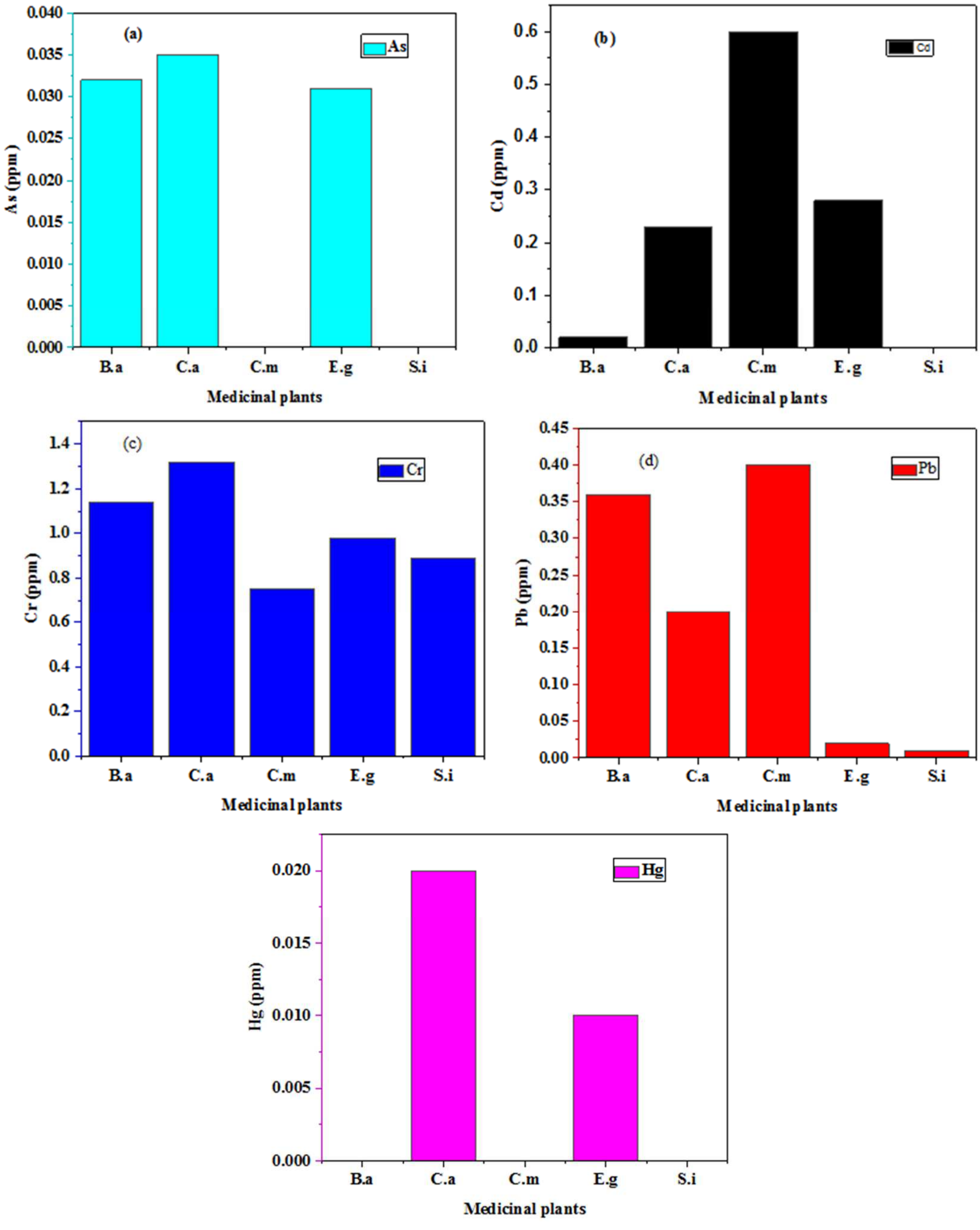

Figure 1. *Concentration levels of element in selected plants.*

4. Conclusion

In the present study, the presence of the most toxic heavy metals levels was revealed in selected medicinal plants. The concentration of mercury was not detected in *Solanum incanum, Bersama abyssinica and Croton macrostachyus,* Arsenic was not detected *Solanum incanum,* and *Bersama abyssinica* and also Cadmium was not detected *Solanum incanum.* Maximum amounts of each harmful heavy metal attained were below the FAO/WHO-set acceptable limits. Thus, it could be concluded that these plants won't result in heavy metal toxicity and could benefit consumers who are deficient in micronutrients.

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