

Assessment of Heavy Metals in Some Anti-Diabetic Medicinal Plants

N. Fatima¹, S. Khurshid², S. Nisar^{1*}

¹Department of Chemistry, University of Karachi, Karachi, Pakistan.

²Food Quality and Safety Research Institute, SARC, PARC, Karachi, Pakistan

*Corresponding author email: nasreenfatima@uok.edu.pk

Abstract

Medicinal plants are extensively used to cure diseases. However due to environmental pollution medicinal plant accumulate heavy metals which can cause adverse affect on animal and human health upon consumption. Hence chemical analysis of four heavy metals (Zn, Cr, Pb and Cd) was performed in nine medicinal plants (*Adiantum capillus-veneris*, *Momordica charantia*, *Eugenia jambolana*, *Gymnema sylvestre*, *Allium sativum*, *Trigonella foenum-graecum*, *Pongamia glabra*, *Sphaeranthus hirtus* and *Clerodendrum inerme*) used as anti-hypoglycaemic agent. Highest level of chromium (5.434µg/g±3.50%) and cadmium (1.900µg/g±0.60%) was reported in *Pongamia glabra* and *Eugenia jambolana* respectively, exceeded the WHO Limits. Other two lethal metals Zn (18.90µg/g±2.00%) and Pb (1.607µg/g±0.16%) in *Momordica charantia* and *Eugenia jambolana* respectively were recorded in permissible limit. It is suggested that stringent quality control system should be put in place to check the heavy metal contamination for avoidance of health hazard and ensuring the safe consumption.

Key words: heavy metal, hypoglycaemic, WHO, Quality control

1. Introduction

Diabetes is a common disease now a day's affecting large numbers of population globally. An estimated 422 million adults have been diagnosed with diabetes in 2014 and the numbers is projected to rise to 642 million by 2040 [1]. The utilization of medicinal plants for curative purpose tends to extend over the years throughout the world due to their apparent effectiveness, low cost and no or less side effects [2,3]. Previous study estimated 65-80% of the world population depending on traditional herbal medicine as their primary health management [4]. However, the utilization of aromatic and medicinal plants (AMPs) has come under scrutiny due to their observed toxicity among other concerns [3]. Medicinal plants has pharmacologically active group like synthetic drugs authoritative for the required therapeutic effect in the body. Plants are highly reactive towards immediate environment and potentially lump various metals in their different parts which can alter the physiochemical properties of the plant [5,6]. The environmental influence of toxic metal contamination related to health issues remain a great area of affliction. Trace amounts of some toxic metal are favourable to human health but their presence exceeding estimated daily safe intake is harmful leading to physiological degradation and cell poisoning [7,8]. The ability to deposit high concentration of metals than in the eco-system due to bio accumulation in plants escalated their injurious effect [7]. High intake/ use of Lead (Pb) can cause high blood pressure (BP) and extensive weakening effects to the organs [7]. Cadmium (Cd) accumulation is associated with renal and respiratory damages as well as kidney injury etc. Likewise Chromium (Cr) has been found to cause skin rashes, liver damage and lungs cancer. Studies have reported Nickel as carcinogen and subsequent adverse effect on lungs. also excessive amount of essential metal like zinc (Zn) and iron (Fe) has been found harmful causing vomiting and abdominal difficulties respectively [9-11]. Several works have been reported earlier on contaminated Medicinal plants with heavy metals [12]. Limited information is available about safe threshold level of heavy metals in traditional herbal plants.

The current study aims to diagnose the concentration of heavy metals in some commonly used anti diabetic medicinal plants in reference to worldwide standard permissible limits.

2. Materials and Methods

System suitability was checked by analysing blank sample to ensure the reliability of the results. The entire plant samples materials were acquired from the local market of Karachi, Pakistan, authenticated at Department of Botany, University of Karachi, Pakistan. Calibration standards were obtained by diluting the standards stock solutions of high concentration (1000ppm). All samples were extracted following the prescribed procedure of AOAC, 1990 [13] and Wiersman and Ven,

1986 [14]. Metals analysis was performed on atomic absorption spectrophotometer (AAS Hitachi Z 8000) coupled with graphite tube analyser (GTA) and wet digestion method reported by AOAC (AOAC, 1990) [13].

3. Results and discussion

World health organization (WHO) reported that 80% of the world population used plant based medication for their primary health care and enlisted 21000 plant species used directly or indirectly as medicine throughout the world [4,15]. Most of these medicinal plants are wild while some are properly cultivated. Plant based medication are generally thought to be free from side effects and cheap but presence of lethal metal in these material causes severe health problems [16,17]. Plant absorbs water, deposit different metals and both essential and non essential metals from soil in their various parts. Medicinal plants have active groups like other synthetic drugs which are contaminated with toxins, Heavy metals and pesticide residues etc. [18]. The general perception about the medicinal plants and the drugs formulated from these natural sources to be safe, leads to the indiscriminate use of these products. Moreover, in some cases medicinal plants can have side effects like other synthetic drugs [3,19]. World Health Organization reports suggested that herbal plant and their formulated remedies should be analysed for toxin and HMs both qualitatively and quantitatively by setting benchmarks permissible levels [3,20,21]. Limits for the analysed lethal metals were shown in the Table 1 given below.

Table 1. Permissible Limits (WHO) of Toxic Metals [7, 15].

Zn	Cr	Cd	Pb
27.40	2.00	0.30	10.00
Finished Herbal material (mg/day)			
-	0.02	0.006	0.02

Chen et al. (2005) [22] reported the existence of various lethal metals in 42 Chinese medicinal plants in 2005 [23], concentration of heavy metals (Cd, Pb & Hg) among selected MP were found slightly above the permissible limit.

Cadmium, lead, arsenic and mercury are considered the most toxic metals responsible for human poisoning [7,24]. Therefore it is recommended that medicinal plants (Table. 2) and their remedies may be investigated for lethal metals concentration. Essential metal also causes injuries if taken in higher concentration, [25] reported high concentration of Zn and Cu in *Ceropegia juncea*.

Table 2. Plants Sample Collected from the Market.

Botanical name	Common name	Family	Part of the plant
<i>Adiantum capillus-veneris</i>	Avenca	<i>Pteridaceae</i>	S
<i>Momordica charantia</i>	Bitter Melon	<i>Cucurbitaceae</i>	F
<i>Eugenia jambolana</i>	Jambul Seeds	<i>Myrtaceae</i>	S*
<i>Gymnema sylvestre</i>	Gurmar	<i>Asclepiadaceae</i>	L
<i>Allium sativum</i>	Garlic	<i>Amaryllidaceae</i>	C
<i>Trigonella foenum-graecum</i>	Fenugreek	<i>Fabaceae</i>	S*
<i>Pongamia glabra</i>	Karanjwa	<i>Leguminaceae</i>	S*
<i>Sphaeranthus hirtus</i>	Paneer herb	<i>Asteracea</i>	L+F
<i>Clerodendrom inerme</i>	Dum Dum	<i>Verbenaceae</i>	L

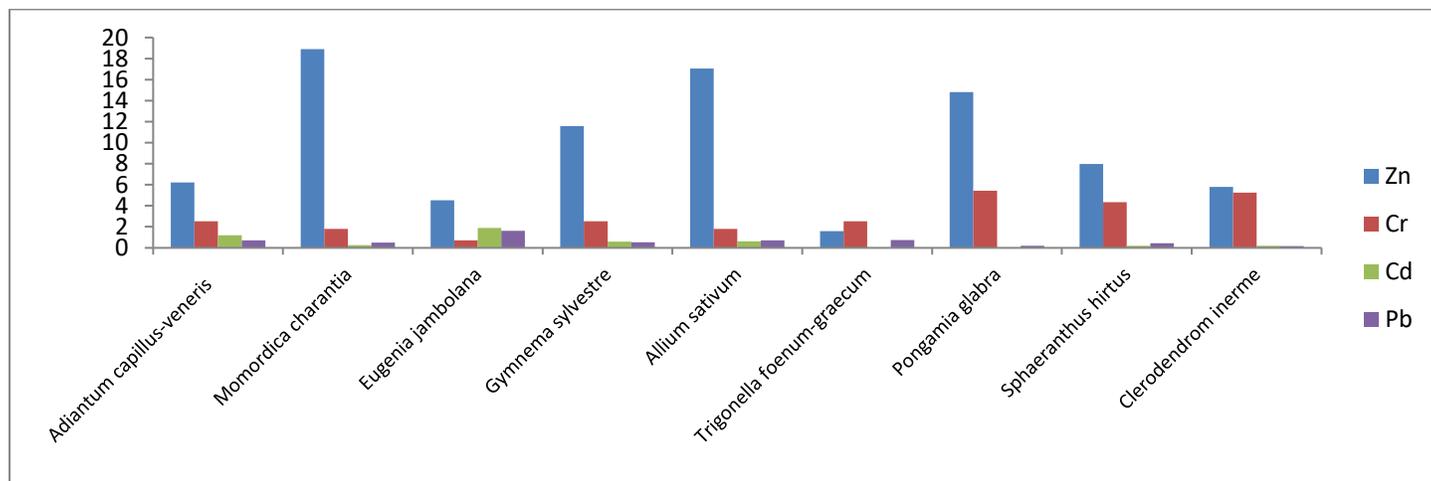
Stems, F=Fruits, L= Leaves, C= Cloves S*= Seed

Plants absorbed minerals and heavy and essential metals in varying concentrations depend upon their rate of transportation from soil & water, deposit it in various parts for their sustainability but higher concentration of these metals is toxic to most of the plants. Presented study was organized to determine the toxic metal concentration in selected Anti-diabetic medicinal plants used as herbal medication by the local residents. The amount of Lead, Cadmium, Chromium, and Zinc in medicinal plants (*Adiantum capillus-veneris*, *Momordica charantia*, *Eugenia jambolana*, *Gymnema sylvestre*, *Allium sativum*, *Trigonella foenum-graecum*, *Pongamia glabra*, *Sphaeranthus hirtus* and *Clerodendrom inerme*) extracted in water and acid (mention its name and concentration) are given in Table (3, 4) and Fig. (1, 2).

Table 3. Concentration ($\mu\text{g/g}$) of heavy metals in selected medicinal plants extracted in water.

Medicinal Plant	Zn	Cr	Cd	Pb
<i>Adiantum capillus-veneris</i>	6.225 \pm 2.40%	2.536 \pm 0.80%	1.200 \pm 1.90%	0.712 \pm 0.63%
<i>Momardica charantia</i>	18.90 \pm 2.00%	1.811 \pm 2.40%	0.250 \pm 1.30%	0.501 \pm 0.25%
<i>Eugenia jambolana</i>	4.525 \pm 0.60%	0.724 \pm 4.70%	1.900 \pm 0.60%	1.607 \pm 0.16%
<i>Gymnema sylvestre</i>	11.57 \pm 1.70%	2.536 \pm 2.00%	0.600 \pm 0.70%	0.518 \pm 0.49%
<i>Allium sativum</i>	17.05 \pm 0.30	1.811 \pm 0.60%	0.620 \pm 0.60%	0.725 \pm 0.20%
<i>Trigonella foenum-graecum</i>	1.600 \pm 3.10%	2.536 \pm 1.50%	ND	0.754 \pm 0.64%
<i>Pongamia glabra</i>	14.82 \pm 2.70%	5.434 \pm 3.50%	ND	0.214 \pm 0.47%
<i>Sphaeranthus hirtus</i>	7.975 \pm 0.00%	4.347 \pm 2.30%	0.200 \pm 2.80%	0.451 \pm 0.10%
<i>Clerodendrom inerme</i>	5.800 \pm 0.40%	5.253 \pm 0.40%	0.200 \pm 1.20%	0.183 \pm 0.72%

ND= not detected

**Fig 1.** Concentration of HMs in selected medicinal plants extracted in water.**Table 4.** Concentration ($\mu\text{g/g}$) of heavy metals in selected medicinal plants extracted in acid.

Medicinal Plant	Zn	Cr	Cd	Pb
<i>Adiantum capillus-veneris</i>	62.00 \pm 1.60%	9.225 \pm 0.50%	6.00 \pm 1.70%	6.00 \pm 0.50%
<i>Momardica charantia</i>	72.25 \pm 2.40%	6.975 \pm 0.40%	3.00 \pm 2.90%	3.50 \pm 4.90%
<i>Eugenia jambolana</i>	27.75 \pm 0.90%	6.100 \pm 0.40%	2.50 \pm 1.20%	3.25 \pm 1.00%
<i>Gymnema sylvestre</i>	107.0 \pm 0.70%	2.003 \pm 2.00%	3.30 \pm 1.30%	4.50 \pm 3.10%
<i>Allium sativum</i>	57.25 \pm 0.90%	6.175 \pm 1.20%	1.50 \pm 2.50%	0.30 \pm 1.50%
<i>Trigonella foenum-graecum</i>	110.75 \pm 2.90%	2.268 \pm 1.80%	0.20 \pm 0.20%	15.50 \pm 1.74%
<i>Pongamia glabra</i>	96.75 \pm 2.70%	1.233 \pm 1.00%	0.30 \pm 1.10%	0.75 \pm 2.35%
<i>Sphaeranthus hirtus</i>	68.00 \pm 4.40%	1.193 \pm 4.20%	0.80 \pm 1.30%	4.25 \pm 4.10%
<i>Clerodendrom inerme</i>	69.00 \pm 0.40%	1.008 \pm 0.70%	0.95 \pm 1.30%	5.00 \pm 2.50%

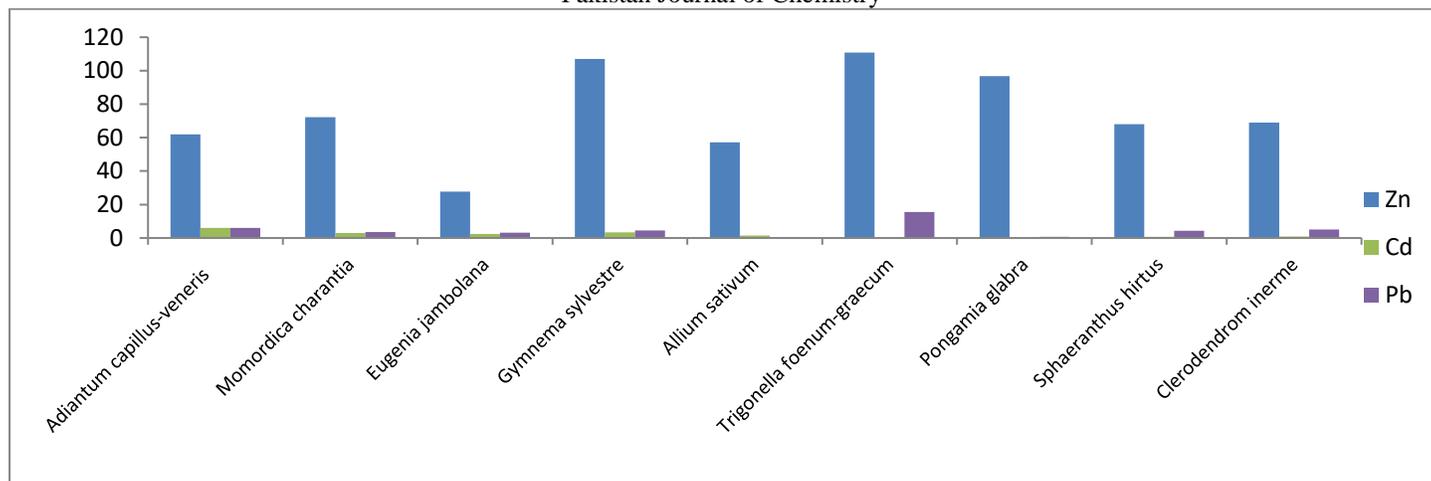


Fig 2. Concentration of various HMs in selected medicinal plants extracted in Acid

Zn is essential trace metal having a vital role in various cell actions like normal growth, brain development, behavioral response and wound healing [24]. Zn is the main component of many plant proteins and metallo-enzyme specifically the enzyme which plays an important role in nucleic acid metabolism but large quantity of Zn can be injurious and responsible for Zn toxicity. Zn intoxication causes the same symptom of illness as lead does such as nausea, vomiting, diarrhea, fever and laziness.

In present study *Momordica charantia* (18.90 µg/g ±2.00%) contained the highest amount of zinc followed by *Allium sativum* (17.05 µg/g ±0.30%) while in *Pongamia glabra* leaf (14.82 µg/g±2.70%), *Adiantum capillus-veneris* (6.225 µg/g ±2.40%), *Eugenia jambolana* (4.525 µg/g ±0.60%), *Gymnema sylvestre* (11.57 µg/g ±1.70%), *Sphaeranthus hirtus* (7.975 µg/g ±0.00% µg/g), *Clerodendrom inerme* (5.800 µg/g ±0.40%) while the least concentration found were in the seed of *Trigonella foenum-graecum* (1.600 µg/g ±3.10%). The amount of the trace metal were determined within the permissible level of WHO (Table 1). Contrary to the investigation of [26] who reported the maximum value for Zn 5.21 mg/Kg in the leaves of *D. alba* our result were relatively high.

Zinc is one of the most important nutrient present 85 percent in muscle and bones 11% in skin and liver tissue while rest in other body tissues [27]. Its deficiency causes the loss of sensitivity (touch and smell) and excess causes abdominal pain, nausea, vomiting and diarrhoea.

Cr is considered among one of the highly toxic element in the world released by tanneries, steel industries and sewage sludge executions along with alloys in motor vehicles. The biological activity of chromium depends on its electronic state (Valence state) and complexes it forms like Cr⁺³ is required for the optimal glucose uptake by cells. Cr regulates insulin and blood glucose while their deficiency increases the blood glucose which may lead to the development of diabetes. Chromium uptakes of 5-30µg/g are considered lethal for the plant as it causes depletion in plant growth and yield.

The permissible level for Chromium in raw and finished plant products given by WHO [28] indicates that among all the samples tested three species i.e. (*Eugenia jambolana* 0.724 µg/g ±4.70%, *Momordica charantia* 1.811 µg/g ±2.40%, *Allium sativum* 1.811 µg/g ±0.60%) contained the element relatively smaller than the limit. However, the remaining species (*Adiantum capillus-veneris*, *Gymnema sylvestre*, *Trigonella foenum-graecum*, *Pongamia glabra*, *Sphaeranthus hirtus* and *Clerodendrom inerme*) had concentration of Cr almost two times higher than WHO limit (Table- 3). Similar results were recorded by Kulhari et al. (2013) [17] as they reported only one plant having Cr concentration within the standard permissible limit set by World health organization.

Cr is an important element required for the normal glucose metabolism and insulin production in pancreas. However, toxic effects of Chromium intake causes severe injuries like nose irritations, skin rash, bleeding, stomach, liver kidney, lung and nasal itches. Also, in Cr^{+4} valance state its behavior has been observed to have carcinogenic causing lung cancer [8].

Cadmium (Cd) too is toxic metal which can inversely affect the plant production at the amount ranging from 5-30 $\mu\text{g/g}$ [17]. In recent years prevalent cadmium accumulation in water, dietary products, soil, milk, herbal plant and their remedies has raised concerns among researchers [17]. The main sources of guiding cadmium deposition to plants and soil are phosphate fertilizers, smelters (non-ferrous), mines of lead and zinc, sewage sludge utilization and combustion of fossil fuels. High concentration of cadmium reduces calcium absorption, which results in Itai-Itai disease showing signs such as non-stiffening of skeleton, anemia, renal damage and eventually death [21]. Cadmium accumulation in the body replaces zinc (Zn) biochemically causing hypertension.

In current study, all tested samples were analysed for cadmium concentration. Among all the species, *Adiantum capillus-veneris*, *Eugenia jambolana*, *Gymnema sylvestre*, *Allium sativum* possessed 2-4 times higher level of the recommended permissible limit. Whereas the levels of cadmium analysed were below the minimum detectable range for *Trigonella foenum-graecum*, *Pongamia glabra*. Similar results were reported by Annan et al. (2013) [20] who found all the collected samples with Cd concentration exceeding the WHO threshold level. However, Begum et al. (2017) [7]; Sindu and Beena (2016) [29] and Maobe et al. (2012) [24] reported all tested samples within permissible limit set by WHO [30].

Intoxication of Cadmium above tolerable limit may result both kind of poisoning (acute and chronic) like irreversible damages of kidney, liver, vascular and immune system [31].

Lead (Pb) is the most common and abundant heavy metal existing in the environment. Lead is considered perilous to animal, plants and micro-organism. The nonstop usage of fertilizer, fuel combustion and sewage sludge are the major sources of rising lead concentration [17]. Lead is non-essential metal incorporated into the body by ingestion, inhalation causes serious body poisoning like heart, kidney, nerves, blood, generative and digestive system [32,33]. Fatal doses of the lead stimulating serious diseases leading to permanent difficulties with cerebrals issues [7]. Their poisonous causes nuisance, anemia, stomach pain and irritability. In critical situations, it may cause seizure, coma and even death [34,21]. The plant tissues tested (stem, leaves, fruit, seed, cloves) contained remarkably lower concentration of lead compared to the permissible level of world health organization.

Maximum amount of lead was found $1.607 \pm 0.16\%$ ($\mu\text{g/g}$) in *Eugenia jambolana*. the lead (Pb) content in *Adiantum capillus-veneris* was $0.712 \mu\text{g/g} \pm 0.63\%$, *Momordica charantia* $0.501 \mu\text{g/g} \pm 0.25\%$, *Gymnema sylvestre* $0.518 \mu\text{g/g} \pm 0.49\%$, *Allium sativum* $0.725 \mu\text{g/g} \pm 0.20\%$, *Trigonella foenum-graecum* $0.754 \mu\text{g/g} \pm 0.64\%$, *Pongamia glabra* $0.214 \mu\text{g/g} \pm 0.47\%$, *Sphaeranthus hirtus* $0.451 \mu\text{g/g} \pm 0.10\%$ and $0.183 \mu\text{g/g} \pm 0.72\%$ for *Clerodendrom inerme*. The permissible limit of lead revealed that all medicinal plant carries fewer amounts than permissible (Table 1). The level of Pb below permissible limit recommending that toxicity could be rise from long term exercise/application of these plants. Our results corroborated with those of Begum et al. (2017) [7] and Sindu and Beena (2016) [29] who reported less concentration of lead comparable to the global standards.

Lead can cause high blood pressure and excessive weakening effects to the organs, mostly affects the central nervous system. The typical symptoms of lead intoxication are nausea, headache, fatigue, and anemia [8].

4. Conclusion

Medicinal plants are the sources of active ingredients, used to cure diseases varying from acute coryza (common cold) to genetic disorder. However continuous environmental pollution leads to the accumulation of heavy metals (Pb, Cd, As,

Hg) in soil, water and ultimately to our food chain. In most of the cases, water extracts of the herbs are taken for the treatment of ailment but few are taken as whole (e.g. *Momordica charantia* and *Eugenia jambolana*). Metals from these medicinal plant may be extracted during acid digestion in stomach, therefore in parallel to the water extract acid digested samples were also taken for evaluation of the total heavy metal contents in selected medicinal plants. Our study indicated that the value of Chromium and Cadmium were slight above the permissible limit and might become chronically dangerous. Therefore it is strongly recommended that medicinal herbs for the production of herbal medicine should be harvested and collected from non contaminated areas. On the basis of our study it is suggested that there should be strict and stringent quality control system to check the heavy metal contamination in medicinal plant or part of plant used for various diseases to assure the safety aspects concerned human consumption.

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