Elemental Analysis of Selected Medicinal Plants by Heavy Metal Composition and Pharmacological Implications in District Lakki Marwat

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Abstract

In this research, we investigated an elemental study of selected medicinal plants collected from different areas of district Lakki Marwat, for better understanding, we were taken seeds and plants of selected medicinal plants. Our study sought to evaluate the pharmacological and health risks that may be related to these plants' elemental compositions. The results showed varying levels of heavy metal contamination across the different plant species. Lead (Pb) concentrations were particularly high in *Pennisetum glaucum* (seed) at 8.05 mg/kg, followed by *Coriandrum sativum* (l) at 4.96 mg/kg and *Cicer arientinum* (s) at 4.71 mg/kg, raising concerns about potential negative health effects. On the other hand, zinc (Zn), a trace element that is vital for immunological function, was found in higher concentrations in *Pennisetum glucam* (seed) at 2.19 mg/kg, suggesting that it may play a part in augmenting the therapeutic qualities of these plants. Amounts of copper (Cu) were also noteworthy; leaves of Coriandrum sativum (l) had amounts of 1.42 mg/kg and 2.19 mg/kg, respectively, indicating that this plant may be harmful and should be handled with caution. The element iron (Fe), which is necessary for all living things, was discovered in large quantities, especially in *Pennisetum glaucum* seed (6.3 mg/kg). Last but not least, the presence of the hazardous metal cadmium (Cd) at high concentrations in Coriandrum sativum (l) at 0.08 mg/kg caused alarm. A comparative examination of the metal concentrations in these particular plants highlights the need to evaluate the presence of heavy metal contamination in conventional medical practices and stresses the significance of developing protocols for the appropriate use of herbal treatments. These findings provide important new understandings of the molecular makeup of medicinal plants and their possible pharmacological effects, which will help traditional healthcare systems employ these plants in a safer and more knowledgeable manner.

Key words:

Heavy metal contamination, Health risks, Lakki Marwat, and Pharmacological implications.

Introduction

Medicinal plants have indeed been extensively used throughout history as valuable sources of therapeutic agents, offering remedies for a wide range of ailments across different cultures[1]. These plants contain a plethora of secondary metabolites that possess medicinal properties, making them crucial in drug discovery and development. Traditional medicinal plants have contributed significantly to modern medicine by providing compounds with anti-microbial, antioxidant, anticancer, and anti-inflammatory properties. The rich diversity of phytochemicals found in plants like polyphenols, alkaloids, terpenes, and polysaccharides has shown promising therapeutic potential in treating various health conditions[2-3]. The World Health Organization (WHO) acknowledges the importance of traditional herbal medicine, highlighting that approximately 80% of the global population depends on medicinal plants for healthcare, especially in regions with restricted access to modern medicine. This reliance on traditional herbal remedies is particularly prevalent in developing countries, where these natural treatments play a vital role in addressing various health concerns and maintaining well-being[4]. The significance of medicinal plants extends beyond their therapeutic potential, encompassing crucial roles in biodiversity conservation, ecosystem sustainability, and cultural heritage. Many medicinal plant species are endemic or endangered, emphasizing the need for their preservation to safeguard biodiversity for future generations[1].

Elemental analysis of medicinal plants plays a crucial role in assessing their quality, safety, and efficacy. Heavy metals, such as lead, cadmium, and mercury, can accumulate in plants through various environmental sources, posing serious health risks to consumers[5-6]. Contamination of medicinal plants with heavy metals can result from anthropogenic activities such as industrial emissions, agricultural practices, and improper waste disposal[7]. The presence of heavy metals in medicinal plants can indeed jeopardize their therapeutic efficacy and pose significant health risks to humans. Chronic exposure to heavy metals through the consumption of contaminated herbal products has been linked to various adverse health effects, such as neurotoxicity, nephrotoxicity, and carcinogenicity[8]. Studies have highlighted the potential dangers associated with heavy metal contamination in medicinal plants, emphasizing the importance of stringent quality control measures and regular monitoring to ensure the safety and effectiveness of herbal remedies for consumers[9]. Elemental analysis techniques, such as atomic absorption spectroscopy (AAS), inductively coupled plasma mass spectrometry (ICP-MS), and X-ray fluorescence (XRF), enable the quantification of heavy metal concentrations in medicinal plants with high sensitivity and accuracy[10]. These analytical methods play a crucial role in ensuring compliance with regulatory standards and quality control measures for herbal products[9]. Furthermore, elemental analysis can provide valuable insights into the geographical origin, environmental conditions, and cultivation practices of medicinal plants, which may influence their chemical composition and pharmacological properties[11]. By identifying and monitoring the presence of heavy metals in medicinal plants, stakeholders can take proactive measures to mitigate contamination risks and safeguard public health[12].

District Lakki Marwat, located in the Khyber Pakhtunkhwa province of Pakistan, is characterized by a rich biodiversity of medicinal plants due to its diverse climatic and geographical features. This region serves as an important hub for the cultivation and utilization of medicinal herbs, contributing significantly to traditional healthcare practices and local economies[13]. This study aims to investigate the heavy metal composition of selected medicinal plants in District Lakki Marwat and assess their pharmacological implications and potential health risks to provide insights into their safety and therapeutic value.

Materials and methods

Study area:

This study was conducted in district Lakki Marwat, which are in the northeast part of Khyber Pakhtunkhwa province of Pakistan, as shown in figure 1. This district has total 3164 km^2. There are four seasons in this district. The climate is so harsh, with very hot summer and very cold winter. The average rainfall is low and usually occurs in July and August

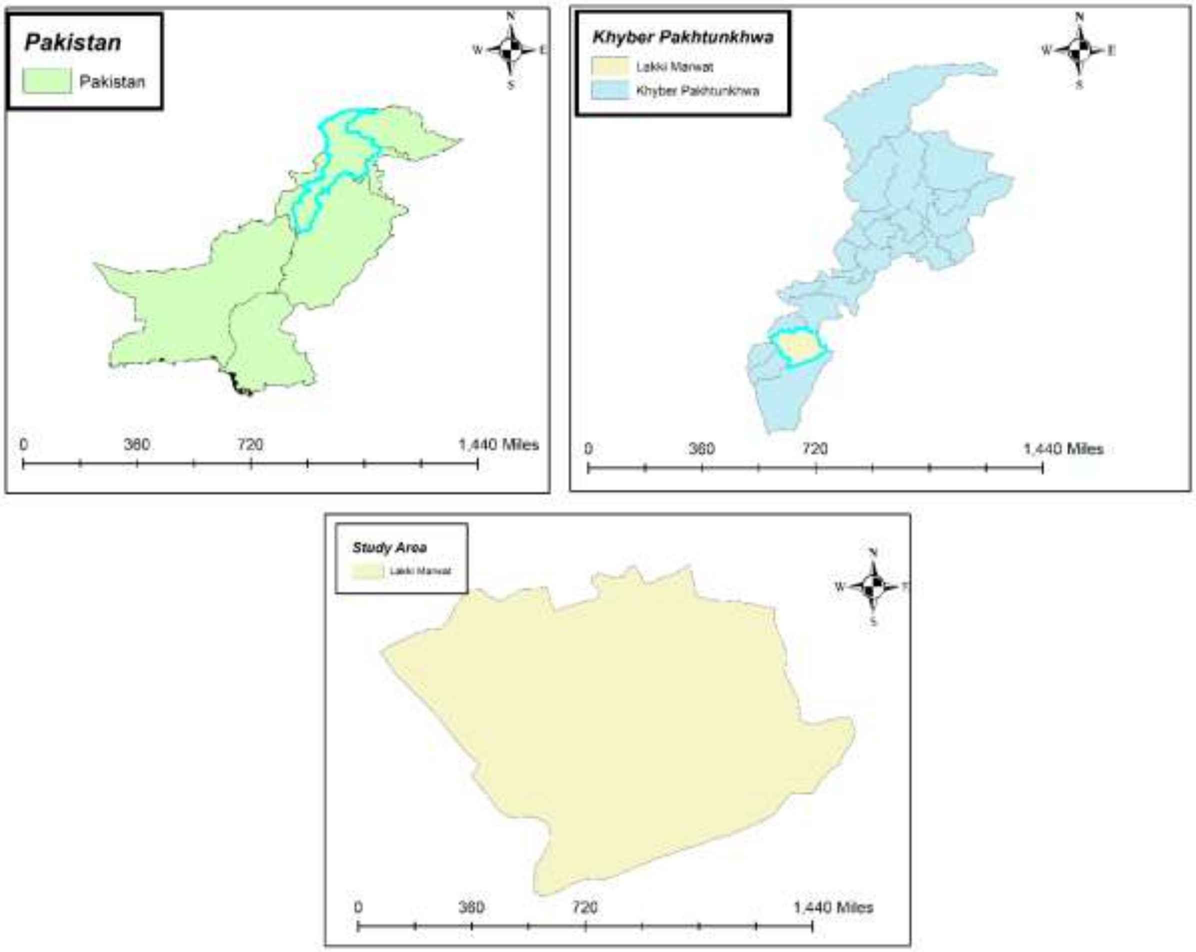

Figure 1. Study area map of district Lakki Marwat, map created through ArcGIS 10.8.2:

Selection of plants and sample collection:

The plants were selected based on their presence of numbers, their medical importance, and their uses. Totally eight plants were selected in this research study (table1). Leaves and seeds of these plants were taken as sample through proper protocol and bring up in Botanical Laboratory of KUST, for further analysis.

Table 1: Detail about selected plants and their collocated parts use in this study:

S. No	Plant name	Collected parts
1	*Cicer arientunum*	Seed
2	*Papaver sominiferum*	Seed
3	*Coriandrum sativum*	Leaf

4	*Pennesitum glucam*	Seed
5	*Triticum aestivum*	Seed
6	*Brassica campestris*	Seed
7	*Tachyspermum ammi*	Seed
8	*Calutropus*	Leaf

Preparation of Plant extraction:

The collected parts of selected parts relevant to medicinal use were clean and dried at room temperature, and subsequently grinded into fine powder. The powdered material from each plant was added to 20ml Falcon tubes along with the plant powder and ethanol. After covering the tubes with aluminium foil, they were regularly shaken for one week. The resulting solutions were filtered, heated, and condensed into sealed Falcon tubes holding 5ml each.

Preparation of plant digestion:

The extracted solution of selected plants was digested into by dividing the contents into 5 ml parts and filling each beaker with 5 ml of nitric acid. The mixture was heated at 35C with continuously shaking until the mixture to solidified.

Preparation of PPM solution:

Each beaker was filled with 100ml of distilled water and 1.5 ml of the digested solutions that had been made. The final 100ml solutions were then labelled, put into bottles, and delivered to KUST's Chemistry Department for atomic absorption analysis.

Trace elements analysis:

Atomic Absorption Spectrometry (AAS) was used to analyze micronutrients, such as lead (Pb), zinc (Zn), copper (Cu), iron (Fe), and cadmium (Cd), in the acid-digested plant samples, followed by proper protocol developed by[14]. The formula used to compute the concentrations of these elements was Elements (ppm) = µg/ml x 100 / Sample wt. (gram), where dilution adjustments were made if the starting volume was 100 ml. Furthermore, 4 ppm stock solutions of these elements were made and subjected to AAS analysis

RESULT

In the present study, heavy metals like Pb, Cd, Fe, Cu and Zn were determined in the seeds and leaves of selected plants.

Lead (Pb):

Lead concentration was recorded higher in *Pennisetum glaucum* (seed) 8.05 mg/kg followed by *Coriandrum sativum* (leaf) 4.96 mg/kg and *Cicer arientinum* (seed) 4.71 mg/kg while lower was recoreded in *Trachyspermum ammi (seed) 1.95mg/kg* and *Calutro*upas (leaf) 1.96mg/kg respectively.

Zinc (Zn):

In this study, Zn higher concentration was recorded in *Pennisetum glucam* (seed) 2.19 mg/kg, followed by Coriandrum sativum 1.4 mg/kg while lower concertation was recorded in Triticum aestivum 0.87mg/kg.

Copper (Cu):

Cu concentration was higher noted in in *Coriandrum sativum* 2.19 mg/kg while lower was recorded in *Calutro*upas 1.08mg/kg.

Iron (Fe):

The higher concentration of Fe was recorded in *Pennisetum glaucum* plant 6.3 mg/kg followed *Cicer arientinum* 4.59 mg/kg while lower was noted in Papersominiferum 2.06mg/kg.

Cadmium (Cd):

The Cd concentration was higher in *Calutro*upas *0.09mg/kg and Coriandrum ativum* 0.08mg/kg while not detected in *Cicer arientinum* , *Papersominiferum, Triticum aestivum and Trachyspermum ammi respectively.*

Table 2: Showing detail about concentration of heavy Matels in selected plants of district Lakki Marwat:

Plant Name	Pb	Zn	Cu	Fe	Cd
Cicer arientinum (s)	4.71±0.102	1.15±0.007	1.35±0.02	4.59±0.13	nd
Papersominiferum (s)	2.86±0.002	1.35±0.02	1.15±0.007	2.06±0.009	nd
Coriandrum sativum (l)	4.96±0.006	1.42±0.004	2.19±0.01	3.91±0.006	0.08±0.04
Pennisetum glaucum (seed)	8.05±0.09	2.19±0.01	1.14±0.15	6.30±0.084	0.05±0.01
Triticum aestivum(s)	2.33±0.01	0.87±0.03	1.11±0.07	2.90±0.004	nd
Brassica campestris (s)	2.52±0.02	1.14±0.15	1.34±0.53	2.95±0.036	0.01±0.02
Trachyspermum ammi (s)	1.95±0.007	1.11±0.07	1.17±0.09	3.68±0.000	nd
*Calutro*upas (l)	1.96±0.13	1.34±0.53	1.08±0.07	2.68±0.000	0.09±0.05

± Standard Deviation., l: leaf, s: seed, nd: not detected, WHO permissible limits for Pb: 10 mg/kg&Cd: 0.3 mg/kg.

Discussion

Medicinal plants play a crucial role in traditional healthcare systems worldwide, including Pakistan, where they are often relied upon for their therapeutic properties. These plants contain various bioactive compounds that possess medicinal properties and have been used for centuries to treat various ailments[15]. The presence of heavy metals in medicinal plants raises concerns about their safety for human consumption. Accumulated heavy metals in plant tissues can compromise the therapeutic efficacy of medicinal plants and, in some cases, pose health risks to consumers due to their toxic effects[16]. This study investigated the heavy metal content in selected medicinal plants from the District of Lakki Marwat, focusing on the implications of the findings for pharmacological use. Our analysis revealed significant variations in the concentrations of lead (Pb), cadmium (Cd), iron (Fe), copper (Cu), and zinc (Zn) across different plant species. These variations highlight the complex interplay between plant physiology and environmental exposure to heavy metals, which has crucial implications for the medicinal use of these plants.

We observed the highest concentration of Pb in *Pennisetum glaucum* (seed) at 8.05 mg/kg, a level that is concerning due to Pb's known neurotoxicity. Comparatively, Coriandrum sativum (leaf) and *Cicer arientinum* (seed) also showed elevated Pb levels at 4.96 mg/kg and 4.71 mg/kg, respectively. These concentrations surpass the safety limits recommended by the WHO, highlighting a significant risk to human health. This contrasts with the lower Pb concentrations found in Trachyspermum ammi (seed) at 1.95 mg/kg and Calutroupas (leaf) at 1.96 mg/kg, suggesting species-specific accumulation trends[17]. Assessment of heavy metal contamination in vegetables grown in and around Nashik City, Maharashtra State, India. *IOSR J. Appl. Chem*, *5*, 9-14. noted similar Pb accumulation patterns, yet our findings indicate a broader geographic prevalence of Pb contamination, extending to areas with minimal industrial activities, thus hinting at widespread environmental Pb pollution.

Zinc, an essential nutrient, was found in the highest concentration in *Pennisetum glaucum* (seed) at 2.19 mg/kg, suggesting its potential as a biofortification candidate. However, when compared to the findings of[18-19]; who reported lower Zn levels in similar species, it underscores the variable nature of heavy metal uptake by plants. Copper's highest concentration was noted in Coriandrum sativum at 2.19 mg/kg, aligning with EFSA's safe consumption thresholds. Yet, the health implications of consuming plants with high Cu levels, especially over prolonged periods, remain a topic of concern, warranting further investigation.

The substantial Fe content observed in *Pennisetum glaucum* at 6.3 mg/kg offers a promising avenue for addressing iron-deficiency anemia, prevalent in many developing regions. This finding correlates with the work of[20], who emphasized the potential of utilizing iron-rich plants as dietary supplements. Nonetheless, the risk of iron toxicity, particularly in populations with conditions like hemochromatosis, necessitates a cautious approach to such interventions.

Although the Cd levels were relatively low across most samples, the highest concentrations found in Calutroupas at 0.09 mg/kg and Coriandrum sativum at 0.08 mg/kg raise significant concerns due to Cd's carcinogenicity. These levels, while low, underscore the importance of continuous monitoring and regulation, as suggested by[21], given Cd's adverse health effects, even at trace concentrations.

Conclusion

It is concluded that the presence of elevated lead levels in Cicer arietinum and detectable cadmium in Brassica campestris and Pennisetum glaucum underscores the need for systematic monitoring and regulatory enforcement to ensure the safe use of medicinal plants.

Informed Consent Statement

Not applicable.

Data Availability Statement

All data generated or analyzed during this study are included in this published article. The datasets used and/or analyzed during the present study are available from the first author upon reasonable request.

Conflicts of Interest

The authors declare no conflict of interest.

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