

An attitude towards the effects of heavy metals in medicinal plants

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Abstract

Heavy metals are naturally occurring elements that can be found in soil and water. They are essential for many biological processes but can also be toxic to humans when present in high concentrations. Medical plants, which are used for their therapeutic properties, may accumulate heavy metals in the soil. The accumulation of heavy metals in medical plants poses a significant risk to human health as these plants are often consumed as herbal remedies or dietary supplements. Long-term exposure to heavy metals such as lead (Pb), mercury (Hg), cadmium (Cd), and arsenic (As) can cause serious health problems such as neurological damage, kidney damage, cancer and developmental disorders. Therefore, it is important to ensure that medical plants are grown in areas with free or less contamination by heavy metals. Additionally, proper processing techniques should be employed to remove any residual heavy metal content before consumption. This review article tries to address and review related scientific papers in regard to heavy metals in medical plants.

Keywords: Medicinal plants, Heavy metals, Health, Herbs, Toxicity, Ayurveda, Rasashastra

1. Introduction

Herbs are plants that are used for various purposes, including medicinal, culinary, and aromatic. They contain a wide range of chemical compounds, such as essential oils, alkaloids, and flavonoids, which give them their characteristic properties [1]. In addition to their medicinal properties, herbs also play an important role in bio-systems. They are often used to create natural habitats for wildlife, provide food and shelter for insects and birds, and improve soil quality. Some herbs are also used in the production of cosmetics, perfumes, and other products [2-3]. Herbs have been used for medicinal purposes for thousands of years, and their use can be traced back to ancient civilizations such as the Greeks, Romans, and Egyptians [1-4]. It is estimated that between 20 till 30 thousand herbs exist, one tenth are being consumed in medical and none-medical purposes However, the distribution and application of herbs in the world is still not clearly mapped [5-8]. Currently, a small number of studies regarding herbal plant safety and positive effects are available. For example, several confirmed cases showed dangerous lead effects on human health [9-10]. The scientific field that deals with the toxicity of heavy metals is Phytotherapy research. Phytotherapy, which involves the use of plants and their extracts for therapeutic purposes, is gaining popularity as a natural alternative to conventional medicine. However, it is important to consider the possible contamination of medicinal plants with toxic heavy metals, which can have negative health effects. Heavy metal contamination in water can be generated from various sources, including industrial

discharges, mining activities, agricultural runoff, and natural weathering of rocks and soil. Some industrial activities that commonly contribute to heavy metal pollution include mining, smelting, electroplating, battery manufacturing, and chemical production. Despite these mentioned cases, the analytical methods for detecting toxic metals in plants have not yet achieved particular progress in summarizing and proving generalities in similar studies, which requires more comprehensive investigations on the regions and plants of the same region or comparing them with each other [11-13]. The scientific community uses different terminology in explaining heavy metals, such as Toxic metals. Toxic materials and Heavy metals, all refereeing to chemical elements like lead, mercury, arsenic, cadmium, iron, copper and etc. [14,15].

2. Definition of heavy metals

These elements are known with atomic numbers higher than 20, sometimes identified as metals whose weight is 6 grams per cubic centimeter. It should be noted that most heavy metals are classified as toxic metals and the basis of their classifications is between 1 and 1000 mg on the soil. These metals have the potential to accumulate in soil and water, and by penetrating and accumulating in different parts of plants and animals, so directly or indirectly used by humans. In general, the presence of metals in the soil is considered a natural thing, but it should be within the standard level of absorption by plants and animals [14, 15, 49].

3. Method

Considering the importance of the subject and the accuracy of the desired information, we screened the most popular publishers, Scopus, Elsevier, Taylor & Francis and Google Scholar, entering the keywords: heavy metals, medicinal plants, modern and traditional methods of measuring heavy metals in plants and vegetables, medicinal plants and food safety status, etc. We have collected more than 40 related articles and reviewed various studies in the field of toxicity elements and observed their effect on the use of medicinal plants.

4. Health related factors and heavy metals

The high content of heavy metals can cause very negative effects on the human body. Increasingly, every day due to the high agricultural usage of fertilizers and pesticides, their entry into the environmental system, which directly leach heavy metals into the ground, harming the soil and plants, and later humans [49]. However, it's a fact that some of the elements found in fertilizers are inseparable and essential elements for the plants survival [16]. Arsenic (As) is known as a toxic heavy metal and causes lack of vitamin A in our body, which is followed by heart issues and night blindness [17]. It is known that acute arsenic toxicity causes serious symptoms within just 30 minutes of ingestion. In addition, it leads to other symptoms like dryness of the mouth, difficulty swallowing, nerve pain, vomiting, nausea, stomach pain, and diarrhea [17]. Further, Arsenic exposing leads to other known disorders, like skin pigmentation, skin cancer, hyperkeratosis of the feet and hands, and liver failure [18-19]. Exposing to cadmium remarkably induced renal damage, cancer, and pulmonary fibrosis. Cd (cadmium) is categorized as a carcinogenic agent, in and in low doses, it causes more harm than other essential elements, such as zinc, calcium, copper, and iron [20, 21]. Health implications of aluminum (Al) are wide, including neurological disease and Alzheimer, cardiovascular diseases and different brain disorders [21-22]. Several studies demonstrated that heavy metals exist in herbs, such as Cu, Fe, Zn, Mn, Cr, Ni, Pb, Se, As, and Cd, [22-23], but also in common vegetables as well [50].

4.1. Assessment of heavy metals in herbs with case studies

The need for medicinal plants is increasing due to their reduced side effects and growing popularity. Medical plants are declared as pure, secure and healthy. However, several medical plants may over accumulate heavy metals or toxic metals, as found in different kale varieties [24-25, 50].

A primary goal for the scientific community is to evaluate the herb ability to accumulate diverse heavy metals and its implications to human health. Based on the absorption capabilities in the tissues of herbs, we could distinguish and indicate their geographical locations. Soil contamination may have unique heavy metal accumulations, different acidity and the presence of different metal-bearing minerals, where increased absorption may be found in cultured areas located in mountain regions. For example, in India, a medical system, known as Ayurveda, is used, based on ancient writings that rely on a "natural" and holistic approach to physical and mental health. Another medical system, known as Rasashastra, an ancient way of deliberately mixing herbs with elements (eg: Hg, Pb, Fe, Zn) and Minerals (eg: mica) and gems (eg: pearl) [26-29]. Based on these systems, some plants are known to include heavy metals concentration as a mixture or a combination. For the detection of heavy metals in plants and soil, several methods are used. Detection of lead concentration on herbs

by Pre-concentration Flow injection analysis and Flame Atomic Absorption Spectrometry is used to analyse different herbs and vegetables. For example in India, the concentration of heavy metals, namely Pb, Cd, Cu (Copper) and Zn (Zinc) were estimated and labeled for many herbal drugs in different market of the country. These plants included *Alpinia galanga*, *Artemesia parviflora*, *Butea monosperma*, *Coleus forskohlii*, *Curcuma amada*, *Euphorbia prostrata*, *Leucas aspera*, *Malaxis accuminata* and *Pueraria tuberosa*. The amount of Pb and Cd was measured beyond the WHO permissible limits in most samples [26]. Bio-concentration of toxic metals in five local species of herbs and five mangrove species in India was studied and the average amount of lead in mangrove samples was 1.75 times that of Inland plants, where mercury was around 11.31 times that of Inland plants [27-28].

Detection of some distinguished heavy metals such as lead, mercury and arsenic were conducted in one project from the USA, which has shown high amount of heavy metals in domestic vs. Indian manufactured drugs. Another effort carried out to measure the concentration of heavy metals with their medical efficacy in Bhasma, known for its ability to maintain optimum alkalinity for optimum health, neutralizing harmful acids that lead to illness; because Bhasma do not get metabolized, so they don't produce any harmful metabolite, rather it breakdowns heavy metals in the body [28]. Increasingly, several similar studies support the traditional application Bhasma in daily lives [29].

Detection of heavy metals was conducted in twenty-seven cases of herbs in several regions in Bielsko Biata [30]. This study used different analytical methods and extractions, using disposable electrochemical sensors. Detailed guidelines for the heavy metal measurement were incorporated into the Indian government in 2004 [31]. Furthermore, two different digestion protocols for Cd, Pb and Zn measurement, named microwave assisted total digestion and an aquaregia extraction procedure, both based on international organization for standardization 11466 method, were validated and declared a fast, low-paid, and simply automated digestion way for showing toxic element concentration in natural outside samples [32]. Detection of Fe, Zn, Pb, Cd and Se (Selenium) heavy metals by X-Ray Fluorescence analysis and Galvanostatic stripping chronopotentiometric analysis was conducted in *Melissa officinalis* L, *Agrimonia eupatoria* L, *Hypericum perforatum* L, *Salvia officinalis* L., and *Achillea millefolium* L was done [33]. Similar detection methods were implemented in the *Typha latifolia* herb, using chromatography and mass spectrometry, concluding that As and Fe (Iron) elements are accumulated in the skin part of latifolia [34]. Analysis of high toxic metals concentrations, using above mention methods, was done with 12 different varieties Chinese crude herbs [35]. The concentration of lead and cadmium varied extensively, recommending that special focus needs to be addressed on the origin of those varieties [35, 36]. Evidence from various countries implies that toxic heavy metals and undeclared prescription drugs in herbal medicines might constitute a serious health problem [37, 39].

Another study showed that heavy metals concentration (Pb, Cd, Cr and Ni), collected from several randomly chosen herbs, heavy traffic locations, industrial places and residential regions showed different alarming results, all depending on the region of collection. For example, Pb was the highest in *Calotropis procera* root from heavy traffic area locations, and other heavy metal elements showed different results in different locations [38]. Evaluation of heavy metals in various species of *Berberis* and its bazaar samples were done in 10 various places of India, concluding that market samples were more polluted than genuine samples [39, 40]. Further, several studies have analyzed the heavy metal detection of Ca, Cu, K, Li, Mg, Mn, Na, Ni and Zn from *Hypericum perforatum* by Atomic Absorption and Emission Spectrometry [40-45].

5. Discussion and conclusion

Due to the importance of measuring heavy metal concentrates, using various methods, several countries have established standards and food cycle factors that include agricultural land, water, identification of suitable species, and investigation of desired elements.

Nowadays, in order to improve and grow our awareness on this topic, we have to understand the methods of nutrients and supplement production from Herbal plants. Unfortunately, due to their widespread use in everyday diet as vegetables medicinal plants do not follow known industrial standards for food analysis. One of the possible solutions is to identify contaminated areas, using soil stabilizers and prevent leaching, using less fertilizers and chemical pesticides in agriculture, using more resistant and high-yielding cultivars, better understanding of medicinal plants and the potential in heavy metal absorption. Further, the healthy agricultural water should be separated from urban sewage and public awareness about medical plants should be increased.

This review confirmed that the presence of heavy metals in the soil is in high concentrations that may lead to destructive effects on human health and the environment. Based on the collected information, it is essential to determine the most appropriate location for the investigation and growth of herbs, especially medicinal plants

[46-51]. Here we propose a simple diagram, as shown in Figure 1 that includes simple steps, showing soil analysis and the selection of the most suitable soil for the cultivation of safe medicinal plants. It is necessary to analyze each medical plant on its ability to absorb heavy metals. Several plants keep heavy metals in their roots, so in this case it is permissible to use the parts of the leaves and stems, whereas other plants transfer their heavy metals to the aerial parts, or keep them in their seeds. Further, special care must be invested in the selection of the suitable land, where produces should test their soils for heavy metal concentrations.



Figure 1: Soil selection and crop analysis process

Conflict of interest

No potential conflict of interest was reported by the authors.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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