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CONTAMINATION OF MEDICINAL PLANTS WITH HEAVY METALS AND IDENTIFICATION OF POTENTIAL HUMAN HEALTH RISKS

BY

DANA-MIHAELA ASIMINICESEI[1] and MARIA GAVRILESCU[1,2,*]

[1]“Gheorghe Asachi” Technical University of Iasi, “Cristofor Simionescu” Faculty of Chemical Engineering and Environmental Protection, Iasi, Romania
[2]Academy of Romanian Scientists, 3 Ilfov Street, 050094 Bucharest, Romania

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Abstract. The increasingly frequency of the use of medicinal plants in everyday life is connected with one of the major problems facing society today, related to the environmental pollution, as a consequence of unsustainable human activities. Therefore, despite the fact that medicinal plants are used as natural sources of health remedies, they can contain various pollutants, as a result of their ability to absorb some toxic chemical compounds from soil, air, water. Among these pollutants, heavy metals generate major impacts in the environment because they are toxic, non-biodegradable, can accumulate in the soil and in biological components of ecosystems and can move through the food chain, then affecting human health.

Considering these aspects, our work aims to concisely present the state of knowledge in the field of contamination of medicinal plants with heavy metals, by: (i) describing the mechanisms of interaction of plants with the environment, (ii) evaluating the mobility of heavy metals in plants, (iii) examination of the way of generation and evaluation of risks for human health.

Keywords: absorption, bioavailability, hazard quotient, persistence, phytotherapy, soil, translocation.

[*]Corresponding author; *e-mail*: mgav@tuiasi.ro

1. Introduction

The decline in environmental quality caused by pollution is a consequence of many different human activities. Pollution generates unwanted changes in the environment, with harmful consequences for plants, animals and humans. The nature and concentration of pollutants determine the severity of environmental impact and adverse effects on human health.

Persistent pollutants - a distinct category of organic or inorganic environmental pollutants possessing some specific characteristics, manifested as: harmfulness (toxicity to ecosystems and people); persistence (they can remain for a long time in the environment, being hardly (bio)degradable); bioaccumulation (they are absorbed into the fatty tissue of living organisms, including humans, where they bioaccumulate, as a result of their transfer into the food chain, where they can be found in higher concentrations); the ability to be transported on long distances (due to their persistence, these pollutants are transported over long distances by air and water, so that they can be found in areas where they have never been used) (Alharbi *et al*., 2018; Gavrilescu, 2009; Gavrilescu *et al*., 2015). Due to their toxicity, these pollutants are also called persistent toxic substances (PTS).

Persistent organic pollutants (POPs) are represented by carbon-based organic compounds and chemical mixtures. Among the first and most well-known POPs are industrial chemicals such as PCBs and pesticides such as DDT, being also toxic substances. POPs appeared relatively recently and their production intensified after the Second World War. To limit the effects of persistent organic pollutants on the environment and human health, the Stockholm Convention, adopted in May 2001 under the United Nations Environment Program (UNEP) (and entered into force in 2004), provided a series of measures to reduce and eliminate the production, use and release of these substances (Fiedler, 2008). In 2002, the Convention covered 12 POPs considered to have the greatest impact, the so-called "dirty dose". Other substances with the same characteristics were then added to the treaty (Fiedler *et al*., 2023).

Persistent inorganic pollutants (PIPs) is another category of persistent pollutants that, similar to POPs, are capable of generating serious impacts and risks on a global scale, not only for environmental components (water, air, soil), but also for human health (Gavrilescu, 2010; Hlihor *et al*., 2009; Hlihor *et al*., 2015). Some inorganic chemicals that are not classified as persistent can transform into PIPs, depending on their physicochemical properties as well as environmental influences (Speight, 2017). In general, PIPs includes substances such as silicate, borate, sulfur derivatives extracted from mines, which possess poisonous properties or can physically interfere with pests, being also used as pesticides. As persistent inorganic pollutants, heavy metals are non-biodegradable, can accumulate in soils and biological compartments and move through the food chain, then affecting the normal functions of the human body

(Abdulfattah *et al*., 2013). Therefore, both POPs and PIPs can generate considerable impacts and risks to ecological systems and people.

Much of the literature devoted to the different pollutants belonging to these two categories specifically addresses the threats associated with the presence of heavy metals in the environment. Heavy metals are significant environmental pollutants, and their toxicity significantly affects ecological, evolutionary, nutritional, and environmental systems. Sources of heavy metal for contamination of ecosystems are areas irrigated long-term with treated or untreated wastewater, those with heavy vehicle traffic, tailings dumps or other types of waste deposits that may contain metals and others (Fig. 1).

Soils in various parts of the world are slightly or moderately contaminated with toxic heavy metals such as Cd, Cu, Zn, Ni, Co, Cr, Pb and As, as a consequence of long-term use of phosphate fertilizers, soil amendment with sludge from sewage treatment plants, traffic, the presence of industrial waste or inadequate irrigation practices (Yadav *et al*., 2010). Heavy metals, as persistent toxic substances, can also generate massive soil and water pollution, the most common toxic metals being lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), nickel (Ni). Most metals cannot be degraded by microbial or chemical action, so they can persist in soils long after their introduction. Toxic metals in soil can severely inhibit the biodegradation processes of some organic pollutants (Manu *et al*., 2018; Wuana and Okieimen, 2011).

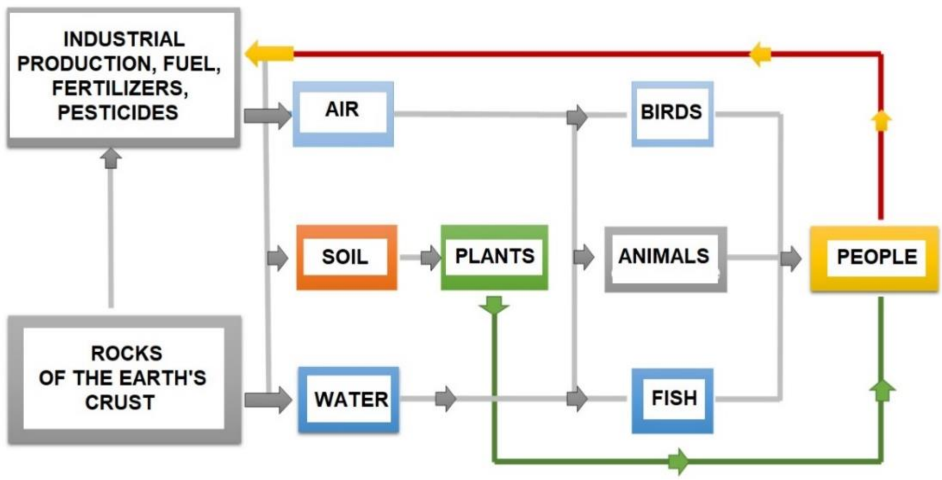

Fig. 1 – Sources of heavy metals in the environment (adapted from Masindi and Muedi, 2018).

Plants constantly interact with soils polluted with heavy metals and, being immobile organisms, have developed complex defense strategies involving an enormous variety of chemical metabolites as tools for overcoming stress conditions. Studies have shown that metals present in the soil solution as a soluble component are bioavailable for being uptaken by plants. Although plants need several metals for growth, development and maintenance, those metals can become toxic if they are in excessive amounts, and the ability of plants to accumulate essential metals makes it possible to absorb other metals, whose presence affects the plant (Sobariu *et al.*, 2017). Some plants can tolerate large amounts of heavy metals, being cultivated to extract them and clean the soil through phytoremediation. Metals can be absorbed and transported from polluted soil to plants through several mechanisms: phytoextraction, phytostabilization, phytovolatilization, rhizofiltration (Fig. 2) and can produce some changes in plants.

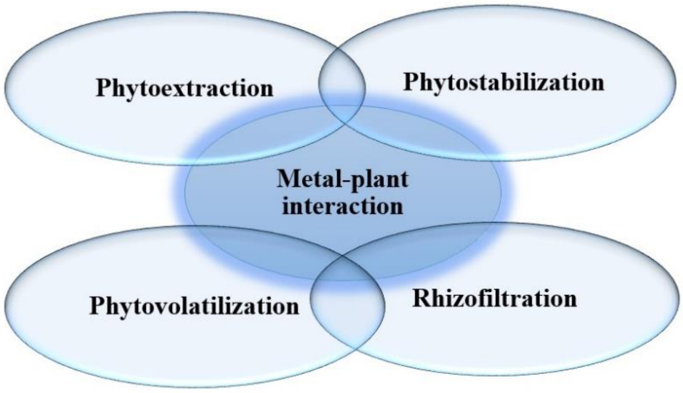

Fig. 2 – Mechanisms of heavy metal uptake from soil.

However, most of the plants grown on contaminated soils are agricultural crops, industrial plants or other beneficial vegetables intended for human consumption and use. Therefore, human health can be seriously affected by the consumption of vegetables and fruits from plants growing in soils containing high concentrations of heavy metals. For example, some studies estimate that about half of the lead in the human body comes from food, of which about 50% comes from plants (Intawongse and Dean, 2006; WHO, 2019).

Specialized literature and daily practice demonstrate that some plants have been and continue to be widely used both in the pharmaceutical industry and in the treatment of diseases through so-called phytotherapy, with consumers showing a growing interest in these products. Phytotherapy exploits many active principles produced by plants as metabolites. Unfortunately, the quality and quantity of these active principles in plants are influenced by a multitude of factors, the most important of which are related to environmental pollutants (Etkin, 2019; Ncube *et al*., 2012). The effects of heavy metal toxicity on medicinal plants used in traditional medicine have been reported worldwide, as the accumulation of heavy metals in medicinal plants requires careful analysis to avoid visible metal concentrations reaching the consumer (Ajasa *et al*., 2004; Obi *et al*., 2006; Sharma *et al*., 2009; Shaw, 1998).

In this context, the aim of the paper is to evaluate how soil pollution with heavy metals can affect medicinal plants and how the consumption and use of these plants can affect human health.

2. Contamination plant medicinal with heavy metals

2.1. Interaction of medicinal plants with the polluted environment

Medicinal plants have been used throughout the world for their beneficial properties and are still an important part of traditional medicine. The World Health Organization (WHO) estimates that 65-80% of the world's population depends on herbal products as their primary form of health care. Traditional herbal remedies are prepared in several ways, some of which are represented by infusions, decoctions, tinctures or macerations. The increased interest in the benefits brought by the use of medicinal plants, led to the expansion of the fields of use, and among them are phytotherapy, aromatherapy, the field of perfumery, the manufacture of products for the purpose of personal care, gastronomy and cosmetology (Asiminicesei *et al*., 2020).

In the context of current pollution, the need for studies regarding the chemical content of plants intended for consumption or use is imperative. By self-harvesting medicinal plants from areas subject to the risk of being contaminated with various pollutants (areas with intense road traffic, highly industrialized areas, acid rain etc.), human health can be put at risk, to the detriment of the benefits offered by these plants.

Inorganic pollutants, such as heavy metals, represent a category of pollutants of wide interest for risk studies because of the impacts they can generate in the environment and on human health. Unlike many organic, biodegradable pollutants, heavy metals are non-degradable, bioaccumulate in the environment, transfer through the food chain and induce negative effects on the environment and human health. Environmental pollution through industrial activities and atmospheric deposition of heavy metals inevitably results in medicinal plants contamination. Uptake of metals by plants occurs through soil, water or air, and as they move through the food chain, metals tend to concentrate in living organisms and can affect human health. The sources of contamination of medicinal plants are varied, and some of them are shown in Fig. 3.

The relevance of the choice of medicinal plants as the object of the study derives from the fact that through the interaction with the environment, they can easily absorb toxic compounds that can subsequently generate risks and dangers for human health. Despite the fact that medicinal plants are consumed as natural medical, food and nutritional sources, they can be contaminated with various pollutants, organic or inorganic (Asiminicesei *et al*., 2020). For example, persistent inorganic pollutants such as heavy metals are considered a category of great interest due to their negative impact on the environment and human health.

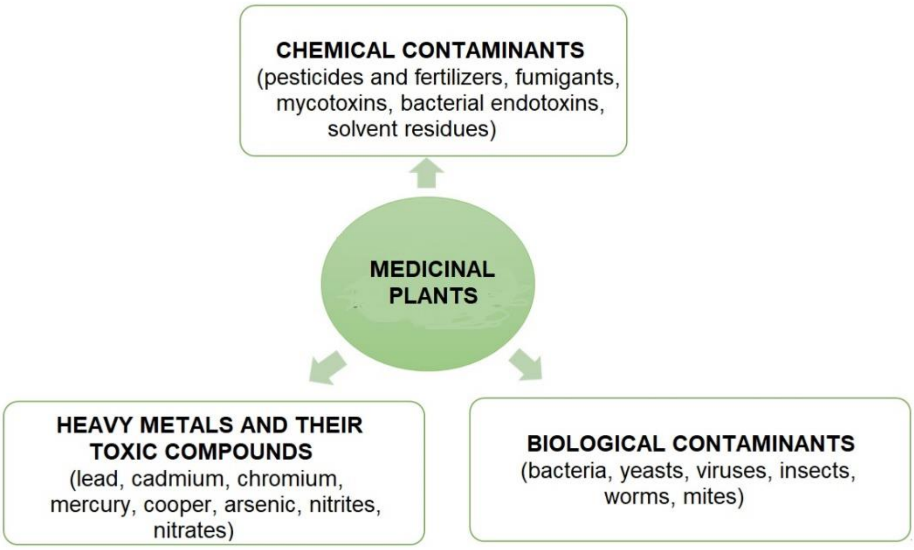

Fig. 3 – Sources of contamination of medicinal plants.

Unlike many organic pollutants as biodegradable organic compounds that can degrade into carbon dioxide and water, heavy metals can accumulate in the environment and induce a series of negative effects on the ecosystems and human health, as mentioned above. Although some medicinal plants are harvested from the wildness, their cultivation for commercial purposes has increased in direct proportion to the requirement (Tripathy *et al*., 2015). The use of pesticides and storage conditions of medicinal plants after harvest can increase the accumulation of heavy metals in plant tissues.

At the level of the European Union and the European Food Safety Authority (EFSA), medicinal plants and products based on medicinal plants are subject to the legislation on pharmaceutical products for human use. Medicines based on medicinal plants contain exclusively active ingredients from one or more plants, which is why the quality of these plants is in the attention of the European Commission, which has developed a series of documents in this context in relation to medicines based on herbs. It is worth mentioning EC Directive 24 (2004), which refers to the registration procedure of herbal medicinal products.

Also, a Committee for Herbal Medicinal Products (HMPC) was established at the European Medicines Agency (EMA).

2.2. Bioavailability of metals heavy for medicinal plants

There are two possibilities for plants to interact with heavy metals: exclusion or accumulation. Through accumulation, the metal ions are retained in the plant cells in a non-toxic form. Exclusion involves leaf fall to remove accumulated metal ions or complexes (Hlihor *et al*., 2015; Pavel *et al*., 2013; Sarma *et al.* 2011). Plants extract from the soil and bioaccumulate the fraction of heavy metals that can be mobilized from the soil, the so-called available fraction, which gives metals the property called metal bioavailability, that is, the degree to which a chemical substance can be absorbed by a living organism and transported inside that organism (Hlihor *et al*., 2009; Intawongse and Dean, 2006). This property is dependent on soil (pH, organic matter content, texture) and plant properties. "Bioavailability is ... the extent to which a substance can be absorbed by a living organism and cause an adverse physiological or toxicological response; … This definition implicitly includes the extent to which a substance can desorb, dissolve, or otherwise dissociate from the environmental medium in which it occurs to become available for absorption" (NAVFAC, 2000). "Bioavailability processes are ... individual physical, chemical, and biological interactions that determine the exposure of plants and animals to chemicals associated with soils and sediments" (NRC, 2003).

Some authors considered that bioavailability is a dynamic process and that it occurs as a result of the existence of three successive processes (Kim *et al*., 2015; Lanno *et al*., 2004; Peijnenburg *et al*., 1997): (1) a process controlled by physico-chemical parameters (desorption, solubilization), which depends on the characteristics of the soil (for example), the metal and the interaction between the two partners, the soil and the metal (called availability); (2) an uptake process controlled by the soil-plant relationship (physiological process, referred to as environmental bioavailability); (3) a process of accumulation of the metal inside the body, controlled by the characteristics of the organism (called toxicological bioavailability). Therefore, bioavailability can be characterized as a complex, dynamic process that depends on the type of organism, the type of exposure and metal speciation (Harmsen, 2007). There are other definitions for bioavailability in the literature, which indicates that this concept is not completely and consistently defined, although it is decisive in metal plant uptake rates (Wu *et al*., 2022; Zuo *et al*., 2023).

2.3. Factors influencing the absorption of heavy metals in plants

Soil is the main source of contamination through which heavy metals can move to the root surface by diffusion or ion exchange between the root surface and soil-water. Plants use active uptake to assimilate essential metals, but they can also take up other toxic elements available in the soil (Hasan *et al*., 2019). At the same time, heavy metals can move through cationic channels in the cell membrane inside the cell (Diaconu *et al*., 2020; Mahmood *et al*., 2017; Sobariu *et al*., 2017). Heavy metals such as arsenic (As), lead (Pb), cadmium (Cd) and mercury (Hg) are not biologically important in living organisms, but can have toxic effects and cause problems in their development. For this reason, a number of heavy metals should be considered a potential threat to medicinal plants and health (Ozden and Ozden, 2018).

One of the methodologies for assessing metal mobility in plants is the transfer-based factor (or translocation factor) (*TF*), as expressed by Eq. (1) (Chojnacka *et al*., 2005; Intawongse and Dean, 2006):

$$TF = \frac{C_{plant}}{C_{total/soil}} \tag{1}$$

where: C_{plant} is the concentration of an element in the plant biomass (dry weight basis) and $C_{total/soil}$ is the total concentration of the same element in soil (dry weight basis) in which the plant was grown. The higher the *TF* value, the higher the availability of the metal.

On the other hand, two bioaccumulation factors (*BAFs*) can be calculated. *BAF* in the root (BAF_{root}) is defined as the ratio of the metal concentration in the root (C_{root}) to that in the soil (C_{soil}); *BAF* in the aerial part (BAF_{aerial}) is calculated as the ratio of the metal concentration in the aerial part of the plant (C_{aerial}) to that in the soil (C_{soil}) (Eq. (2)) (Garcia Martin *et al*., 2020).

$$BAF_{root} = C_{root} / C_{soil} \tag{2}$$

Metal extraction ratio (MER) can be calculated with Eq. (3) (Ongy and Belonias, 2018).

$$MER = (C_{plant} \times M_{plant} / C_{soil} \times M_{rooted\ zone}) \times 100 \tag{3}$$

where: C_{plant} is the metal concentration in the harvested component of the plant biomass; M_{plant} is the mass of harvestable above-ground biomass produced during harvesting; C_{soil} is the metal concentration in the soil volume; $M_{rooted\ zone}$ is the mass of soil volume rooted by the studied species.

Table 1 shows some bioaccumulation parameters of different heavy metal-medicinal plant combinations. Some plants show visible toxic effects, such as necrosis, while other plants show no visible effects, which requires chemical analysis. Some studies show that certain medicinal plant species have different bioaccumulative potentials (Table 2).

Table 1
Parameters that can characterize the mobility of heavy metals from the soil in different medicinal plants

Plant species	Metal	Bioaccumulation parameters	References
Artemisia vulgaris	Pb	BAF = 2.71 TF = 2.46 MER = 3.94	Ongy and Belonias 2018
Plectranthus amboinicus	Pb	BAF = 2.13 TF = 0.81 WED = 31.0	
Ocimum sanctum	Al	BAF = 0.025	Maharia *et al*., 2010
	Mg	BAF = 0.338	
Aloe barbadensis	Al	BAF = 0.013	
	Mg	BAF = 0.205	
Ocimum tenuiflorum	Cd	C = 0.64 ($\mu g \cdot g^{-1}$)	Kumar *et al*., 2018
	Pb	C = 13 ($\mu g \cdot g^{-1}$)	
	Cr	C = 18.63 ($\mu g \cdot g^{-1}$)	
Rosa rubiginosa	Cd	C = 0.74 ($\mu g \cdot g^{-1}$)	
	Pb	C = 51.77 ($\mu g \cdot g^{-1}$)	
	Cr	C = 47.18 ($\mu g \cdot g^{-1}$)	
Rumex acetosa	Cd	TF = 1.35	Balabanova *et al.* 2015
		BAF = 0.11	
	Cu	TF = 1.03	
		BAF = 0.19	

For example, Galal and Shehata (2015) showed that *Pltantago major* is a hyperaccumulator of iron (Fe) and aluminum (Al), as it can accumulate concentrations higher than 1000 mg kg^{-1}. Another study by Angelova *et al*. (2015) concluded that lavender (*Lavandula vera L.*), can tolerate heavy metals being considered a hyperaccumulative plant for Pb, Cd and Zn and can be successfully used in phytoremediation of heavy metal polluted soils. A study by Lajayer *et al*., (2019) showed that the edible parts of the basil plant can accumulate small amounts of micronutrients and heavy metals, while the study by Fattahi *et al*., (2019) shows that the development of basil was significantly affected by soil contaminated with Cd and Pb. In addition, growing basil in contaminated soils and fields that are irrigated with wastewater can cause undesirable effects on seed germination as well as plant morphology and physiology.

The study by Fattahi *et al*. (2019) showed that increased Cd and Pb concentrations in soil also lead to increased metal content in leaf and root samples. The heavy metal content was higher in the leaves than in the roots, while the Pb concentration in the plant tissue was higher than the Cd concentration. The standard permissible level for Pb and Cd in basil leaves is 0.1-0.3 mg kg^{-1} dry weight. Another study by Gajalakshmi *et al*. (2012) showed that *Balanites aegyptiaca* can accumulate a high level of copper in leaves.

Table 2
Medicinal plant parts affected by heavy metals

Species	Heavy metals	Plant components	References
Ocimum basilicum	Pb, Cd	Leaf > root	Fattahi *et al*., 2019
Pltantago major	Fe, Al	Stem	Galal and Shehata, 2015
Menthe spicata	Cd	Leaf > stem	Anju *et al*., 2016
Calendula officinalis	Cu	Leaf	Sunayana and Suchismita, 2016
Mentha	Cd	Leaf, stem	Zheljazkov *et al*., 2008
Matricaria chamomilla	Cd	Leaf	Kováčik *et al*., 2006
Balanitis aegyptiaca	Cu	Leaf	Gajalakshmi *et al*., 2012

However, the accumulation of heavy metals in different parts of the plant depends on the plant species, but the most reported cases have shown that the accumulation of metals occurs mainly in the leaves, which are commonly used for tea (Reza *et al*., 2019).

3. Potentials risks generated by metals heavy

3.1. Potential risks for ecosystem and plants

It is estimated that more than 70% of the world's population uses medicinal plants to treat a condition. However, various studies have shown that they can be a source of risk to human health as a result of exposure to a number of toxic elements contained in plants and the environment.

Soil pollution with heavy metals can generate directly or indirectly, through harvested plants, hazards and risks for ecosystems and human health by the following vectors: food chain (soil-plant-humans or soil-plant-animal-humans), direct ingestion, decrease in agricultural production due to phytotoxicity, decreasing agricultural land use (Wang *et al*., 2017; Zhang *et al*., 2019).

3.2. Potential risks for the human health

There are several ways that heavy metals can enter the human body, including dust inhalation, soil ingestion, dermal contact, and consumption of plants grown on contaminated soil. In the human body, heavy metals pose an increased risk of cardiovascular, neurological and renal diseases. Studies show that a primary route of exposure to heavy metals is through the consumption of contaminated food. Worldwide, more than 420,000 people die each year after the ingestion of contaminated food, and one in ten people become ill. Eating contaminated food can cause acute and chronic disease risks, from digestive infections to cancer (Zheng *et al*., 2020). Numerous studies have shown that heavy metals exert dangerous effects on human health, causing cancer, damage to the nervous system, blood composition (Kohzadi *et al*., 2018; Okatch *et al*., 2012).

Interest in the effects of heavy metals on medicinal plants has increased in recent decades, expressing the acute need to monitor and analyze the status of medicinal plants affected by the presence of heavy metals, in order to avoid health hazards. The risks to human health associated with the presence of heavy metals in medicinal plants have led to the establishment of safety standards for herbal remedies that prescribe maximum permissible concentrations for some heavy metals in natural remedies (Kohzadi *et al*., 2018).

Despite the fact that there are data on the content of heavy metals in plants in literature studies, there are no safety limits established by the authorities for all heavy metals. However, due to the toxicity of heavy metals to plants and human health and to ensure the quality of herbal medicines, teas, nutraceuticals and other herbal preparations, large-scale analyzes of the metal content of medicinal herbs. In addition, the World Health Organization and the US Food and Drug Administration (FDA) have standardized maximum permissible limits for the concentration of certain metals (As, Hg, Pb, Cd) in these plants, but not for all metals. Safety limits for Cd, Pb and Hg have been developed by the European Pharmacopoeia (Ph. Eur), while the World Health Organization (WHO, 2003) and the Food and Agriculture Organization (FAO, 2005) have jointly proposed acceptable levels of toxic substances that can be ingested weekly, provisional tolerable weekly intake (PTWI) (Kohzadi *et al*., 2018; Sarma *et al*., 2011) (Table 3). Analytical results for heavy metal content in medicinal plants are an important step for detecting potentially toxic levels of heavy metals that may be dangerous to living organisms. Another important step is the knowledge of hyperaccumulative medicinal plants, because they can absorb large amounts of metal ions and thus pose risks to human health. Plants with hyperaccumulative potential can absorb 50, 100 times more metal than normal plants. This phenomenon of hyperaccumulation is intensified if the environment has high concentrations of heavy metals. To date, 500 species of hyperaccumulator plants are recognized (Sarma *et al*., 2011).

There are several indicators that help in assessing the potential risks from commonly consumed medicinal plants. The estimated average daily intake (*EDI*) of heavy metals (Al, As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb and Zn), which depends on the metal concentration in plants and the degree of plant consumption can be calculated using Eq. (4), suggested by US EPA (Kohzadi *et al*., 2018; USEPA, 2011), where *EDI* is the average daily intake or ingestion dose (mg/kg body weight/day); *C* is the concentration of heavy metals in the exposure environment (mg/L or mg/kg); F_{IR} is the daily consumption rate; W_{AB} is weight average body.

Table 3

Maximum allowed limits of different heavy metal concentrations in medicinal plants

Metal	WHO/FDA	PhD Eur. ($mg \cdot kg^{-1}$)	FAO/WHO PTWI ($mg \cdot kg^{-1}$)
As	10	1	15
Cd	0.3	0.5	7
Hg	1	0.1	5
Pb	10	5	25

$$EDI = C\frac{F_{IR}}{W_{AB}} \tag{4}$$

The target hazard quotient (*THQ*) (Eq. 5) characterizes the human health risk posed by exposure to heavy metals (Kohzadi *et al*., 2018; USEPA, 2011), as the ratio of the average *EDI* resulting from exposure at average sites to the dose of reference (*RfD*) for an individual pathway and chemical compound.

$$THQ = \frac{C \times IR \times EF \times ED}{BW \times AT \times RfD} \tag{5}$$

where: *C* is the concentration of heavy metals in the exposure environment (mg/L or mg/kg); *IR* is the ingestion rate (L/day or kg/day); *EF* is the exposure frequency (days/year); *ED* is duration of exposure (years, equivalent to average lifetime); *BW* is body weight in kilograms; *AT* is the average time for non-carcinogens (days/year×number of years of exposure, assuming for example 70 years).

The risk to human health can be assessed by the health risk index (*HRI*), which can be calculated from the daily intake of metals through plant consumption ($C_n \times D_n$) and then compared to the prescribed oral reference dose, as appropriate (Abbasi *et al*., 2013; Li *et al*., 2012). This index can be calculated using Eq. (6).

$$HRI = \sum_n (C_n \times D_n) / RfD \times B_w \tag{6}$$

where C_n is the average metal concentration in plants based on fresh weight (mg/kg); D_n is the average daily intake rate of herbs; *RfD* is the safe level of oral exposure; B_w is the average body weight (70 kg in an adult). An index below 1.0 is considered safe.

As a result of the risks induced by the presence of heavy metals in medicinal plants, both in children and in adults and which can be highlighted by processing some experimental data, there may be concerns due to *ECRs* above the acceptable range. Therefore, for the consumption of such plants, it is necessary to highlight these risks and their management, in support of the population that must be warned about the hazards and risks posed by the consumption of medicinal plants harvested from areas with intense pollution.

4. Conclusions

This paper highlights the important role that medicinal plants play in the pharmaceutical and health care fields of the 21st century. Although the use of medicinal plants is an ancient practice, dating back to ancient times, it continues to exist worldwide. However, medicinal plants can be a source of exposure to toxic elements, depending on their origin and nature, creating in particular a risk of exposure to the toxic action of heavy metals. It should be remembered that some heavy metals are important as micronutrients for the proper functioning of plants, but in high concentrations they become toxic. Moreover, some heavy metals are toxic even in low concentrations.

Increased environmental contamination with heavy metals inevitably causes contamination of medicinal plants. These are absorbed from the soil and transported by the roots through the stem to the leaves, and these are the most contaminated parts of the plants, which are frequently used to extract the active principles from the plants. Plants also develop specific defense mechanisms that can alter chemical and physiological functions, with consequences for their pharmaceutical and health care value.

Medicinal plants, used as a means of treatment to be used to make cosmetic products, teas, drinks etc., must be collected from areas that are not contaminated with heavy metals. It is therefore recommended that self-harvested medicinal plants are screened for heavy metal levels before being used for pharmaceutical or personal care purposes.

Also, increasing the interest in consumer safety by the producers and distributors of medicinal plants would be one of the ways to avoid the accumulation of heavy metals in the human body as a result of the consumption and use of products based on medicinal plants.

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CONTAMINAREA PLANTELOR MEDICINALE CU METALELE GRELE ŞI IDENTIFICAREA RISCURILOR POTENŢIALE PENTRU SĂNĂTATEA UMANĂ

(Rezumat)

Utilizarea tot mai frecventă a plantelor medicinale aduce în prim-plan una dintre problemele majore cu care se confruntă societatea de astăzi, legată de fenomenul poluării mediului înconjurător, ca o consecință a activităților umane nesustenabile. Prin urmare, în ciuda faptului că plantele medicinale sunt folosite ca surse naturale de remedii ale sănătății, ele pot conține diverși poluanți, ca urmare a capacității lor de absorbție a unor compuși chimici toxici din sol, aer, apă. Dintre acești poluanți, metalele grele generează impacturi majore în mediu deoarece sunt toxice, nebiodegradabile, se pot acumula în sol și în componentele biologice ale ecosistemelor și se pot deplasa prin lanțul trofic, afectând apoi sănătatea umană.

Având în vedere aceste aspecte, lucrarea își propune să prezinte succint stadiul cunoașterii în domeniul contaminării plantelor medicinale cu metale grele, prin: (i) descrierea mecanismelor de interacțiune a plantelor cu mediul, (ii) evaluarea mobilității metalelor grele în plante, (iii) examinarea modului de generare și evaluare a riscurilor pentru sănătatea umană.