

HEAVY METALS: A SOURCE OF CONTAMINATION FOR MEDICINAL PLANTS AND POSSIBLE IMPLICATIONS TO HUMAN HEALTH

METALE GRELE: O SURSĂ DE CONTAMINARE PENTRU PLANTELE MEDICINALE ȘI POSIBILE IMPLICAȚII ASUPRA SĂNĂTĂȚII UMANE

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Abstract. Due to the antioxidant properties of medicinal plants and their beneficial effects on human health, they are used and consumed as natural medical sources. Despite this, due to the current pollution of environmental compartments (soil, water, air), they can be contaminated with various pollutants. Heavy metals are a category of toxic compounds of great interest, due to the negative action on the environment and human health. Although some heavy metals are important in maintaining the proper functioning of plants, in high concentrations, they can become toxic. In the context of heavy metal pollution of the environment and possible contamination of medicinal plants with these pollutants, the need for chemical analysis of toxic plant compounds is necessary. This paper approaches results from literature which show that medicinal plants can be subjected to contamination with heavy metals, and this has the consequence of altering the normal functions of medicinal plants. Moreover, following consumption through the food chain (soil - plant - human or soil - plant - animal - human), human health may be endangered. This paper also investigates the toxic action of heavy metals in plants, represented, in principle, by the production of reactive oxygen species (ROS), enzyme inhibition and damage to antioxidants.

Key words: abiotic stress, heavy metals, human health risks, pollution, reactive oxygen species

Rezumat. Datorită proprietăților antioxidante ale plantelor medicinale și efectelor benefice asupra sănătății umane, ele sunt utilizate și consumate ca surse medicale naturale. În ciuda acestui fapt, datorită poluării actuale a compartimentelor de mediu (sol, apă, aer), acestea pot fi contaminate cu diverși poluanți. Metalele grele sunt o categorie de compuși toxici de mare interes, datorită acțiunii negative asupra mediului și a sănătății umane. Deși unele metale grele sunt importante în menținerea bunei funcționări a plantelor, în concentrații mari, ele pot deveni toxice. În contextul poluării cu metale grele a mediului și a eventualei contaminări a plantelor medicinale cu acești poluanți,

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este necesară analiza chimică a compușilor toxici ai plantelor. Această lucrare abordează rezultatele din literatura de specialitate care arată că plantele medicinale pot fi supuse contaminării cu metale grele și acest lucru are drept consecință modificarea funcțiilor normale ale plantelor medicinale. Mai mult, în urma consumului prin lanțul alimentar (sol - plantă - om sau sol - plantă - animal - om), sănătatea umană poate fi pusă în pericol. Această lucrare investighează, de asemenea, acțiunea toxică a metalelor grele din plante, reprezentată, în principiu, de producerea de specii reactive de oxigen (ROS), inhibarea enzimelor și deteriorarea antioxidanților.

Cuvinte cheie: stres abiotic, metale grele, riscuri pentru sănătatea umană, poluare, specii reactive de oxigen

INTRODUCTION

As a result of pollution, environmental compartments (soil, water and air) are subjected to contamination with various pollutants. Heavy metals are an important category of pollutants with negative effects for the environment and also for the human health. Medicinal plants received a special interest in research due to the complexity of the fields of use in medicine, aromatherapy, perfumes and cosmetics. Phytochemicals contained in medicinal plants, such as polyphenols, tannin, flavonoid and ascorbic acid are functional elements for many human diseases (diabetes and its complications). They have a low cost and, due to their antioxidant and antimicrobial properties, are of great interest for their use as synthetic compounds in pharmaceuticals, perfumery or cosmetics (Neagu *et al.*, 2018; Zhi *et al.*, 2020).

Although medicinal plants contain natural compounds that have effects on the healing process and have the potential to reduce and inhibit inflammatory processes (Ghuman *et al.*, 2019), their development in environments contaminated with heavy metals may reduce the beneficial effect of their use. Heavy metals produce negative changes in the structure of the plant, and by entering into the food chain, human health can be endangered (Asimnicesei *et al.*, 2020; Lajayer *et al.*, 2017).

Considering the above information, the objectives of this paper are: (i) to identify the response of medicinal plants to heavy metal stress, (ii) to show the antioxidant properties of medicinal plants and (iii) make an overview on the implications to human health due to contaminated medicinal plants.

HEAVY METALS STRESS AND THE RESPONSES OF MEDICINAL PLANTS

Although some metals, in low concentrations, are essential for plant growth (Zn, Cr, Mn, Cu), others even in insignificant amounts can be toxic for plant growth and development (Pb, Cd, As, Ni). Negative effects of heavy metals on plants include damage to antioxidants, accumulation of reactive oxygen species (ROS) and enzymatic inhibition (fig. 1). As a result of the contact between the plant and the heavy metal, the metabolic activity of the plant intensifies and

physiological changes occur to combat the toxic action of metals (Anyanwu *et al.*, 2018) (tab. 1).

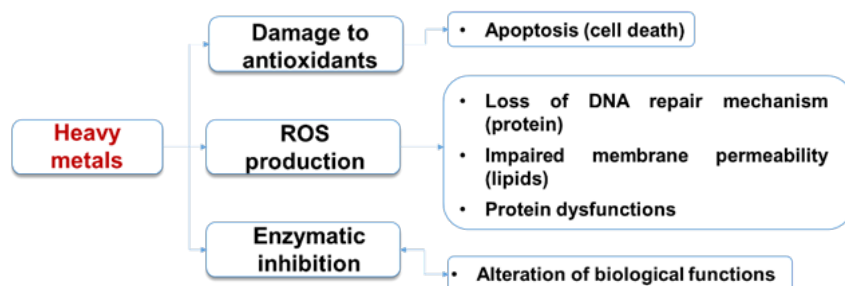


Fig. 1 Heavy metal damage to plant cell

Table 1

The physiological and chemical response of medicinal plants subjected to heavy metals stress (Adapted upon Maleki *et al.*, 2017)

Medicinal plant species	Heavy metal	Concentration	Effects
<i>Allium sativum</i> L. (garlic)	Cd	10^{-2} – 10^{-3} M	Reduction of plant growth
<i>Portulaca oleracea</i> (fat grass)	Se, Hg	0.1–5ppm	Shoot and root inhibition
<i>Ocimum tenuiflorum</i> (holy basil)	Cr	10–100 μ M	Reductions in protein, photosynthetic pigments, cistein
<i>Ocimum basilicum</i> L. (basil)	Pb	500, 600, 750, 900 mgkg ⁻¹	Raising of essential oils
	Cu	270, 300, 500, 700 mgkg ⁻¹	
	Cd	6, 10, 20, 30mgkg ⁻¹	
<i>Mentha crispa</i> (spearmint)	Pb	900, 1800, 3600, 7200, and 9000 mgkg ⁻¹	Raising of essential oils
<i>Mentha spicata</i> L. (spearmint)	Cd	6, 10, 20, 30mgkg ⁻¹	Change in the composition of essential oils
<i>Hypericum perforatum</i> (yellow rattle)	Ni	25 and 50mM	Produces a decrease in the concentration of hypericin and pseudohypercine
<i>Matricaria chamomilla</i> (chamomile)	Cd	60 and 120 μ M	Pronounced decrease in chlorophyll and water in the leaves

Some plants use certain defense strategies against the toxic action of metals, including the accumulation of secondary metabolites, but this depends on the metal concentration with whom the plant interacts, as well as the plant species (Maleki *et al.*, 2017).

ANTIOXIDANT PROPERTIES OF MEDICINAL PLANTS

It is well known that medicinal plants are used worldwide as natural medical sources due to their antioxidant properties and significant amounts of nutrients and are used as a remedy for diseases caused by oxidative stress (aging, Parkinson's disease, certain disorders of cognitive function) (Alzoubiet *et al.*, 2020; Mani *et al.*, 2017; Shabanet *et al.*, 2016). Antioxidants support human health, and they are nutrients that can delay certain cellular degradation caused mainly by the effect of free radicals, and consist of a complex of nutrients that can reduce the toxic effects of free radicals (Alok *et al.*, 2014; Mauricette *et al.*, 2018) (fig. 2).

The main compounds synthesized by medicinal plants are secondary metabolites (such as alkaloids, terpenoids or phenolic compounds), and they provide to medicinal plants anti-inflammatory, anti-cancer and antioxidant properties (Moreira de Almeida *et al.*, 2020).

Research has shown that herbs have a significant antioxidant activity. Herbal antioxidants have major properties against cellular diseases. For example, silymarin found in *Silybummarianum* is a liver antioxidant that protects the liver from pharmaceutical damage or alcohol. Nature is a good "medicine" for all the diseases that mankind faces, and medicinal plants have an important and vital role in terms of antioxidant properties. Thus, the undesirable effects of modern medicine have turned many people's attention to herbal medicines (Alok *et al.*, 2014).



Fig. 2 Antioxidant properties of medicinal plants

IMPLICATIONS OF MEDICINAL PLANTS CONTAMINATION TO HUMAN HEALTH

The interaction between medicinal plants and soils contaminated with heavy metals leads to the assimilation of essential metals by active absorption, while by ion exchange between roots and water or roots-soil, non-essential metals (heavy metals) can penetrate the plant cells (Akinci *et al.*, 2019; Diaconu *et al.*, 2020; Hasan *et al.*, 2019). Once inside plants, heavy metals can reach the human body through consumption. Harvesting medicinal plants from areas subject to heavy metal contamination, for example from areas with heavy road traffic or from long-term irrigated areas with wastewater, or from areas where the chemical

composition of the soil is unknown, favors the entry of toxic compounds into the human body (Wang *et al.*, 2017; Zhang *et al.*, 2019).

Despite the fact that medicinal plants bring many health benefits due to their antioxidant properties, through contamination with heavy metals, they can become a source of risk to human health (Asimicesei *et al.*, 2020). The penetration of heavy metals into the body triggers a number of health risks, including lung cancer, gastrointestinal cancer, kidney damage and liver disease, epigenetic changes, genetic mutations (Liu *et al.*, 2018). For example, the entry of lead into the body can affect the central nervous system or the respiratory system (Abdul *et al.*, 2015).

CONCLUSIONS

Although medicinal plants are a significant source of compounds beneficial to human health, they can pose health risks through their contamination with heavy metals. Some heavy metals are important as micronutrients for the proper functioning of plants, but in high concentrations they become toxic, moreover, some metals are extremely toxic even in low concentrations. Heavy metals produce negative effects on the structure of medicinal plants, and these include damage to antioxidants, ROS production or enzyme inhibition. In this way, by entering into the food chain, human health can be endangered.

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