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Heavy Metal Accumulation in *Sideritis montana* near Landfill: A Case Study

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ABSTRACT

The Gornje Polje Landfill, like many waste disposal sites, raises concerns about the potential environmental contamination of nearby ecosystems. This study investigates the accumulation of selected priority pollutants -heavy metals: mercury (Hg), arsenic (As), and cadmium (Cd) in a potential medicinal species - *Sideritis montana* populations, located near the Gornje Polje Landfill. Our research explores the levels of these priority heavy metal pollutants in *S. montana*. Elevated levels of Hg, As, and Cd are observed compared to samples collected at the control site distant from the landfill. There is a potential influence of landfill activities on heavy metal bioavailability and uptake by *S. montana*. In addition to quantifying selected heavy metal concentrations, the ICP-OES method was employed, and determined concentrations for Hg, As, and Cd were 0.019, 0.109 and 0.025 ppm, respectively and are not for safe plant use. This study provides quantitative data of ICP-OES-determined selected priority pollutants heavy metals in *the Sideritis montana* population plant near the Gornje Polje Landfill, offering a case study that contributes to the broader understanding of environmental health and ethnobotanical considerations in proximity to waste disposal sites.

Keywords: *Sideritis montana, heavy metals, mercury, arsenic, cadmium, environmental contamination*

Introduction

This study focuses on the assessment of mercury (Hg), arsenic (As), and cadmium (Cd) accumulation in Sideritis montana, a plant species commonly found near a landfill site. Heavy metal contamination of any ethnobotanical significant plant can have cascading effects on the food web, highlighting the need for rigorous investigation and monitoring for potential medicinal or proven medicinal plants.

Plant species from the genus *Sideritis* (*S. scardica, S. reiserii*), known under the name *Mountain Tea*, are well known for their various traditional and medicinal uses and originate from the region of southern Europe, primarily the Mediterranean and Balkan areas. *Mountain Tea* has a rich history of traditional use in various cultures. The dried leaves and flowers of plants of the genus *Sideritis* are commonly used to prepare herbal teas that are used as a soothing drink and are believed to have several medicinal properties. Traditional practitioners have used these plants to relieve mild respiratory and gastrointestinal inflammation, and their aromatic leaves can be added to salads and used as a spice in cooking (Pljevljakušić et al., 2011; Pieroni et al., 2013).
In Turkey, an infusion of the aerial parts of the plant is used against stomach ailments (Bulut et al. 2017). In Central Macedonia, Greece, *Sideritis montana* is used for decoction against respiratory tract inflammation and cough (Tsioutsiou et al. 2019).

Koleva et al. 2003 and Firuzi et al. 2010 determined that the extracts show high antioxidant activity.

Toth et al. (2015) investigated the neuronal and smooth muscle effects of a methanol extract (prepared from the air-dried flowering aerial parts of *Sideritis montana*)for *in vitro* investigations of Guinea-pig ileum.

Tóth et al. 2017 isolated and identified new abietane diterpenoids from *S. montana*, and their antiproliferative properties were established, and remarkable activities were detected.

Miladinović et al. 2012 concluded that the essential oil of *S. montana* has a high antibacterial potential and should be further studied to apply it.

The essential oil showed noteworthy inhibition on tumour cells (Venditti et al. 2016).

The Serbian flora recognises only *Sideritis montana* L., a perennial herbaceous plant from the genus *Sideritis* (Diklić, 1974). According to Koleva et al. 2003, this plant is not used in traditional medicine due to its potential pro-oxidant properties. Extract from the *S. montana* plant has an intense antioxidant activity (Alexandre et al., 2013), which can qualify this species as a potential medicinal plant species.

Experimental

Analytical grade nitric and perchloric acid were used as reagents for the wet digestion of samples. Ultra-scientific ICP multi-element standard solutions were used as a stock solution for calibration. All analyses were carried out on aniCAP 6000 inductively coupled plasma optical emission spectrometer (ThermoScientific, Cambridge, United Kingdom), which uses an Echelle optical design and a Charge Injection Device (CID) solid-state-detector.

Sideritis montana was collected from an area near Gornje Polje landfill at Kosovo and Metohija, Serbia, in May 2017 (the flowering stage) and from the control site Kravlje, near the City of Niš, Serbia, in June 2017, far from the potentially contaminated sites. Voucher specimens *S. montana* from different locations (No 13889 and No 13890) were deposited in the Herbarium

of the Department of Biology and Ecology, Faculty of Science and Mathematics (HMN), University of Niš.

Before the analysis, aerial vegetative parts (leaf and flower) were dried at room temperature. The dried samples were powdered in a stainless-steel mill and kept in polypropylene pouches for analysis. The wet digestion method was adopted to enable the measurement of the metal concentrations. The metal content in the plant material was determined after the acidic treatment. First, concentrated HNO_3 was added to the sample and heated up in the open glass to a small volume (until red vapours originating from NO_2 were removed); then, digestion was continued with 70% $HClO_4$ and again evaporated to a low volume. Finally, the solutions were transferred to standard vessels and diluted to a volume of 25 mL (Ilić et al. 2021).

This research investigates the levels of mercury (Hg), cadmium (Cd), and arsenic (As) in *Sideritis Montana* collected from an area near the Gornje Polje landfill and from the control site far from the potential ecotoxicological contamination. Inductively coupled plasma optical emission spectroscopy (ICP-OES) was utilised to determine heavy metal concentrations accurately and sensitively. At the same time, acid/peroxide digestion was used as a sample preparation method preceding ICP-OES analysis. The study aims to assess the impact of landfill proximity on heavy metal contamination in the plant, offering insights into potential environmental and health risks.

Results and discussion

The results presented in this study were presented and contributed to the Second conference about medicinal and wild growing edible plants Pirot. Serbia (Stankov Jovanović et al., 2023). This study provides results of the accumulation of heavy metals, including mercury (Hg), arsenic (As), and cadmium (Cd), in *the Sideritis montana* population located near the Gornje Polje Landfill, at Kosovo and Metohija, in Serbia. Our research contributes to the literature that provides the levels of these priority heavy metals in *S. montana* or other medicinal or potential medicinal plants. It assesses the ecological and human health implications in the context of landfill proximity. Elevated levels of Hg, As, and Cd are observed compared to samples collected at the control site distant from the landfill. According to the results obtained, landfill activities potentially influence heavy metal bioavailability and uptake by *S. montana*. The ICP-OES method was employed to quantify selected heavy metal concentrations, and determined concentrations for Hg, As, and Cd were 0.019, 0.109 and 0.025 ppm, respectively, higher than in *S. montana* collected at a control location and higher than the officially prescribed limits for safe use of the plant.

Table 1. ICP-OES determined concentrations of Heavy Metals in *Sideritis montana*

Sideritis montana	Hg [ppm]	As [ppm]	Cd [ppm]
Landfill Site (Gornje Polje, Serbia)	0.019±0.020	0.109±0.010	0.025±0.003
Control Site (Kravlje, Serbia)	not detected	0.060±0.001	0.007±0.001

Conclusion

The study highlights the impact of landfill proximity on heavy metal contamination in *Sideritis montana*. Contaminated plants can have ecological implications, potentially affecting the ecosystem. This research utilised ICP-OES to determine the concentrations of mercury (Hg), cadmium (Cd), and arsenic (As) in *Sideritis montana* near an active landfill. The results suggest that the plant exhibits increased heavy metal contamination in an area close to the landfill, and it is not for safe use. Continued monitoring and safety measures are essential to assess the environmental and health risks associated with plants from such locations.

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Conflict of Interest Statement

The authors did not declare any conflict of interest.

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