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Short communication

Environmental impact on the pharmaceutical quality and safety of traditionally used wild medicinal plants in North Macedonia: a preliminary study

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Introduction

Medicinal plants remain an important source of herbal raw materials used in traditional medicine, phytotherapy and pharmaceutical preparations. Owing to their widespread use, ensuring their quality, safety and efficacy has become an important aspect of pharmaceutical practice. The quality of medicinal plants depends not only on their botanical identity and phytochemical characteristics but also on environmental factors that may influence the accumulation of potentially toxic elements. Environmental contamination originating from industrial activities represents one of the major challenges affecting the quality of medicinal plant materials. Among environmental contaminants, heavy metals are of particular concern because of their persistence, bioaccumulation potential and possible transfer into herbal medicinal products. Consequently, determination of heavy metal concentrations has become an important component in the pharmaceutical quality assessment of herbal raw materials intended for medicinal use. The quality of herbal raw materials is influenced by numerous environmental factors, including soil characteristics, atmospheric deposition and proximity to industrial emission sources. Continuous monitoring of medicinal plants collected from natural habitats is essential for ensuring compliance with pharmaceutical quality and safety requirements. Such investigations are particularly important in regions where medicinal plants are traditionally harvested for personal use and commercial purposes.

The REK Oslomej thermal power plant is one of the major industrial emission sources in western North Macedonia. However, information regarding the pharmaceutical quality and environmental safety of medicinal plants growing in this area remains limited. Establishing a systematic monitoring approach is therefore essential for future quality assessment and safe utilization of medicinal plants collected from environmentally exposed habitats. The aim of this preliminary study was to establish a systematic sampling framework for assessing the pharmaceutical quality and safety of traditionally used wild medicinal plants collected from industrially impacted and reference areas in North Macedonia through evaluation of heavy metal accumulation.

Materials and methods

Field investigations were conducted during the 2025 and 2026 vegetation seasons. Medicinal plant samples were collected from eight sampling sites surrounding the REK Oslomej thermal power plant

and one reference site located near Leunovo in Mavrovo National Park. To investigate the potential influence of industrial emissions on heavy metal accumulation, the study area surrounding REK Oslomej was divided into two exposure zones according to the distance from the pollution source. Zone I included sampling sites located 0.5–1.0 km from the thermal power plant, while Zone II included sites situated 2.0–4.0 km away. Within each zone, sampling was performed in the north, south, east and west directions in order to account for potential differences in pollutant dispersion. The reference site near Leunovo represented an area with minimal anthropogenic influence. The investigated species included *Matricaria chamomilla* L., *Plantago major* L., *Plantago lanceolate* L., *Achillea millefolium* L., *Urtica dioica* L., *Hypericum perforatum* L., *Taraxacum officinale* F.H. Wigg., *Thymus serpyllum* L. and *Mentha* sp. The selected species were chosen based on their occurrence within the study area, widespread use in traditional medicine, pharmaceutical importance and published evidence supporting their suitability for environmental biomonitoring. Whole plant specimens were collected whenever available to facilitate reliable botanical identification, while root systems were retained in selected samples where appropriate. Soil samples were simultaneously collected from each sampling site after removal of the surface vegetation layer. Botanical identification was performed by the authors in collaboration with the Institute of Biology, Faculty of Natural Sciences and Mathematics. Plant materials were air-dried in a dark, dry and well-ventilated environment, stored in labelled paper bags and prepared for laboratory analysis. Heavy metal concentrations will be determined using Atomic Absorption Spectrometry (AAS).

Results and discussion

This preliminary investigation established a structured sampling strategy for evaluating the pharmaceutical quality and safety of wild medicinal plants growing in industrially impacted and reference areas of North Macedonia. During the 2025 and 2026 vegetation seasons, the majority of the planned plant and soil samples were successfully collected, botanically identified and prepared for laboratory analysis. The inclusion of both polluted and reference locations provides an appropriate basis for future comparison of heavy metal accumulation patterns among different medicinal plant species.

The selected medicinal plants are widely used in traditional medicine and represent important herbal raw materials. Several of these species have previously been reported as suitable bioindicator species of environmental contamination, supporting their selection for the present study. The subsequent determination of heavy metal concentrations by Atomic Absorption Spectrometry will provide valuable information regarding the environmental safety and pharmaceutical quality of these medicinal plants. Previous studies have demonstrated that medicinal plants differ considerably in their ability to accumulate potentially toxic elements depending on species characteristics, environmental conditions and soil composition. Therefore, comparative investigation of medicinal plants collected from industrially impacted and reference areas may contribute to improved understanding of environmental influences on pharmaceutical quality and safety.

Conclusion

The present preliminary study establishes a standardized methodological framework for assessing heavy metal accumulation in traditionally used wild medicinal plants collected from industrially impacted and reference areas in North Macedonia. The developed sampling strategy, botanical identification and standardized sample preparation provide a reliable basis for the forthcoming analytical phase. The generated data are expected to contribute to the evaluation of pharmaceutical quality and safety of herbal raw materials and support future environmental monitoring of medicinal plants.

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