

Opinion



on a doctoral dissertation submitted for the award of the educational and scientific degree of Doctor (PhD), Field of Higher Education: *Natural Sciences, Mathematics and Informatics*
Professional Field: 4.4 Earth Sciences, Scientific Specialty: *Ecology and Ecosystem Conservation*

Author of the dissertation: Maria Radkova Ikhtyarova, part-time doctoral candidate, Department of Chemistry, Phytopharmacy, Ecology and Environmental Protection, Agricultural University – Plovdiv.

Dissertation topic: "Phytoremediation of Heavy Metal-Contaminated Soils Using Plants of the Family Asteraceae"

Opinion prepared : Prof. Dr. Ekaterina Dimitrova Pavlova, University of Forestry, Sofia (retired), Field of Higher Education: Natural Sciences, Mathematics and Informatics, Professional Field 4.4 Earth Sciences, Scientific Specialty: Ecology and Ecosystem Conservation, appointed as a member of the Scientific Jury by Order No. RD 16-809/29.06.2026 of the Rector of the Agricultural University.

1. Relevance of the Research Problem

The submitted dissertation addresses a highly relevant issue concerning the impact of direct and indirect human activities on areas surrounding mining and metallurgical processing enterprises, where extensive land degradation has occurred. It is well established that heavy metal contamination has an adverse effect on soil fertility. Once introduced into the soil, heavy metals reduce its biological activity, alter its structure, and disrupt its chemical balance.

One of the most promising approaches for improving soil quality and restoring heavily contaminated sites is phytoremediation, which utilizes plants to remove, stabilize, or immobilize pollutants. Through various physiological mechanisms, plants either absorb limited quantities of heavy metals or accumulate them to a moderate extent. Species belonging to the Asteraceae family combine adaptability to heavy metal contamination with high productivity. As essential oil crops, they may also be used for the production of essential oils.

The research provides a foundation for developing sustainable and economically efficient strategies for the management of contaminated soils. It demonstrates the potential for integrating essential oil crops into both phytoremediation and pharmacognostic applications. These factors determine the dissertation's high scientific relevance and practical significance.

The results obtained have both scientific and practical value. The integration of scientific, technical, and technological solutions represents an effective approach to the conservation and sustainable use of natural resources.

2. Research, Objective Tasks, Hypotheses and Methods

The objective of the dissertation is clearly formulated:

"To investigate the effects of industrial contamination with Pb, Cd, and Zn on the soil–plant–essential oil system and the associated terpene secondary metabolites."

The research focuses on selecting suitable plant species with high tolerance to heavy metal contamination and the capacity either to accumulate or stabilize these metals, while also evaluating their potential as essential oil crops.

The research objectives are methodologically sound and logically structured to ensure the comprehensive achievement of the stated aim. The methodological approach is multidisciplinary and based on current knowledge of heavy metal behavior within the soil–plant system and its influence on the biosynthesis of secondary metabolites.

Modern analytical methods and established research standards have been applied. The dataset is based on both field investigations and experimental studies. Specific indices and coefficients were used for data evaluation, while statistical methods and correlation analyses were employed to verify the reliability of the results.

3. Presentation and Illustration of the Results

The dissertation comprises 157 pages and is organized into the following sections: Introduction ,Literature Review , Aim, Objectives and Working Hypotheses , Materials and Methods , Results and Discussion , General Conclusions , Findings, Contributions and Recommendations , References

The dissertation also contains 5 appendices, 21 tables, and 11 informative figures and diagrams.

4. Discussion of the Results and Literature Review

5. Contributions of the Dissertation

I accept the scientific and applied contributions formulated by the doctoral candidate, which expand the existing body of research in phytoremediation and the behavior of heavy metals within the soil–plant–essential oil system.

Among the principal contributions are:

1. The investigated plant species were classified according to their capacity for heavy metal uptake, translocation, and accumulation, enabling a comparative assessment of their phytoremediation potential.
2. A conceptual "**dual selective filter**" model was developed to explain the limited transfer of heavy metals into the essential oils produced by these plants.
3. It was established that contamination with Pb, Cd, and Zn does not alter the chemotype identity of the essential oils but results only in quantitative changes in their terpene profile without loss of chemical identity.
4. Practical guidelines were proposed for the use of Asteraceae species on contaminated sites, combining ecological restoration with the production of pharmacognostically valuable products.
5. An applicable conceptual model was proposed for assessing risks to plant systems under contaminated environmental conditions. This model may serve as a methodological framework for planning ecological and phytotechnological interventions.

6. Critical Remarks and Questions

I have the following observation for the doctoral candidate:

The literature review includes only a limited number of Bulgarian authors who have published research on heavy metal-contaminated soils and the phytoremediation of areas surrounding mining and metallurgical enterprises.

I recommend that these works be considered in future research.

7. Publications and Citations

The doctoral candidate, Maria Ikhtyarova, has presented five scientific publications related to the dissertation, one of which is currently in press.

These publications are directly connected with the conducted research and ensure the dissemination of its results. A list of four citations to two of the publications has also been provided, demonstrating the interest of researchers both in Bulgaria and abroad and confirming the significance of the research findings.

The submitted dissertation abstract accurately reflects the structure and content of the dissertation.

Conclusion

Based on the research methods applied by the doctoral candidate, the correctly designed and conducted experiments, and the well-founded analyses, conclusions, and findings, I consider that the submitted dissertation fully complies with the requirements of the Academic Staff Development Act of the Republic of Bulgaria (ASDARB) and the Regulations for its implementation at the Agricultural University.

Therefore, I give the dissertation a positive evaluation.

I respectfully recommend that the distinguished Scientific Jury also vote in favor of awarding Maria Radkova Ikhtyarova the educational and scientific degree of Doctor (PhD) in the scientific specialty Ecology and Ecosystem Conservation.

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