



UNIVERSITY OF LIFE SCIENCES "KING MIHAI I" FROM
TIMISOARA
"YOUNG PEOPLE AND MULTIDISCIPLINARY RESEARCH
IN APPLIED LIFE SCIENCES"

13-14 November 2025



"Young people and multidisciplinary
research in applied life sciences"

LAVENDER CULTIVATION AS A TOOL FOR SOIL REMEDIATION
AND BIODIVERSITY ENHANCEMENT

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Abstract:

Lavender (*Lavandula* spp.) cultivation has emerged as a promising strategy for sustainable land management, particularly in areas affected by soil degradation and biodiversity loss. This study explores the potential of lavender as a phytoremediation crop capable of improving soil health while fostering ecological diversity. Lavender's deep root system enhances soil structure, reduces erosion, and promotes microbial activity, contributing to the restoration of nutrient cycles in marginal or contaminated soils. Furthermore, its tolerance to drought and poor soil conditions makes it an ideal candidate for rehabilitating semi-arid and degraded lands. Beyond soil improvement, lavender cultivation supports biodiversity enhancement by providing nectar and habitat resources for a wide range of pollinators, including bees, butterflies, and other beneficial insects. The establishment of lavender-based agroecosystems encourages the coexistence of multiple species, thereby strengthening local ecosystems and promoting ecological resilience. Additionally, lavender's essential oil production offers an economically viable pathway for farmers to engage in environmentally friendly practices without sacrificing income. Integrating lavender cultivation into agricultural and land restoration frameworks thus represents a dual-benefit approach—addressing both ecological and socio-economic objectives. Overall, this research highlights lavender's multifunctional role as a tool for soil remediation and biodiversity enhancement, emphasizing its potential contribution to sustainable agriculture and landscape restoration efforts in the context of climate change and declining soil fertility.

Keywords: lavender cultivation; phytoremediation, soil restoration, biodiversity enhancement, sustainable agriculture.



• Results and discussions

Lavender cultivation significantly improved soil quality and biological activity compared to the control plots. After three growing seasons, soil organic matter increased by an average of 22% in lavender plots, while bulk density decreased, indicating better soil structure and aeration. pH levels remained stable, but available nitrogen and phosphorus showed moderate increases, likely due to enhanced microbial mineralization. In the contaminated site, concentrations of heavy metals such as lead and cadmium decreased by 10–18%, demonstrating lavender's moderate phytoremediation capacity. Bioaccumulation and translocation factors were highest in roots and leaves, confirming lavender's potential to immobilize contaminants within plant tissues rather than transferring them into the food chain. Plant growth was vigorous in both sites, with over 85% survival and consistent biomass yields. Essential oil production averaged 22 mL·kg⁻¹ DW, comparable to standard cultivation under favorable conditions, showing that soil degradation did not significantly affect oil yield or quality. This economic return strengthens lavender's viability as a dual-purpose crop for ecological restoration and income generation. Biodiversity assessments revealed a notable increase in pollinator activity, with lavender plots attracting up to three times more pollinators than control plots. The abundance of bees and butterflies increased throughout the study period, enhancing ecosystem services such as pollination. Ground arthropod diversity and vegetation cover also improved, indicating a gradual recovery of ecological function. Overall, the results confirm that lavender cultivation contributes to soil remediation, biodiversity enhancement, and rural sustainability. By stabilizing degraded soils and attracting beneficial species, lavender supports both environmental and socio-economic objectives.



Introduction

Soil degradation and biodiversity loss are among the most pressing environmental challenges of the 21st century, driven largely by unsustainable agricultural practices, industrial pollution, and climate change. Restoring degraded lands while maintaining economic productivity requires innovative, eco-friendly solutions that combine environmental remediation with sustainable resource use. In this context, lavender (*Lavandula* spp.) has gained increasing attention as a multifunctional crop capable of addressing both ecological and socio-economic needs. Lavender is a hardy, perennial plant well adapted to arid and semi-arid environments, thriving even in nutrient-poor or contaminated soils. Its extensive root system helps stabilize the soil, prevent erosion, and improve its physical and biological properties. Moreover, lavender's natural tolerance to harsh conditions allows it to grow where conventional crops may fail, making it a valuable candidate for phytoremediation—the use of plants to remove, contain, or neutralize pollutants from soil and water. Beyond soil restoration, lavender cultivation significantly contributes to biodiversity enhancement. Its long flowering period and high nectar production attract a wide variety of pollinators such as bees and butterflies, which are essential for ecosystem balance and agricultural productivity. Furthermore, the cultivation of lavender can diversify rural economies through the production of essential oils and related products, promoting sustainable agriculture and local development. This paper explores the dual role of lavender in soil remediation and biodiversity conservation, highlighting its potential as a sustainable land management tool that supports both ecological restoration and rural livelihoods.



Material and methods

The research was conducted on two degraded sites: a marginal agricultural field and a lightly contaminated post-industrial area. A randomized block design was used with three treatments—lavender (*Lavandula angustifolia*), a reference crop, and an unplanted control—replicated across five blocks per site. Each plot measured 6 × 6 meters and was monitored over three growing seasons. Lavender was planted at a density of 0.8 × 0.8 meters and irrigated only during the establishment phase. Weeds were controlled mechanically without herbicides, and no fertilizers were applied except minimal nitrogen in the agricultural field. Soil samples were collected before planting and annually at depths of 0–20 cm and 20–40 cm. Analyses included texture, pH, organic matter, available nutrients, and heavy metal content using ICP-MS. Soil structure, infiltration, and aggregate stability were also assessed. Lavender growth (height, canopy, biomass) and essential oil yield were recorded annually. Plant tissues (roots, stems, leaves, flowers) were analyzed for contaminant uptake to calculate bioaccumulation and translocation factors, as well as overall remediation efficiency. Soil biological activity was monitored through microbial respiration, enzyme activity, and microbial biomass. Pollinator diversity was measured through transect walks and pan traps during the flowering season, while ground arthropods were sampled with pitfall traps. Plant species diversity within plots was recorded seasonally to evaluate changes in vegetation cover. Data were analyzed using ANOVA and multivariate statistics (PERMANOVA, NMDS) to identify treatment effects on soil quality, plant performance, and biodiversity indicators.



Conclusions

The results of this research demonstrate that lavender (*Lavandula angustifolia*) cultivation is an effective and sustainable strategy for improving degraded and contaminated soils while enhancing local biodiversity. Over three growing seasons, lavender significantly increased soil organic matter, improved structure and microbial activity, and contributed to the gradual reduction of heavy metal concentrations in contaminated sites. Its strong root system and tolerance to poor soil conditions make it suitable for areas where conventional crops cannot thrive. Beyond soil restoration, lavender cultivation fostered greater ecological diversity by attracting pollinators such as bees and butterflies, as well as improving ground arthropod and vegetation richness. These ecological benefits were accompanied by steady essential oil yields of commercial quality, offering farmers a potential source of income while contributing to environmental rehabilitation. Overall, lavender represents a multifunctional crop that links economic productivity with ecological restoration. Its integration into sustainable land management programs can promote long-term soil health, biodiversity conservation, and rural development, particularly in semi-arid or degraded landscapes. Future research should focus on optimizing cultivation practices, evaluating long-term remediation efficiency, and assessing the potential of lavender in combination with other native or aromatic species to maximize environmental and economic benefits..



Acknowledgement:

Support was also received by the project Horizon Europe (HORIZON) 101071300 - Sustainable Horizons - European Universities designing the horizons of sustainability (SHEs)