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LAVENDER CULTIVATION AS A TOOL FOR SOIL REMEDIATION AND BIODIVERSITY ENHANCEMENT

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Abstract. *Soil degradation and biodiversity loss are interconnected environmental crises demanding innovative and sustainable solutions. This research investigates the potential of lavender (Lavandula spp.) cultivation as a multifunctional tool for phytoremediation and biodiversity enhancement in degraded agricultural landscapes. Lavender, a perennial, drought-resistant aromatic plant, is known for its hardiness and low-input requirements. We hypothesized that its deep root system, specific biochemical exudates, and floral characteristics could concurrently improve soil health and support diverse pollinator populations. A two-year field experiment was conducted on a marginally productive, slightly contaminated site, comparing lavender plots with control plots of spontaneous vegetation. Soil samples were analysed pre- and post-cultivation for key parameters, including heavy metal content (Pb, Zn), polycyclic aromatic hydrocarbons (PAHs), soil organic carbon (SOC), aggregate stability, and microbial biomass. Above-ground invertebrate biodiversity was assessed using pitfall traps and pan traps to monitor pollinator and beneficial insect activity. Results demonstrated that lavender cultivation significantly increased SOC by 18% and improved water-stable aggregates by 25% compared to controls. Notably, the lavender plots showed a 30% reduction in bioavailable fractions of lead and a 15% reduction in certain light PAHs, indicating a phyto-stabilization and microbial degradation enhancement capacity. Furthermore, the lavender fields supported a 50% greater abundance and a 40% higher species richness of pollinators, including bees, butterflies, and hoverflies, compared to control areas. The study concludes that lavender cultivation presents a viable, economically attractive strategy for the ecological restoration of marginal lands. It offers a simultaneous win-win outcome: remediating soil contaminants through phyto management while creating high-value agricultural products and critical habitats for biodiversity, thereby contributing to both ecological and economic resilience.*

Keywords*: lavender, biodiversity, soil, standards, pollinator.*

INTRODUCTION

The health of our planet's soils is fundamental to ecosystem stability and agricultural productivity. However, vast areas of land worldwide are affected by degradation, resulting from industrial pollution, agricultural intensification, erosion, and loss of organic matter.

This degradation is intrinsically linked to a parallel crisis: the precipitous decline in biodiversity, particularly among invertebrate pollinators, essential for the reproduction of most flowering plants and many crops.

Conventional remediation techniques, such as soil excavation and chemical treatment, are often prohibitively expensive, destructive to soil structure, and do little to restore ecological function. There is, therefore, an urgent need for sustainable, cost-effective strategies that can address soil remediation and biodiversity conservation simultaneously.

Phytoremediation, the use of plants to stabilize, extract, or degrade contaminants, has emerged as a promising, nature-based solution. Many traditional phytoremediation species are non-productive, offering little economic incentive for land managers to adopt them on a large scale.

This research explores the potential of cultivating high-value aromatic plants, specifically lavender (*Lavandula angustifolia* and allied species), as a multifunctional tool for ecological restoration (GIULIANI ET L., 2020). Lavender is not merely a candidate for phytoremediation but represents a paradigm shift towards "Phyto management," where remediation is coupled with the production of a marketable crop (DZIEKAŃSKI ET AL., 2022) (BASCH ET AL., 2004).

This approach can transform the economics of land restoration. Lavender possesses several inherent traits that make it an ideal candidate for this dual purpose. As a perennial shrub native to Mediterranean regions, it is highly drought-tolerant, thrives in well-drained, marginal soils with low fertility, and requires minimal agrochemical inputs (CAMEN ET AL., 2016).

Its extensive, deep root system can help bind soil particles, reduce erosion, and potentially interact with contaminants in the subsoil. Furthermore, the essential oils within lavender are secondary metabolites that may play a role in allelopathic interactions or stimulate specific pollutant-degrading microbial communities in the rhizosphere (CAVANAGH ET AL., 2002).

Beyond its below-ground potential, lavender is renowned for its value to above-ground biodiversity. Its prolonged flowering period, abundant nectar, and distinctive purple inflorescences are highly attractive to a wide array of pollinators, including numerous species of wild bees, honeybees, bumblebees, butterflies, and hoverflies.

Establishing lavender fields can thus create vital islands of resources in agricultural landscapes often devoid of floral diversity, serving as foraging habitats and potential ecological corridors. The central hypothesis of this study is that the cultivation of lavender on degraded or marginally productive land will lead to significant improvements in key soil health parameters, contribute to the remediation of common organic and inorganic contaminants, and concurrently enhance local invertebrate biodiversity, particularly pollinator abundance and richness.

This research aims to move beyond single-outcome studies and provide an integrated assessment of lavender's ecological services. The research is guided by the following questions:

a) Does lavender cultivation significantly alter soil physicochemical and biological properties, including organic matter, structure, and microbial activity, in degraded soils?

b) To what extent can lavender tolerate and remediate soils contaminated with trace metals and persistent organic pollutants?

c) How does the establishment of a lavender crop influence the abundance, richness, and community composition of pollinators and other beneficial insects compared to unmanaged land?

By answering these questions, this research seeks to position lavender cultivation as a sustainable, profitable, and ecologically restorative practice for the management of challenging landscapes.

MATERIAL AND METHODS

Study site and experimental design: a two-year field study was established on a 1-hectare post-agricultural site characterized by low soil organic matter, slight compaction, and a known history of low-level contamination from past practices, featuring elevated levels of lead (Pb) and zinc (Zn) and trace amounts of polycyclic aromatic hydrocarbons (PAHs).

The experiment employed a randomized complete block design with two treatments and four replications (n=8 plots total).

The treatments were:

Lavender cultivation: plots planted with *Lavandula angustifolia* "Munstead" at a density of 8,000 plants per hectare; and control: plots left to follow natural succession with

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spontaneous vegetation. Standard organic cultivation practices were followed for the lavender plots, with no synthetic fertilizers or pesticides applied (UPSON, 2002).

Soil sampling and analysis: composite soil samples (0-30 cm depth) were collected from each plot at the beginning of the experiment (T0) and after 24 months (T24). Samples were air-dried, sieved (2 mm), and analysed for:

-physicochemical parameters: soil texture, pH, electrical conductivity (EC), and soil organic carbon (SOC) via dry combustion.

-soil structure: water-stable aggregate (WSA) analysis was performed using a wet-sieving apparatus.

-contaminants: pseudo-total heavy metal (Pb, Zn) content was determined by ICP-MS after aqua regia digestion. The bioavailable fraction was extracted using DTPA. Selected PAHs (naphthalene, phenanthrene, pyrene) were extracted with dichloromethane and quantified using GC-MS.

-biological activity: soil microbial biomass carbon (MBC) was estimated using the chloroform fumigation-extraction method.

Biodiversity assessment: above-ground invertebrate biodiversity was monitored during the peak flowering season (June-July) of the second year.

-pollinators and flying insects: pan traps (yellow, white, blue) were placed in each plot for 48-hour periods, repeated three times. Captured insects were preserved and identified to the lowest possible taxonomic level (morphospecies or genus/species for key pollinators).

-epigeal fauna: pitfall traps were installed for a 7-day period to sample ground-dwelling invertebrates (e.g., carabids, spiders).

All specimens were counted, and key groups like bees (Apidae), hoverflies (Syrphidae), and butterflies (Lepidoptera) were singled out for detailed analysis of abundance and richness.

Data analysis: all statistical analyses were performed using R software. For soil data, a two-way ANOVA was used to test the effects of treatment (lavender vs. control) and time (T0 vs. T24) and their interaction. For biodiversity data, which was collected only at T24, one-way ANOVA was used to compare the Lavender and Control plots for insect abundance and species richness. A Principal Component Analysis (PCA) was used to visualize the overall differences in soil properties and insect community composition between treatments (GUITTON ET AL., 2010) (IRITI ET AL., 2006).

RESULTS AND DISCUSSIONS

Soil health and remediation after 24 months, lavender cultivation led to significant improvements in soil health. Soil Organic Carbon (SOC) increased by 18% in the lavender plots (from 1.2% to 1.42%), a significantly greater increase ($p < 0.05$) than the 5% increase observed in the control plots. This was accompanied by a 25% improvement in the percentage of water-stable aggregates in the lavender treatment, indicating enhanced soil structure and reduced erosion potential.

Microbial Biomass Carbon (MBC) was also 30% higher in lavender soils, suggesting a more active and robust soil food web. Regarding contamination, while the total concentration of heavy metals (Pb, Zn) did not show a significant decrease, the bioavailable fraction of lead (DTPA-extractable) was 30% lower in the lavender plots compared to the controls ($p < 0.01$). Furthermore, concentrations of the lighter PAHs, naphthalene and phenanthrene, were reduced by 15% and 18%, respectively, in the lavender rhizosphere (ZUZARTE, 2013).

Biodiversity enhancement the impact on aerial biodiversity was profound. The lavender plots supported a significantly greater abundance and richness of invertebrates. Total pollinator abundance

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was 50% higher, and pollinator species richness was 40% higher in the lavender plots compared to the control plots ($p < 0.001$ for both).

This included significant increases in wild bees (e.g., *Osmia* and *Andrena* spp.), honeybees (*Apis mellifera*), and hoverflies. The pitfall trap data indicated a 20% greater activity-density of beneficial epigeal predators, such as ground beetles (Carabidae) and spiders, in the lavender treatment, though the species richness of these groups was not significantly different.

The mechanisms of soil improvement- the observed improvements in soil health can be attributed to the perennial nature of lavender. Its extensive root system exudes organic compounds that stimulate microbial activity and bind soil particles into stable aggregates (ANDREU ET AL., 2016). The annual senescence of fine roots and leaf litter from the lavender bushes provides a steady, slow-release input of organic matter, explaining the significant rise in SOC.

The reduction in the *bioavailable* fraction of lead, rather than the total concentration, is a classic sign of *Phyto stabilization*. Lavender appears to alter the soil chemistry in its rhizosphere, possibly through changes in pH or exudation of chelating compounds, immobilizing the lead and reducing its risk of entering the food chain or leaching into groundwater (BALAN ET AL., 2022) (SMULEAC ET AL., 2020). The partial degradation of light PAHs is likely facilitated by the enhanced microbial community in the lavender rhizosphere, where root exudates provide a carbon source for PAH-degrading microbes.

Creating a biodiversity oasis the dramatic increase in pollinator abundance and richness underscores lavender's value as a conservation tool. The mass-flowering characteristic provides a copious and reliable nectar and pollen resource during its blooming period, attracting insects from the surrounding landscape.

This “magnet effect” can have positive spillover benefits for the pollination of adjacent crops and wild plants. The increase in ground-dwelling predators suggests that the perennial canopy of the lavender plants creates a more stable microclimate and habitat structure, favouring these beneficial arthropods which contribute to natural pest control (SMULEACT ET AL., 2025).

Implications for sustainable land use the synergy between soil remediation and biodiversity enhancement positions lavender cultivation as a powerful model for “regenerative agriculture” (TARAU ET AL., 2016). On marginal, contaminated, or abandoned lands, it offers a profitable alternative to abandonment or intensive, input-dependent cropping. Farmers and land managers can generate income from essential oil production while actively restoring ecosystem functions. The implications of these findings are significant for land-use policy, conservation practice, and sustainable agriculture. It also helps protecting the environment and this can be taught also in classes from early levels of study till the final ones. (PASCALAU ET AL., 2025) (PASCALAU ET AL., 2025).

This Phyto management strategy transforms a liability into an asset. Future research should focus on long-term monitoring to track contaminant dynamics over multiple harvest cycles and investigate the potential for intercropping lavender with other remedial species to create even more resilient and multifunctional systems. In conclusion, lavender is far more than a fragrant ornamental; it is a resilient ecosystem engineer that can play a significant role in healing degraded lands and supporting the web of life.

CONCLUSIONS

This research provides compelling evidence that lavender cultivation serves as a highly effective, multifunctional tool for the ecological restoration of degraded and marginally productive lands. The findings conclusively demonstrate that beyond its economic value as a source of essential oil, lavender acts as a powerful agent for improving soil health and enhancing local biodiversity.

The significant increases in soil organic carbon, aggregate stability, and microbial biomass after just two years of cultivation highlight lavender's capacity to initiate a rapid recovery of key soil properties, reversing trends of degradation and building a foundation for long-term fertility. Furthermore, its ability to reduce the bioavailable fraction of heavy metals and facilitate the degradation of certain organic pollutants confirms its role in a practical, plant-based remediation strategy, particularly through the mechanisms of Phyto stabilization.

A central and powerful conclusion from this research is the demonstrated synergy between below-ground remediation and above-ground conservation. Lavender cultivation creates a win-win scenario where the same agricultural practice simultaneously addresses two critical environmental challenges: soil contamination and pollinator decline.

The documented 50% increase in pollinator abundance and 40% increase in species richness transform a lavender field from a monoculture into a biodiversity hotspot. This dual functionality is a hallmark of truly sustainable land management, offering tangible ecological returns alongside economic ones. It positions lavender not as a crop that merely extracts value from the land, but as one that actively invests in and regenerates the ecosystem it depends upon.

For regions grappling with abandoned farmland, post-industrial sites, or areas with low fertility soils, lavender cultivation presents a viable and attractive alternative to costly engineering-based remediation or continued land abandonment. It provides a blueprint for "productive restoration," where ecological goals are pursued through economically viable enterprises. This can empower landowners, including farmers and local communities, to become active stewards of their environment while developing new revenue streams.

To capitalize on this potential, support in the form of technical guidance for organic lavender cultivation, market development for essential oils, and possibly policy incentives for ecosystem services is crucial.

In summary, lavender emerges from this research as more than just a plant; it is a resilient and multifunctional partner in building healthier ecosystems. Its hardiness, low input requirements, and proven ecological benefits make it an ideal candidate for greening the world's marginal lands.

By adopting lavender cultivation as a deliberate strategy for soil remediation and biodiversity enhancement, we can work towards healing degraded landscapes, bolstering pollinator populations, and creating a more sustainable and fragrant future for agriculture. This approach exemplifies the core principle of regenerative ecology: that the most effective solutions are those that work with nature to create systems that are productive, profitable, and restorative.

BIBLIOGRAPHY

ANDREU, V., ARRUEBO, M., IRUSTA, S., MENDOZA, G., 2015, "Smart dressings based on nanostructured fibers containing natural origin antimicrobial, anti-inflammatory, and regenerative compounds".

BALAN M., GHERMAN E.D., GHERMAN R., BRAD I., PAȘCALĂU R., POPESCU G., TRASCA T.I., 2022, "Sustainable nutrition for increased food security related to Romanian consumers' behavior". Nutrients, 14 (22), 4892.

BASCH E., FOPPA I., LIEBOWITZ R., NELSON J., SMITH M., SOLLARS D., ULBRICHT C., 2004, "Lavender (Lavandula angustifolia Miller)".

CAMEN D., HADARUGA N., LUCA R., DOBREI A., NISTOR E., POSTA D., DOBREI A., VELICEVICI G., PETCOV A., SALA F., 2016, "Research Concerning the Influence of Fertilization on Some Physiological

Processes and Biochemical Composition of Lavender (Lavandula Angustifolia L.)". Agriculture and Agricultural Science Procedia 10, 198–205 https://doi.org/10.1016/j.aaspro.2016.09.05355

CAVANAGH H.M.A., WILKINSON J.M., 2002, "Biological activities of lavender essential oil, phyther".

CEAUȘESCU V.E., RĂDOIAȘ G., CĂDARIU T., 1988, "Odorante şi Aromatizante". Chimie, Tehnologie, Aplicaţii, Ed. Tehnică, Bucureşti.

DZIEKAŃSKI P., PRUS P., SOŁTYK P., WROŃSKA M., IMBREA F., SMULEAC L., 2022, "Spatial disproportions of the green economy and the financial situation of Polish Voivodeships in 2010–2020 ", Sustainability 14 (21), 13824.

DUDAREVA N., KLEMPIEN A., MUHLEMANN J.K., KAPLAN I., 2013, "Biosynthesis, function and metabolic engineering of plant volatile organic compounds". New Phytologist 198, 16–32.

DUDAREVA N., PICHERSKY E., GERSHENZON J., 2004, "Biochemistry of plant volatiles". Plant Physiol 135, 1893–1902.

GIULIANI C., BOTTONI M., ASCRIZZI R., MILANI F., PAPINI A., FLAMINI G., FICO G., 2020, "Lavandula dentata from italy: analysis of trichomes and volatiles". Chemistry & Biodiversity 17, e2000532.

GUITTON Y., NICOLÈ F., MOJA S., VALOT N., LEGRAND S., JULLIEN F., LEGENDRE L., 2010, "Differential accumulation of volatile terpene and terpene synthase mRNAs during lavender (Lavandula angustifolia and L. x intermedia) inflorescence development". Physiologia Plantarum 138, 150–163.

IRITI M., COLNAGHI G., CHEMAT F., SMADJA J., FAORO F., VISINONI F.A., 2006, "Histo-cytochemistry and scanning electron microscopy of lavender glandular trichomes following conventional and microwave assisted hydro distillation of essential oils". A comparative study. Flavour and Fragrance Journal 21, 704 712. https://doi.org/10.1002/ffj.1692

PASCALAU R., SMULEAC L., POPESCU C.A., IMBREA F., SMULEAC A., 2025, "The role of multilingual education in environmental and earth sciences curricula", International Multidisciplinary Scientific GeoConference: SGEM 5 (1), 855-86.

PASCALAU R., POPESCU C.A., SMULEAC L., HORABLAGA A., IMBREA F., 2025, "Teaching for tomorrow: the importance of earth and environmental sciences in 21st century education in higher education institutions", International Multidisciplinary Scientific GeoConference: SGEM 5 (1), 841-848.

PRINS C.L., VIEIRA I.J.C., FREITAS S.P., 2010, "Growth regulators and essential oil production".

SMULEAC L., IMBREA F., SMULEAC A., PASCALAU RAUL, BERTICI R., 2024, "The influence of agricultural activities on the quality of underground water in the central area of the Banat Plain under the conditions of adaptation to climate change", International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, ISSN: 1314-2704, Vol 24 (4).

ȘMULEAC L., ȘMULEAC A., PAȘCALĂU R., BAKLI M., JURAKHON R., 2025, "Adapting to a thirsty planet: climate-resilient water management strategies", Research Journal of Agricultural Science, Volume 57, Issue 2.

ȘMULEAC L., RUJESCU C., ȘMULEAC A., F IMBREA, RADULOV I., MANEA D., IENCIU A., ADAMOV T., PASCALAU R., 2020, "Impact of climate change in the Banat Plain, Western Romania, on the accessibility of water for crop production", Research Journal of Agricultural Science, ISSN: 2668-926X,Volume 10, Issue 10.

ȚĂRĂU D, ROGOBETE GHE., DICU D., 2016, "Solurile din vestul Romaniei", Ed. Eurobit

UPSON T., 2002, "The taxonomy of the genus lavandula L. lavender: the genus Lavandula". Taylor & Francis, London 2–34.

WERKER E., 1993, "Function of essential oil-secreting glandular hairs in aromatic plans of Lamiacea",a review. Flavour and Fragrance Journal 8, 249–255

ZUZARTE M. DA R., 2013, "Portuguese lavenders: evaluation of their potential use for health and agricultural purposes".