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Urban Lichen Diversity Reflecting Air Quality Patterns across European Cities

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INTRODUCTION & AIM

As poikilohydric organisms, epiphytic lichens lack a protective cuticle, making them highly susceptible to atmospheric pollutants such as SO_2, NO_x, and particulate matter (PM). This physiological trait positions them as critical biological proxies for urban ecosystem health. The primary research objectives include conducting a comparative analysis of lichen diversity indices across European metropolises with varying climatic and pollution regimes to establish a broader environmental baseline. Furthermore, this study aims to identify statistical correlations between urban density, vehicular emissions, and lichen community composition to pinpoint specific anthropogenic pressures. Finally, the research evaluates the role of green infrastructure as biodiversity refugia within anthropized environments, determining how vegetated areas mitigate the negative impacts of urbanization on biological communities.

METHOD

This systematic review was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol:

Eligibility Criteria: A systematic screening of studies published between 2014–2026, focusing on European urban biomonitoring (e.g., Italy, Germany, Romania, Spain).
Analyzed Indicators: Systematic evaluation of the Index of Atmospheric Purity (I.A.P.), Lichen Diversity Value (L.D.V.), and bioaccumulation metrics (heavy metals, PAHs).
Data Synthesis: Systematically evaluating "Center-to-Periphery" gradients and cross-referencing biological data with instrumental air quality monitoring station records.

RESULTS & DISCUSSION

Analysis of consolidated data from multiple European urban studies reveals a consistent relationship between urban architecture, emission levels, and biological health:

- Nitrogen-Driven Homogenization: Across European cities, high-traffic zones exhibit a "biotic leveling" where specialized lichen communities are replaced by nitrophilous taxa (e.g., *Xanthoria parietina*). This shift reflects the saturation of nitrogen oxides (NO_x) and a significant loss of phylogenetic diversity in urban cores.
- Growth Form Sensitivity: A clear hierarchical response exists based on morphology; Fruticose (shrub-like) lichens disappear first under atmospheric stress, while Crustose species persist. This makes growth-form mapping an efficient, low-cost proxy for identifying "lichen deserts" and high-risk pollution zones.
- Impact of Urban Geometry: The "canyon effect" in dense city centers traps pollutants, leading to localized biological degradation. Lichens in well-ventilated areas or open squares show higher vitality than those in sheltered street canyons, proving that urban morphology directly influences air quality patterns.
- Mitigation via Green Infrastructure: Urban parks and botanical gardens act as essential microclimatic buffers. These "green oases" maintain higher humidity and lower temperatures, allowing sensitive species to survive and providing a "nature-based" blueprint for sustainable urban reforestation and ecological corridors.
- Standardized Biomonitoring Accuracy: Statistical analysis shows a strong correlation ($r^2 > 0.75$) between the Index of Atmospheric Purity (I.A.P.) and instrumental $PM_{2.5}$ data. This validates biological monitoring as a high-resolution spatial tool that successfully complements traditional air quality sensor networks.

CONCLUSION

Diagnostic Validity: A strong inverse correlation exists between transport density and lichen biodiversity, confirming biological response as a precise reflection of atmospheric stress.
Practical Application: Lichen communities serve as "early warning" indicators, providing high-resolution spatial data that complements traditional electronic sensor networks.
Urban Sustainability: Protecting "biodiversity islands" is essential for maintaining indicator species and their associated ecosystem services in anthropized environments.

FUTURE WORK / REFERENCES

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