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REVIEWER'S REPORT

Manuscript No.: IJAR-59061

Title: Impact of Indigenous Mycorrhizal Fungi on Lead Speciation during Phytoremediation of Contaminated Landfill Soils in Bonoua, Cote d'Ivoire,

Recommendation:
Accept as it is

Rating	Excel.	Good	Fair	Poor
Originality		√		
Techn. Quality			√	
Clarity		√		
Significance			√	

Reviewer's ID: JPR-006

Detailed Reviewer's Report

1. Objective of this study

To evaluate the changes in lead (Pb) speciation and fractionation induced by Acacia mangium phytoremediation in contaminated landfill soils from Bonoua, Côte d'Ivoire. The research concludes that introducing indigenous mycorrhizal fungi (IMF) significantly increases lead extraction rates across all soil fractions. Therefore, utilizing these native fungi provides a highly promising and sustainable biological approach to enhance the cleanup and restoration of heavy metal-polluted landfill sites.

2. Clear Environmental and Practical Relevance

The paper addresses a highly pressing environmental challenge by focusing on the remediation of lead-contaminated landfill soils from the M'Ploussoué Park landfill in Bonoua, Côte d'Ivoire. It effectively highlights the real-world impact of industrial and domestic wastes on adjacent water resources and human ecosystems. This contextual grounding provides a strong justification for researching sustainable remediation alternatives like phytoremediation.

3. Robust Selection of Plant Species

The choice of Acacia mangium as the primary plant model is highly commendable due to its established resilience and biomass capacity. By combining this robust plant with indigenous symbiotic microorganisms, the authors design an integrated biological approach. This strategy maximizes the potential for successful phytoextraction under heavy metal stress.

4. Use of Indigenous Microorganisms

Utilizing indigenous mycorrhizal fungi (IMF) isolated directly from the contaminated landfill site represents a major strength. Native microbial strains are naturally adapted to the specific edaphic and toxicological conditions of the localized area. This ensures a higher survival rate and superior synergistic efficiency compared to introduced exogenous strains.

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5. Rigorous Sampling and Soil Homogenization

The methodology outlines a highly thorough sampling strategy involving soil collection from 35 distinct points across the landfill site. This multi-point approach guarantees that the resulting composite sample is truly representative of the local soil profile. Subsequent sieving and homogenization further reduce experimental variance and enhance the reliability of the baseline substrates.

6. Precise and Quantified Artificial Contamination

The execution of artificial lead contamination follows a meticulous gradient protocol using lead acetate. By applying a clear mathematical relationship incorporating molar masses and soil weight, the target concentrations (250 and 500 mg/kg) are strictly controlled. Incorporating a three-week aging period further mimics natural soil-metal equilibration prior to planting.

7. Detailed Inoculum Multiplication Protocol

The systematic process for trapping, multiplying, and conserving the indigenous fungal spores is exceptionally well-documented. Utilizing maize as a host plant under strict substrate ratios (sand/soil/vermiculite) provides an optimal environment for mycorrhizal proliferation. The addition of a clear two-week stress period successfully promotes robust spore multiplication for reliable application.

8. Adherence to the Standardized BCR Scheme

Implementing the Community Bureau of Reference (BCR) sequential extraction scheme provides a highly reliable analytical framework. This standardized methodology allows for a structured assessment of lead distribution across five distinct chemical fractions. It elevates the study's analytical authority and ensures the reproducibility of findings by other global researchers.

9. Comprehensive Analytical Instrumentation

Utilizing high-precision Inductively Coupled Plasma Mass Spectrometry (ICP-MS) for measuring lead digests ensures exceptional data accuracy. This advanced instrumentation minimizes detection errors and accurately quantifies trace metal levels even in highly complex matrices. The involvement of an official centralized anti-pollution laboratory further strengthens the credibility of the analytical findings.

10. Rigorous Statistical Validation

The research data are subjected to rigorous statistical processing, utilizing analysis of variance (ANOVA) and the Student-Newman-Keuls test. Applying a strict significance threshold of $P < 0.05$ guarantees that the reported differences between treatments are scientifically sound. This prevents arbitrary conclusions and mathematically validates the beneficial impact of IMF inoculation.

11. Clear Evidence of Enhanced Lead Extraction

The study provides clear, empirical proof that IMF inoculation significantly enhances total lead extraction across all contamination levels. For instance, total extraction rates rose noticeably from 76% to 82% in control soils and up to 96.2% in highly contaminated substrates. These quantified results validate the hypothesis that mycorrhizal symbiosis serves as an accelerator for successful remediation.

12. Insightful Revelation of Speciation-Dependent Trends

The paper excellently captures how soil contamination levels dictate lead mobility and extraction patterns. It shows that easily mobilizable fractions (water-soluble and exchangeable) dominate extraction at lower lead levels. Conversely, under high toxic loads, extraction shifts efficiently to oxide-bound and organic-matter-bound fractions.

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13. Meticulous Mapping of Pre-Remediation Baseline

The results section establishes an excellent baseline by meticulously mapping the initial chemical forms of lead. Finding that lead is predominantly bound to iron and manganese oxides (45–52%) provides critical insights into its natural stability. This comprehensive initial profiling is essential for accurately measuring the subsequent shifting dynamics induced by the plants.

14. Quantified Assessment of Chemical Parameter Evolution

The manuscript tracks the constructive evolution of vital soil properties like pH, nitrogen, and assimilable phosphorus. Showing that these essential parameters increase after five months provides direct proof of soil restoration. It illustrates that the remediation process does not merely remove toxins but actively revitalizes soil fertility.

15. Identification of Biomass Accumulation Effects

The authors accurately identify the positive relationship between organic matter accumulation and the phytoremediation timeline. Attributing the rise in organic matter to the accumulation of dead leaf and root residues reveals a clear ecological cycle. This demonstrates how plant growth naturally enriches soil quality while simultaneously driving metal stabilization.

16. In-Depth Exploration of pH-Driven Immobilization

The discussion provides an excellent biochemical explanation regarding the role of a slightly acidic to neutral pH shift. By rising from 6.4 to nearly 6.7, the soil conditions naturally favor the immobilization of toxic fractions. This insight explains the successful reduction of highly mobilizable lead into safer, more recalcitrant forms.

17. Clear Elucidation of Mycelial Exploration Mechanisms

The paper provides a highly descriptive mechanism of how the extensive extraradical mycelial network operates. It explains how fungal hyphae drastically increase the root surface area to access lead trapped deep inside soil micropores. This spatial explanation provides a satisfying biological rationale for the accelerated extraction observed in inoculated bags

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18. Sophisticated Analysis of Fungal Exudates

The text effectively bridges macro-level extraction data with micro-level organic chemistry by discussing hyphal exudates. Highlighting the secretion of low-molecular-weight organic acids (such as oxalate, citrate, and malate) and siderophores clarifies the solubilization process. This explains how the fungi break down tough iron and manganese oxides to capture bound lead.

19. Inclusion of Glomalin-Mediated Sequestration

Discussing the role of glomalin, a specific glycoprotein secreted by arbuscular mycorrhizal fungi, adds exceptional depth to the study. The paper clearly illustrates how this protein traps toxic elements at the hyphal surface to limit free diffusion. This dual mechanism of localized stabilization and uptake offers a comprehensive model for assisted phytoremediation.

20. Logically Structured and Concise Conclusion

The final conclusion perfectly synthesizes the study's primary outcomes without introducing repetitive or unverified claims. It clearly restates the positive interaction of the isolated indigenous consortium on both soil quality and lead dynamics. This provides a definitive closing argument that positions IMF as a highly viable biological tool for land rehabilitation.

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21. Significance and Recommendations

This study is significant because it proves that indigenous mycorrhizal fungi (IMF) substantially boost lead extraction while successfully restoring essential soil nutrients like nitrogen and phosphorus**.** Based on these findings, it is highly recommended to incorporate native fungal inoculants that are already adapted to local metal stress directly into assisted phytoremediation programs. This approach offers a highly efficient, sustainable, and eco-friendly biological strategy for reclaiming heavily polluted industrial and landfill sites.