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REVIEWER'S REPORT

Manuscript No.: IJAR-55662

Title: DIVERSITÉ FLORISTIQUE ET ESPÈCES BIOINDICATRICES ET ACCUMULATRICES DE MÉTAUX LOURDS AUX ABORDS DU PARC À RÉSIDUS MINIER DE SABODALA (SÉNÉGAL)

Recommendation:
Accept as it is

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

Reviewer Name: Dr. Manju M

Detailed Reviewer's Report

1. Study Area and Research Rationale

The investigation was carried out in the Sabodala gold mining area located in the Kédougou region of southeastern Senegal. This region lies within the Sudano–Guinean ecological zone and is both mineral-rich and biodiversity-sensitive. Mining tailings in the area are major sources of trace metal dispersion into surrounding ecosystems. Assessing floristic diversity provides insight into ecosystem resilience under mining pressure. Simultaneously, evaluating metal contamination in soils and plants reveals ecological risk levels. The study integrates ecological and geochemical perspectives to address mining-related environmental concerns. This combined approach supports sustainable environmental assessment and management.

2. Objectives of the Study

The primary objective was to characterize floristic diversity around the tailings storage facility of the Sabodala mine. A second objective focused on assessing trace metal contamination in rhizospheric soils and plant tissues. The study also aimed to identify plant species capable of accumulating or indicating metal contamination. Special attention was given to arsenic, antimony, cadmium, and nickel due to their toxicity and mining relevance. Another goal was to evaluate soil–plant metal transfer mechanisms. The outcomes were intended to support biomonitoring and phytoremediation strategies. Overall, the study contributes to sustainable mining area management.

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3. Description of Environmental and Geological Context

The Sabodala area experiences a Sudano–Guinean climate with annual rainfall of about 900 mm and high dry-season temperatures. Vegetation consists of savanna–woodland mosaics influenced by agriculture, grazing, and mining. Geologically, the area belongs to the Mako greenstone belt, characterized by Birimian volcano-sedimentary formations. Lithologies include granitic, mafic, ultramafic, quartzitic, and sandstone units. These formations strongly influence soil chemistry and metal availability. Ultramafic rocks are particularly enriched in nickel. This geological background partly explains observed metal concentrations.

4. Floristic Survey Methodology

A roving floristic survey was employed to document plant diversity across the mining-impacted area. This method allows comprehensive species recording without fixed plots. Surveys were conducted across multiple microhabitats to capture maximum diversity. All encountered species were collected and documented systematically. Specimens were pressed and identified using standard floras and herbarium references. Taxonomic classification followed internationally accepted nomenclature. This methodology ensured accurate and representative floristic data.

5. Floristic Composition and Diversity

The survey recorded a total of 37 plant species belonging to 29 genera and 17 families. Angiosperms exclusively constituted the flora, with dicotyledons dominating species richness. Only one monocotyledon species was observed. The moderate species richness reflects adaptation to disturbed savanna–woodland environments. Despite mining pressure, vegetation diversity remained relatively stable. This indicates resilience of local flora to environmental stress. Such baseline data are essential for long-term ecological monitoring.

6. Dominant Plant Families

Four plant families accounted for more than half of the recorded species. Combretaceae was the most dominant family, followed by Malvaceae, Fabaceae, and Lamiaceae. These families are well adapted to dry tropical and semi-arid environments. Their dominance suggests ecological tolerance to nutrient-poor and metal-stressed soils. Many species from these families contribute to soil stabilization and nutrient cycling. Their presence enhances ecosystem resilience. Such families often dominate disturbed mining landscapes.

7. Biological Spectrum and Life-Form Structure

Life-form analysis based on Raunkiaer's classification revealed a dominance of phanerophytes. Mesophanerophytes and microphanerophytes together represented over 78% of species. This indicates a

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woody vegetation structure dominated by trees and shrubs. Such life forms are better adapted to withstand environmental stress. Therophytes and parasites were less represented. The biological spectrum reflects relative ecological stability. It also suggests regeneration capacity in the mining landscape.

8. Phytogeographical Characteristics

Phytogeographical analysis showed a dominance of Afrotropical and Soudanian species. Pantropical and Paléotropical species contributed moderately. Cosmopolitan and Afro-Malagasy taxa were scarce. This chorological structure reflects strong regional biogeographical influence. Species composition is closely linked to climatic and edaphic conditions. Such analysis supports regional biodiversity comparisons. It also aids in conservation prioritization for mining regions.

9. Selection of Species for Metal Analysis

Eighteen plant species were selected for metal analysis, including fourteen woody and four herbaceous species. Selection was based on abundance, distribution, and ecological relevance. For each species, rhizospheric soils, roots, and leaves were sampled. This design enabled assessment of metal transfer within the soil–plant system. Sampling across compartments improves understanding of uptake mechanisms. It also allows comparison among life forms. The approach enhances ecological interpretation of contamination patterns.

10. Sample Preparation and Analytical Techniques

Soil and plant samples were carefully prepared to ensure analytical accuracy. Rhizospheric soils were air-dried, ground, and sieved to 63 µm. Plant tissues were washed, dried, ground, and similarly sieved. Chemical digestion protocols were applied prior to analysis. Trace metal concentrations were determined using ICP-OES. This technique provides high sensitivity and multi-element capability. Analytical rigor strengthens the reliability of the results.

11. Total Metal Concentrations in Soils

Total metal analysis revealed variable concentrations across rhizospheric soils. The average concentration order was Ni > Sb > As > Cd. Nickel showed the highest levels, reflecting geological enrichment and mining influence. Cadmium concentrations were consistently low. Antimony exhibited elevated values in certain locations. These results highlight both natural and anthropogenic metal sources. Total concentrations provide an overview of contamination intensity.

12. Metal Speciation and Bioavailability in Soils

Sequential extraction following the Tessier method was used to assess metal speciation. Arsenic and antimony were entirely confined to the residual fraction. This indicates strong mineral binding and very low bioavailability. Cadmium showed partial distribution among residual, sulfide, and exchangeable

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fractions. Nickel was mainly residual but also associated with sulfides. Speciation patterns determine ecological risk. They strongly influence plant uptake behavior.

13. Soil–Plant Interaction Mechanisms

The study highlights complex interactions between soil chemistry and plant uptake. Soil mineralogy, pH, and organic matter influence metal mobility. Plants respond through selective absorption and compartmentalization. Root sequestration acts as a detoxification mechanism. In some cases, metals are translocated to aerial parts. These interactions explain inter-species variability in accumulation. Understanding them is essential for remediation planning.

14. Metal Concentrations in Plant Tissues

Metal analysis of plant tissues revealed distinct accumulation patterns. Cadmium concentrations were generally higher in roots than leaves. This indicates restricted translocation to aerial parts. Nickel showed significant accumulation in both roots and leaves of certain species. Such patterns reflect physiological adaptation to metal stress. Plant metal concentrations provide insight into contamination exposure. They also help identify tolerant and accumulator species.

15. Bioaccumulation and Translocation Indices

Bioconcentration factor (BCF) and translocation factor (TF) were calculated for all analyzed species. BCF values assess soil-to-root metal transfer. TF values indicate root-to-leaf translocation efficiency. Values greater than one signify effective accumulation or transport. These indices are widely used in phytoremediation studies. They help distinguish accumulators, excluders, and indicators. Their use strengthens ecological interpretation.

16. Cadmium Behavior in the Soil–Plant System

Cadmium showed limited accumulation in plant tissues. Most species exhibited BCF and TF values below one. Roots accumulated more Cd than leaves, indicating restricted mobility. This physiological control limits Cd entry into the food chain. Only a few species showed moderate translocation. Cadmium thus poses a moderate ecological risk. Continuous monitoring remains necessary due to its toxicity.

17. Nickel Accumulation in Roots

Several species exhibited high nickel concentrations in roots. Root values exceeded 100 ppm in some taxa. BCF values were frequently greater than one. This indicates efficient soil-to-root uptake. Root sequestration reduces metal toxicity in aerial parts. Such behavior reflects tolerance mechanisms. Root-accumulating species play a role in natural attenuation.

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18. Nickel Translocation to Leaves

Certain species efficiently translocated nickel to their leaves. Leaf concentrations reached exceptionally high values. High TF values confirmed active root-to-shoot transport. This behavior is characteristic of accumulator or hyperaccumulator-like species. Such plants are effective bioindicators of soil nickel contamination. They also show potential for phytoextraction. Leaf analysis allows non-destructive monitoring.

19. Inter-Species Variability in Metal Uptake

Metal accumulation varied greatly among plant species. This variability reflects genetic and physiological differences. Some species restrict metals to roots, while others translocate them to leaves. Such functional diversity enhances ecosystem resilience. It also allows identification of species with specific ecological roles. Understanding this variability supports targeted remediation strategies. It is crucial for selecting suitable indicator species.

20. Identification of Bioindicator Species

A few species showed TF values close to or exceeding one for cadmium and nickel. These species respond sensitively to soil metal levels. Their leaves reflect contamination intensity. Such traits make them suitable bioindicators. Bioindicator species enable cost-effective environmental monitoring. They provide early warning signals of ecosystem degradation. Their use complements chemical assessments.

21. Nickel Accumulator Species and Phytoremediation

Several species demonstrated strong nickel accumulation capacity. Among them, Hexalobus monopetalus showed exceptional behavior. Both BCF and TF values exceeded one. This indicates efficient uptake and translocation. Such traits are ideal for phytoremediation applications. Accumulator species can reduce soil metal loads over time. They offer an eco-friendly remediation option.

22. Ecological Significance of Hexalobus monopetalus

Hexalobus monopetalus exhibited the highest nickel concentrations among studied species. Leaf concentrations reached approximately 247 ppm. Root concentrations exceeded 130 ppm. Both accumulation and translocation were highly efficient. This species shows strong tolerance to nickel stress. It represents a potential hyperaccumulator-like taxon. Its use could support nickel phytoextraction strategies.

23. Implications for Ecological Restoration

The study supports the use of local flora in ecological restoration. Native species are better adapted to local climatic and edaphic conditions. Their use reduces ecological risks and maintenance costs. Vegetation restoration enhances soil stability and ecosystem function. Accumulator species can be

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integrated into remediation plans. Such strategies promote gradual recovery of mining landscapes. They align with sustainable land management principles.

24. Overall Conclusions and Management Perspectives

The study demonstrates the effectiveness of integrating floristic and geochemical approaches. Local vegetation provides valuable information on environmental quality. Strong links were identified between soil chemistry, plant diversity, and metal dynamics. Results support biomonitoring and phytoremediation in Sudano–Guinean mining areas. The findings provide baseline data for sustainable mining management. Long-term monitoring and field-scale remediation are recommended. This approach promotes environmentally responsible mining practices.