HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

EFFECTS OF HEAVY METAL POLLUTION ON SOIL MICROORGANISMS AND BIOCHEMICAL PROCESSES

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Abstract

Heavy metal pollution is a serious environmental problem that affects soil fertility and microbial activity. Soil microorganisms play a key role in nutrient cycling, organic matter decomposition, and ecosystem stability. This study examines the effects of heavy metals on soil microbial communities and biochemical processes. The findings indicate that cadmium, lead, mercury, and chromium reduce microbial biomass, inhibit enzyme activity, and disturb nitrogen and carbon cycles.

Keywords: heavy metals, soil microorganisms, pollution, enzymes, ecological toxicity

Introduction

Soil ecosystems depend on complex interactions between microorganisms, organic matter, minerals, and environmental conditions. Heavy metals enter soil through industrial emissions, mining, wastewater irrigation, and agricultural chemicals. Unlike many organic pollutants, heavy metals are persistent and may accumulate in soil for long periods. Their toxic effects impair microbial metabolism and reduce soil productivity.

Materials and Methods

The study analyzed scientific literature on heavy metal toxicity in soils. Indicators such as microbial biomass, dehydrogenase activity, urease activity, phosphatase activity, nitrification, and organic matter decomposition were reviewed. Comparative analysis was applied to evaluate the impact of different metals.

Results

Heavy metal contamination reduced microbial diversity and enzyme activity. Cadmium and mercury showed strong inhibitory effects on microbial respiration. Lead accumulation decreased nitrogen transformation processes. Chromium exposure altered microbial community structure and reduced organic matter decomposition. Soil enzyme activity was identified as a sensitive indicator of pollution.

Discussion

Microorganisms are highly sensitive to heavy metal toxicity because metals bind to proteins, damage membranes, and disrupt enzyme function. Reduced microbial activity negatively affects nutrient cycling and soil fertility. Some microorganisms develop resistance mechanisms, including metal sequestration, efflux pumps, and biosorption. These mechanisms may be useful in bioremediation.

Conclusion

Heavy metal pollution significantly disrupts soil microorganisms and biochemical processes. Monitoring microbial and enzymatic indicators is important for assessing soil health. Bioremediation using resistant microorganisms may provide sustainable solutions for polluted soils.

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