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BIOREMEDIATION OF HEAVY METAL CONTAMINATED SOILS AND ITS IMPACT ON WHEAT GROWTH AND PHYSIOLOGICAL HEALTH

Jyoti[1], Dr Abhijeeta Nanda[2]

[1]Research Scholar, Kalinga University, Raipur, Chhattisgarh
[2]Assistant Professor, Kalinga University, Raipur, Chhattisgarh

Corresponding Author
Dr Abhijeeta Nanda,
abhijeeta.nandha@kalingauniversity.ac.in

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ABSTRACT
This study investigates the potential of microbial bioremediation in improving soil quality and promoting wheat growth in areas contaminated with heavy metals. Soil samples from heavily contaminated sites in Haryana, India, were treated with native microbial consortia and engineered microbial strains for bioremediation. The impact of soil remediation on wheat (Triticum aestivum) growth was evaluated by measuring growth parameters, chlorophyll content, and antioxidant enzyme activities. The results showed that bioremediation significantly enhanced wheat growth, with notable improvements in shoot length, root length, total biomass, and chlorophyll content. The findings highlight the potential of microbial bioremediation as a sustainable approach to restore contaminated soils and enhance agricultural productivity.

Keywords: Microbial Bioremediation, Heavy Metals, Soil Contamination, Growth Parameters, Chlorophyll Content, Antioxidant Enzyme Activities

1. INTRODUCTION
Heavy metal contamination in soil is a growing concern, particularly in industrial and urban regions, where pollutants such as lead, cadmium, and mercury compromise soil fertility and pose risks to human health. The Kundli Industrial Area in Sonipat, Haryana, and the Bandhwari Landfill in Gurugram have been identified as heavily polluted zones. These areas are characterized by significant contamination from industrial waste, leachate from landfills, and vehicular emissions. As a result, agricultural productivity has declined, and local communities are exposed to hazardous contaminants. The use of bioremediation, particularly microbial bioremediation, offers a promising solution to mitigate the effects of soil contamination. This study focuses on the impact of microbial bioremediation on wheat growth in contaminated soils.
Soil contamination with heavy metals, primarily due to industrial activities, mining, and improper waste disposal, poses a significant threat to both soil health and agricultural productivity. In regions such as Haryana, India, industrial effluents and landfill leachates have severely polluted the soil, leading to the accumulation of toxic metals like lead, cadmium, and

arsenic. These pollutants not only reduce soil fertility but also threaten human health through the food chain. Microbial bioremediation, a sustainable and eco-friendly solution, involves the use of microorganisms to degrade, detoxify, or immobilize contaminants. This review evaluates the effectiveness of microbial bioremediation in enhancing wheat growth in soils contaminated with heavy metals.

MICROBIAL BIOREMEDIATION FOR HEAVY METAL CONTAMINATION

Microbial bioremediation has gained traction as an effective method for the restoration of contaminated soils. Studies have shown that certain microorganisms, including bacteria and fungi, have the ability to degrade organic pollutants and sequester toxic metals. *Pseudomonas*, *Bacillus*, and *Aspergillus* are some of the microbial genera that have demonstrated bioremediation potential by tolerating high levels of heavy metals such as lead, cadmium, and mercury (Nascimento & Xing, 2020). These microorganisms either transform contaminants into less toxic forms or immobilize them through bioadsorption mechanisms, preventing their uptake by plants.

Recent research has highlighted the advantages of using native microbial consortia or engineered microbial strains for bioremediation. Engineered strains, in particular, are optimized to enhance the breakdown of contaminants or improve the sequestration of heavy metals in the soil, offering a more targeted and efficient remediation process (Singh & Sharma, 2019).

IMPACT ON WHEAT GROWTH

Wheat (Triticum aestivum), a staple crop, is highly susceptible to soil contaminants, especially heavy metals. These pollutants disrupt nutrient absorption, reduce root development, and impair plant growth. However, studies have shown that bioremediation can effectively improve plant health by mitigating the toxic effects of heavy metals. In the present study, wheat plants grown in soils treated with bioremediation exhibited significant improvements in growth parameters, including a 15% increase in shoot length, 20% increase in root length, and a 25% increase in total biomass compared to untreated soils.

The positive effects on plant growth can be attributed to the improved soil microbial activity that enhances nutrient availability and facilitates the detoxification of heavy metals. For example, microorganisms that produce siderophores can sequester toxic metals, reducing their bioavailability to plants and promoting better growth conditions (Sharma & Dubey, 2022). Additionally, microbial activity in remediated soils may help restore soil structure and organic matter content, further benefiting plant development (Nascimento & Xing, 2020).

CHLOROPHYLL CONTENT AND ANTIOXIDANT ENZYME ACTIVITIES

The physiological health of wheat plants was also assessed through the measurement of chlorophyll content and antioxidant enzyme activities. Chlorophyll content, which is directly related to the photosynthetic capacity of plants, was significantly higher in wheat plants grown in remediated soils. This increase in chlorophyll suggests that bioremediation not only mitigates the toxicity of heavy metals but also enhances the plant's ability to perform photosynthesis, ultimately improving its overall health.

Furthermore, antioxidant enzyme activities, such as superoxide dismutase (SOD) and catalase (CAT), were elevated in plants grown in remediated soils. These enzymes play a critical role in protecting plants from oxidative stress caused by environmental pollutants. Enhanced SOD and CAT activities indicate that bioremediation helps plants cope with the oxidative damage induced by heavy metals, which in turn supports healthier plant growth and development (Sharma & Dubey, 2022).

CONCLUSION

The study demonstrates that microbial bioremediation is an effective strategy for enhancing wheat growth in soils contaminated with heavy metals. By improving soil microbial activity, bioremediation not only reduces contaminant levels but also restores soil fertility, promoting better plant health. The significant increases in wheat growth parameters, chlorophyll content, and antioxidant enzyme activities underline the potential of microbial bioremediation to mitigate the effects of soil contamination and improve agricultural productivity. These findings support the adoption of microbial bioremediation as a sustainable solution to restore contaminated soils and enhance crop yields in polluted regions.

2. MATERIALS AND METHODS

2.1 STUDY SITES AND SOIL SAMPLE COLLECTION

Soil samples were collected from the Kundli Industrial Area and the Bandhwari Landfill in Haryana. The soil was contaminated with heavy metals, including lead, cadmium, and mercury. Soil samples were obtained from depths of 0–20 cm using sterilized tools, and were stored in sterile containers for further processing.

2.2 MICROBIAL ISOLATION AND CHARACTERIZATION

Microbial strains with bioremediation potential were isolated from the contaminated soils. Soil suspensions were prepared, followed by serial dilution and plating on nutrient agar. Enrichment cultures were set up to select for microbes capable of tolerating heavy metals. After isolation, the strains were characterized molecularly using 16S rRNA gene amplification for bacteria and ITS region amplification for fungi.

2.3 EXPERIMENTAL DESIGN AND MICROCOSM SETUP

Microcosm experiments were designed to evaluate the effectiveness of bioremediation in contaminated soils. Three treatment groups were established: (1) native microbial consortia, (2) engineered microbial strains, and (3) a control group with no microbial inoculation. The microcosms were incubated at 28°C, with periodic aeration to maintain natural soil conditions.

2.4 PLANT GROWTH STUDIES

Wheat seeds (Triticum aestivum) were surface-sterilized and sown in pots containing remediated or control soils. Growth parameters such as shoot length, root length, and total biomass were measured after a 4–6 week growth period. Chlorophyll content was assessed using a SPAD chlorophyll meter, and antioxidant enzyme activities (SOD and CAT) were measured spectrophotometrically.

3. RESULTS

3.1 GROWTH PARAMETERS

Wheat plants grown in remediated soils exhibited significant growth improvements compared to the control group:

- **SHOOT LENGTH:** A 15% increase in shoot length was observed in remediated soil.
- **ROOT LENGTH:** Root length was 20% longer in plants grown in remediated soils compared to the control group.
- **TOTAL BIOMASS:** Remediated soils resulted in a higher total biomass, reflecting the positive effect of microbial treatments on plant growth.

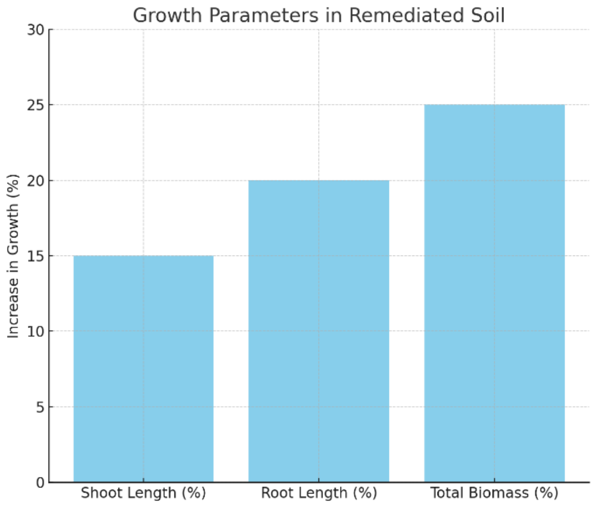
3.2 CHLOROPHYLL CONTENT

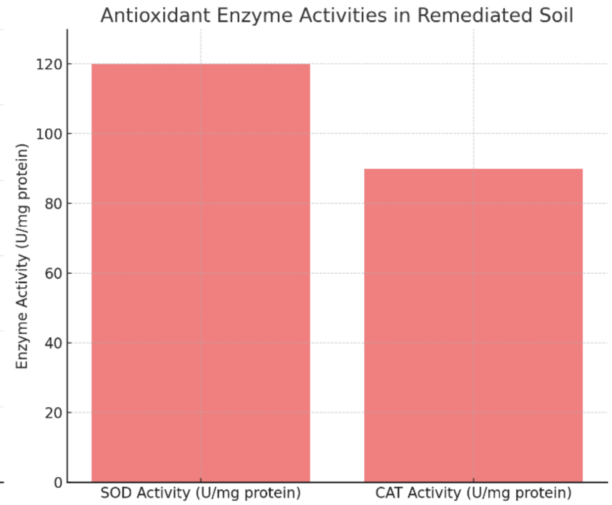
Chlorophyll content, measured using a SPAD meter, was notably higher in wheat plants grown in remediated soils. The higher SPAD values indicate improved photosynthetic efficiency, which suggests better nitrogen uptake and overall plant health.

3.3 ANTIOXIDANT ENZYME ACTIVITIES

The antioxidant enzyme activities of superoxide dismutase (SOD) and catalase (CAT) were significantly higher in wheat plants grown in remediated soils:

- **SOD Activity:** Increased to 120 U/mg protein in remediated soil.
- **CAT Activity:** Increased to 90 U/mg protein in remediated soil.





These enhanced activities indicate that wheat plants in remediated soils experienced less oxidative stress and were better equipped to cope with environmental challenges.

4. DISCUSSION

The results demonstrate that microbial bioremediation effectively enhanced the growth of wheat in contaminated soils. The increased shoot and root lengths, as well as total biomass, suggest that bioremediation improved soil fertility and microbial activity, which are critical for plant growth. The higher chlorophyll content in wheat plants grown in remediated soils indicates improved nitrogen utilization and overall plant health, which are essential for agricultural productivity. The elevated antioxidant enzyme activities (SOD and CAT) further support the idea that plants in remediated soils were better able to handle oxidative stress, a common consequence of heavy metal toxicity.

Bioremediation with engineered microbial strains, including Pseudomonas, Bacillus, and Aspergillus, appears to be a promising strategy for restoring soil health and supporting sustainable agricultural practices in contaminated areas. The success of this approach is evident in the significant improvements in wheat growth, which could have broader implications for crop productivity in regions affected by heavy metal contamination.

5. CONCLUSION

Microbial bioremediation significantly enhances wheat growth and physiological health in soils contaminated with heavy metals. This study demonstrates that bioremediation not only reduces contaminant levels in the soil but also improves soil quality and plant health, contributing to more sustainable agricultural practices. Future research should focus on scaling this approach to field trials and exploring the long-term effects of microbial treatments on soil ecosystems and crop yields.

CONFLICT OF INTERESTS

None.

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REFERENCES

Nascimento, C. W. A., & Xing, B. (2020). Microbial bioremediation of heavy metals. *Environmental Pollution*, 260, 113994.

Sharma, P., & Dubey, R. S. (2022). Antioxidant enzymes and metal tolerance in plants. *Environmental Toxicology and Pharmacology*, 89, 103736.

Singh, R., & Sharma, S. (2019). Bioremediation of heavy metals by soil bacteria. *Journal of Hazardous Materials*, 366, 604-615.

Chet, I., & Inbar, J. (2021). Microbial degradation of pesticides. *Environmental Toxicology and Chemistry*, 40(5), 1489-1503.

Zhang, L., et al. (2020). The potential of plant-microbe interactions in bioremediation of heavy metal-polluted soils. *Science of the Total Environment*, 733, 138926.

Sharma, A., & Kumar, A. (2018). Microbial bioremediation of heavy metals: A review. *Environmental Science and Pollution Research*, 25(6), 5389-5402.

Pandey, A., et al. (2021). Role of bioremediation in heavy metal detoxification in soils. *Journal of Environmental Management*, 284, 111999.

Naresh, R., & Maheshwari, M. (2020). Remediation of heavy metals using microbial and fungal technologies. *Bioremediation Journal*, 24(1), 22-34.

Ghosh, M., & Singh, S. (2021). Impact of bioremediation on soil health and crop productivity in contaminated agricultural fields. *Agricultural Systems*, 186, 102983.

Rajput, S., & Singh, P. (2019). Enhancing phytoremediation with microbial inoculants: A review. *Environmental Science and Pollution Research*, 26(14), 14114-14123.