ISSN: 3048-6580

AgroPedia
e - Publication for Agriculture Popular Articles
Volume: 03, Issue: 08 (August, 2026)
Available online at: https://www.agropedia.co.in

Utilization of different microbial inoculants for improvement of problematic soils

Dr. Bhagyaresha R. Gajbhiye*, Neha Ingole and Dr. R. N. Khandare

All India Network Project on Soil Biodiversity-Biofertilizers,
Department of Soil Science, VNMKV, Parbhani 431402 (M.S.) India
**Corresponding author - bhagyabr123@yahoo.co.in*

Abstract

Problematic soils are those soils that restrict plant growth due to unfavorable physical, chemical or biological conditions. These soils create stress conditions for plants, resulting in poor germination, stunted growth and low crop yield. The main problems associated with problematic soils include osmotic stress, ion toxicity, nutrient imbalance, poor soil structure, reduced microbial activity, and accumulation of toxic substances.

These factors significantly reduce the availability of essential nutrients and hinder root development, ultimately affecting plant growth and productivity. Traditionally, the reclamation of problematic soils has relied heavily on chemical amendments such as gypsum, lime and other synthetic inputs. Although these methods can be effective, they are often expensive, may cause environmental pollution, and do not provide long-term sustainability. In recent years, the use of microbial inoculants has emerged as an eco-friendly, cost-effective and sustainable approach for the improvement of problematic soils.

Introduction

Soil is one of the most important natural resources that supports plant growth, agricultural productivity and overall ecosystem sustainability. However, due to various natural processes and anthropogenic activities, a significant portion of agricultural land has become degraded and is now classified as problematic soil. The major types of problematic soils include saline, sodic, saline-sodic, acidic, acid sulphate, calcareous, heavy metal contaminated and waterlogged soils.

Globally, it is estimated that more than 7% of the total arable land is affected by salinity and sodicity, while in India alone, approximately 6 to 7 million hectares of land are salt-affected. In addition, large areas are affected by soil acidity, heavy metal contamination, and waterlogging, posing a serious threat to sustainable agriculture and food security.

Microbial inoculants are beneficial microorganisms that enhance soil fertility and plant growth through various mechanisms such as nitrogen fixation, phosphate solubilization, production of plant growth-promoting

substances and improvement of soil structure. These microorganisms, including plant growth-promoting rhizobacteria (PGPR), arbuscular mycorrhizal fungi (AMF) and other beneficial microbes, play a crucial role in restoring soil health by improving nutrient availability, enhancing stress tolerance, and reducing the toxic effects of salts and heavy metals.

Therefore, the utilization of different microbial inoculants offers a promising strategy for the reclamation of problematic soils and the promotion of sustainable agricultural practices. This seminar focuses on understanding the role of microbial inoculants in improving different types of problematic soils and their future potential in modern agriculture.

Key Microbial Inoculants for Soil Improvement

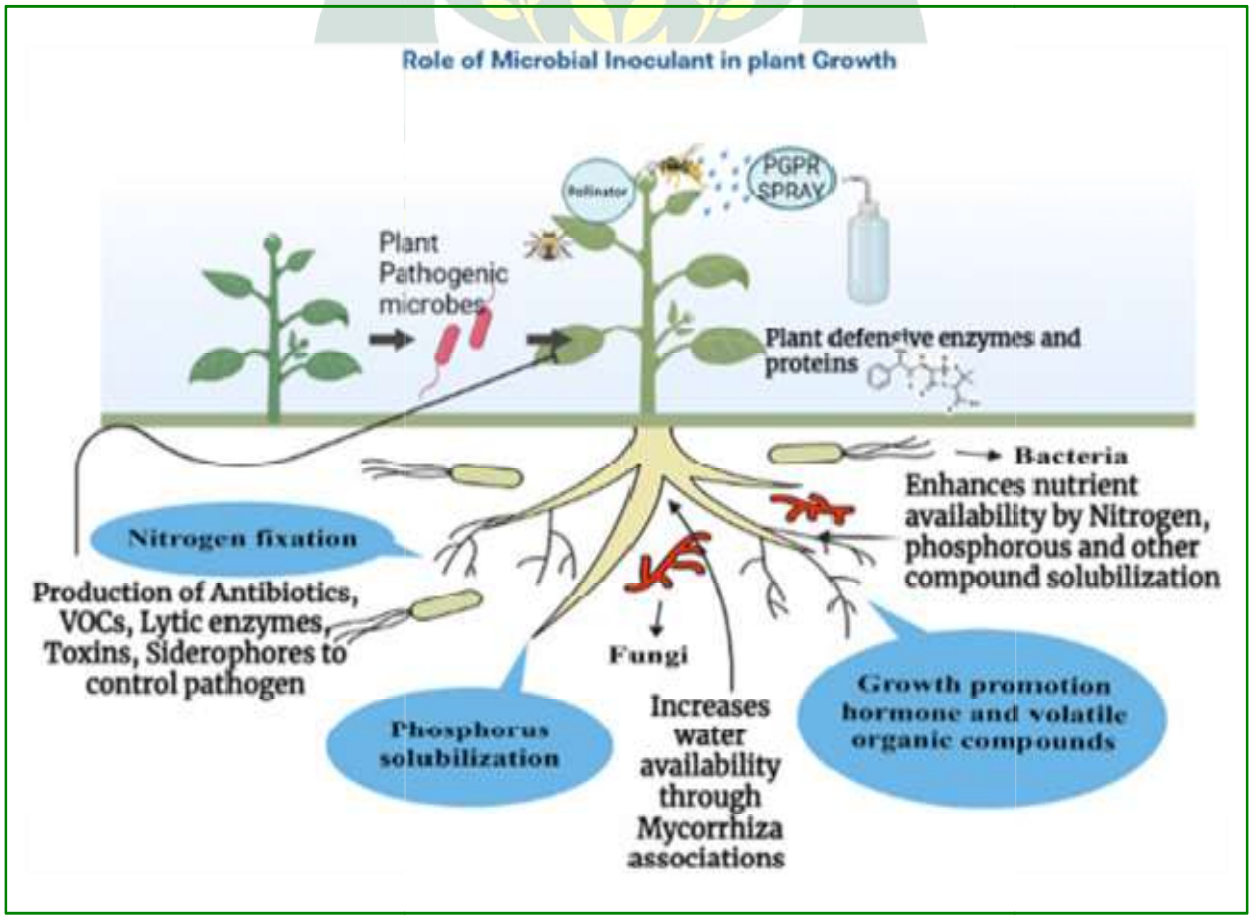
1) **Plant Growth-Promoting Rhizobacteria (PGPR)**: *Pseudomonas, Bacillus, Azotobacter, Azospirillum*.

2) **Phosphate Solubilizing Bacteria/Fungi (PSB/PSF)**: *Bacillus, Pseudomonas, Aspergillus*.

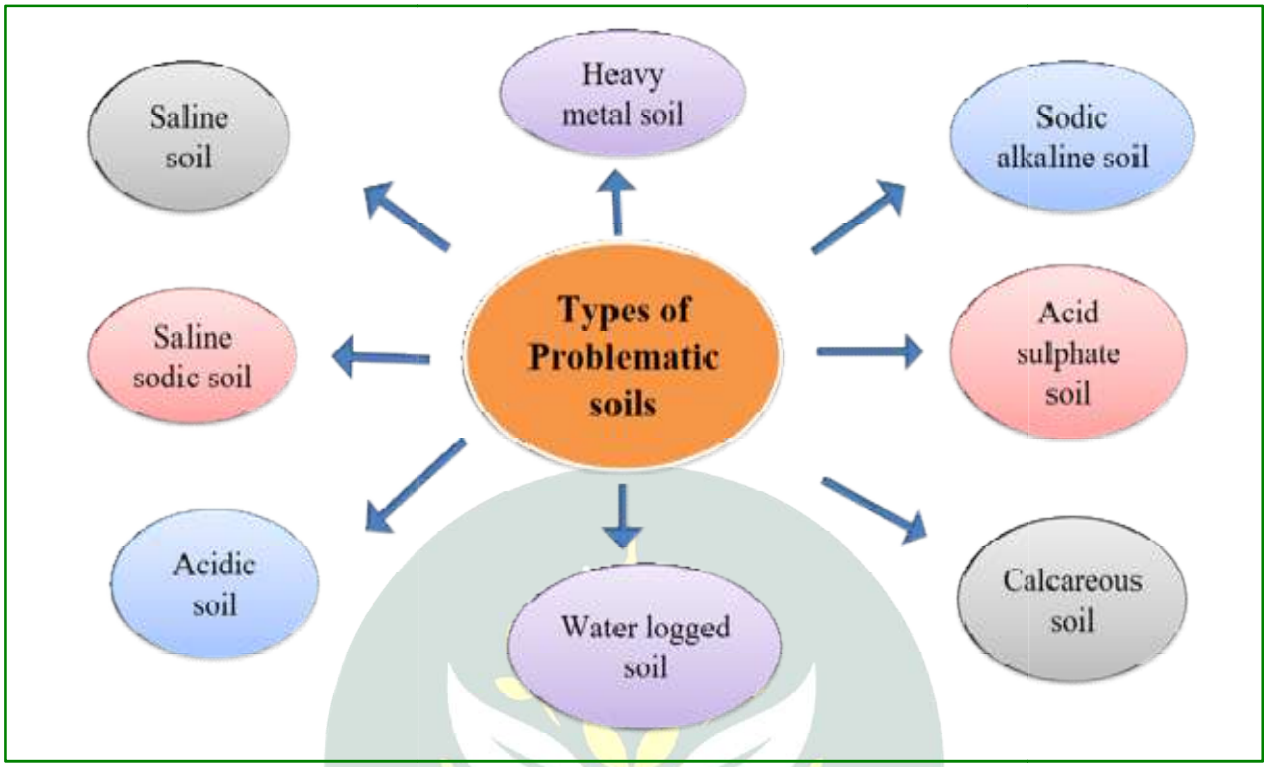
3) **Arbuscular Mycorrhizal Fungi (AMF)**: *Glomus spp.*

4) **Halophilic Microbes**: Salt-tolerant microbes for salinity management.

5) Cellulolytic Microbes: For organic matter decomposition**.**



Types of problematic soil



Saline soil

Saline soil is soil that contains a high concentration of soluble salts in the root zone, which negatively affects plant growth.

Main problems caused by high salinity

1) **Osmotic stress:** High salt concentration reduces water availability to plants

(physiological drought).

2) **Ion toxicity:** Excess Na^+ and Cl^- damage plant cells.

3) **Nutrient imbalance:** Reduced uptake of essential nutrients like K^+ and Ca^{2+}.

4) **Poor soil structure:** Weak aggregation and reduced permeability.

5) **Reduced microbial activity:** High salinity suppresses beneficial soil microbes.

Acidic soil

Acidic soil is soil with pH below 6.5 in which acidity is high enough to reduce crop growth due to aluminum toxicity and nutrient deficiency.

Main problems caused by Acidity

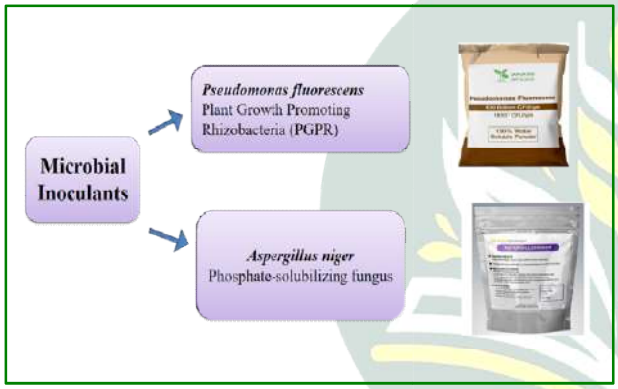
1) **Aluminum (Al) toxicity:** At low pH, Al^{3+} becomes soluble and toxic to plant roots.

2) **Iron (Fe) toxicity:** Excess Fe interferes with plant metabolism.

3) **Phosphorus (P) deficiency:** P gets fixed by Al and Fe, becoming unavailable to plants.

4) **Low microbial activity:** Beneficial microbes do not perform well in very acidic conditions.

5) **Poor root growth:** Due to toxic metals and nutrient deficiency.



Saline – Sodic Soil

A soil containing both high levels of soluble salts and a high percentage of exchangeable sodium.

Main problems caused by saline -sodic soil

1) **Complex Management:** This is the most difficult soil to reclaim. If you flush the salts (leaching) without adding calcium first, the soil converts into a pure sodic soil, causing the structure to collapse.

2) **Osmotic Stress:** High salt content prevents plants from absorbing water, even when the soil is wet (physiological drought).

3) **Ion Toxicity:** High levels of sodium and chloride ions are toxic to many plants, causing leaf burn and stunted growth.

Sodic Alkaline Soil

A soil containing sufficient exchangeable sodium to interfere with plant growth, but low levels of soluble salts. The high sodium causes the soil to become highly alkaline.

Main problems caused by Sodic Alkaline Soil

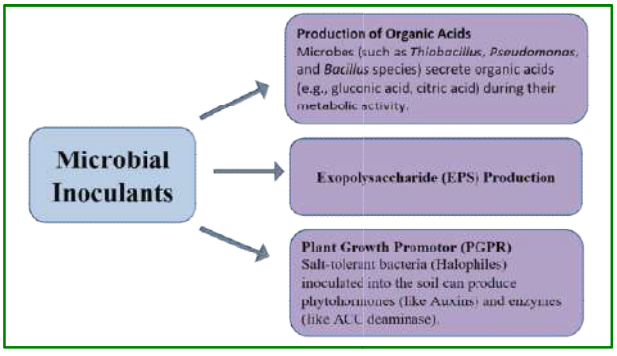
1) **Physical Degradation:** The high sodium causes clay particles to repel each other disperse). This leads to the breakdown of soil aggregates, making the soil structure massive and hard.

2) **Water Stagnation:** Due to dispersion, soil pores become clogged, leading to extremely

poor water infiltration, surface crusting, and waterlogging.

3) **Nutrient Unavailability**: The high pH (> 8.5) precipitates essential nutrients like Calcium (Ca), Zinc (Zn), Iron (Fe), and Manganese (Mn), making them unavailable to plants.

4) **Black Alkali:** The dispersed organic matter dissolves at high pH and moves to the surface, often forming a black, oily-looking crust.

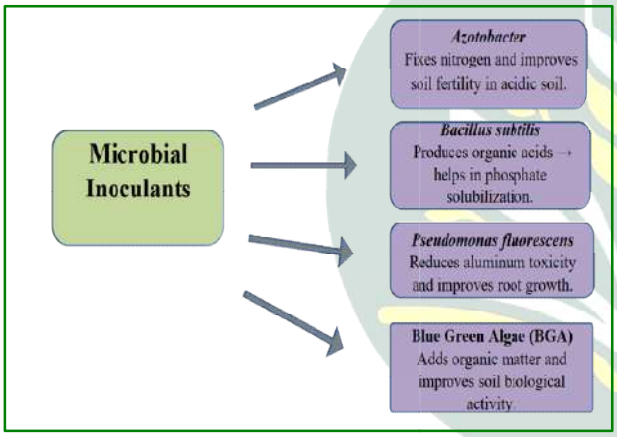


Acid Sulphate Soil

Acid sulphate soils are soils containing iron sulfide (FeS_2, pyrite) which, when exposed to air due to drainage or excavation, oxidize to produce sulfuric acid, making the soil highly acidic (pH < 4).

Main problems caused by Acid sulphate soil

1) Very low pH (high acidity)
2) Aluminum (Al) and Iron (Fe) toxicity
3) Phosphorus deficiency
4) Poor plant growth
5) Death of soil microbes
6) Water pollution due to acid drainage

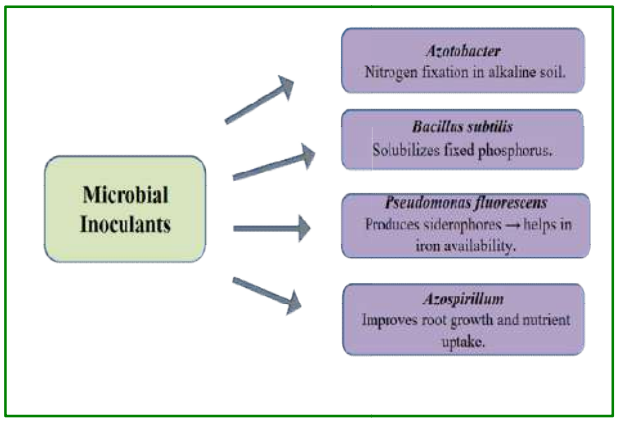


Calcareous soil

Calcareous soils are soils that contain high amounts of calcium carbonate ($CaCO_3$) and have alkaline pH (> 7.5).

Main problems occur within Calcareous soil

1) Iron chlorosis (yellow leaves)
2) Zinc deficiency
3) Phosphorus fixation
4) Poor availability of micro-nutrients
5) Low organic matter decomposition



Heavy metal affected soils

Heavy metal affected soils are soils contaminated with toxic metals like Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Mercury (Hg) beyond permissible limits.

Main Problems caused by metal affected soils

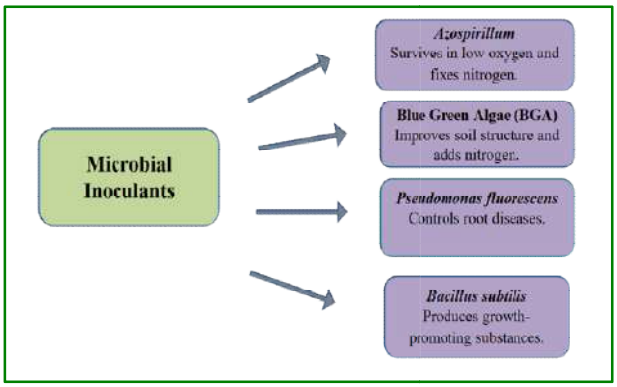
1) Toxic to plants and microbes
2) Reduced seed germination
3) Enters food chain
4) Poor soil fertility
5) Enzyme inhibition in plants

Waterlogged soils

Waterlogged soils are soils where excess water fills soil pores, resulting in poor aeration and low oxygen supply to plant roots.

Main Problems caused by Waterlogged soils

1) Oxygen deficiency
2) Root rot diseases
3) Denitrification (loss of nitrogen)
4) Toxic substances formation (H_2S, Fe^{2+})
5) Poor microbial activity
6) Reduced crop yield



Methods of application

Microbial inoculants can be applied in different ways:

a) Seed Treatment

- Seeds are coated with microbial culture before sowing
- Ensures early colonization of roots
- Most common and effective method

b) Soil Application

- Mixed with compost or farmyard manure (FYM)
- Applied directly to soil
- Improves soil microbial population

c) Root Dipping

- Seedlings roots are dipped in microbial solution before transplanting
- Common in rice and vegetable crops

d) Foliar Spray

- Sprayed on plant leaves
- Used for quick absorption and disease control

Conclusion

Microbial inoculants are an eco-friendly and sustainable solution for the reclamation of problematic soils. They improve soil physical, chemical and biological properties and increase crop productivity. In future, advanced microbial technologies and microbial consortium will play an important role in sustainable soil management and food security. Specific microbes, such as *Pseudomonas, Bacillus,* and *Brevibacterium,* play critical roles in mitigating aluminum toxicity in acidic soils and reclaiming calcareous sodic soils.

References

Rezapour, S., Nouri, A., Asadzadeh, F., Qin, R., & Erpul, G. (2025). Integrated organochemical–microbial solutions remediate degraded saline-sodic soils. International Soil and Water Conservation Research, 13, 992–1007.

Shahwar, D., Mushtaq, Z., Mushtaq, H., Alqarawi, A. A., Park, Y., Alshahrani, T. S., & Faizan, S. (2023). Role of microbial inoculants as biofertilizers for improving crop productivity: A review. *Heliyon, 9*(6), e16134.

Sharma, S. B., Sayyed, R. Z., Trivedi, M. H., & Gobi, T. A. (2013). Phosphate solubilizing microbes: Sustainable approach for managing phosphorus deficiency in agricultural soils. *SpringerPlus, 2*, 587.

Timofeeva, A. M., Galyamova, M. R., & Sedykh, S. E. (2023). Plant growth-promoting soil bacteria: Nitrogen fixation, phosphate solubilization, siderophore production, and other biological activities. *Plants, 12*(24), 4074.

Wang, Z., Zhang, H., Liu, L., Li, S., Xie, J., Xue, X., & Jiang, Y. (2022). Screening of phosphate-solubilizing bacteria and their abilities of phosphorus solubilization and wheat growth promotion. *BMC Microbiology, 22*, 296.