

Diversity and Conservation of Plant Growth Promoting Microbes in Paddy Field Soils of Industrializing Palghar District, Maharashtra, India

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Abstract: *Paddy field ecosystems host diverse plant growth promoting microbes (PGPM) that play a crucial role in sustainable agriculture by enhancing nutrient availability, producing growth regulators, and improving plant tolerance to environmental stress. The present study explores the biodiversity and conservation significance of PGPM in paddy soils of Palghar district, Maharashtra, India (19.7°N, 72.8°E). The region experiences a tropical monsoon climate with annual rainfall of 2000–2500 mm, high humidity, and moderate temperatures that favor rice cultivation. Soils are predominantly lateritic to alluvial, slightly acidic to neutral, and moderately rich in organic matter.*

Rice is cultivated during the monsoon season, followed by pulses, vegetables, and millets in the post-monsoon period. Crop rotation and mixed cropping systems influence microbial diversity by altering rhizospheric nutrient dynamics and root exudation patterns, thereby supporting nitrogen fixers, phosphate solubilizers, potassium mobilizers, and phytohormone-producing microorganisms.

In recent decades, rapid industrialization in Palghar, including expansion of steel, chemical, and textile industries, has led to conversion of agricultural land and potential soil contamination. Industrial emissions and effluents may modify soil physicochemical characteristics and disrupt native microbial communities.

Documentation and conservation of indigenous PGPM are essential for maintaining soil fertility, improving crop productivity, and promoting environmentally sustainable agriculture. Conservation approaches such as microbial isolation, characterization, biofertilizer development, and adoption of sustainable farming practices are vital for preserving beneficial soil microflora and ensuring long-term agricultural sustainability...

Keywords: Plant Growth Promoting Microbes, Paddy Soil, Microbial Diversity, Industrialization, Soil Health, Sustainable Agriculture, Palghar

1. Introduction

Soil is a dynamic biological system that sustains plant productivity and ecosystem stability. Among soil microorganisms, plant growth promoting microbes (PGPM) enhance plant development by improving nutrient uptake, synthesizing growth regulators, and increasing stress tolerance (Glick, 2014; Ansabayeva et al., 2025). These beneficial microbes colonize the rhizosphere and contribute to plant health through multiple biological mechanisms.

Rice-based agroecosystems provide a unique ecological niche supporting diverse microbial communities due to alternating aerobic and anaerobic conditions (Bhattacharyya & Jha, 2012). The rhizosphere region, enriched with root exudates, supports active microbial interactions that facilitate nutrient cycling and plant growth (Fanai et al., 2024).



Palghar district of Maharashtra is an important rice-growing region; however, rapid industrial expansion and land-use changes may influence soil biological health. Industrial pollutants and environmental stress can alter microbial diversity and soil fertility (Iqbal et al., 2024). Therefore, understanding microbial diversity and emphasizing conservation is essential for sustainable agriculture.

2. Study Area Characteristics

Palghar district is located in the northern coastal region of Maharashtra, India (19.7°N, 72.8°E). The area receives heavy monsoon rainfall ranging from 2000 to 2500 mm annually, accompanied by high humidity and moderate temperatures, which favor rice cultivation.

The soils are primarily lateritic to alluvial, slightly acidic to neutral in reaction, and moderately rich in organic matter. Such soil characteristics support microbial growth and active nutrient cycling (Sharma et al., 2013).

3. Cropping Systems and Microbial Diversity

Rice is cultivated during the monsoon season under flooded conditions, followed by pulses, vegetables, and millets in the post-monsoon period. This cropping diversity influences soil microbial communities through variations in root exudates and organic inputs.

Crop rotation and mixed cropping practices enhance microbial diversity by improving soil organic matter and nutrient availability (Ng et al., 2024). Flooded rice soils support anaerobic microbial processes, while post-monsoon crops promote aerobic microbial populations, thereby enriching functional microbial diversity.

These systems support beneficial microbial groups such as nitrogen-fixing bacteria, phosphate solubilizers, potassium mobilizers, and phytohormone-producing microorganisms (Khosro et al., 2024).

4. Functional Role of Plant Growth Promoting Microbes

Nutrient Mobilization

PGPM convert unavailable nutrients into plant-accessible forms through nitrogen fixation, phosphorus solubilization, and potassium mobilization (Vessey, 2003).

Production of Growth Regulators

Many rhizospheric microbes synthesize phytohormones such as indole acetic acid, gibberellins, and cytokinins, enhancing root development and plant vigor (Ansabayeva et al., 2025).

Stress Mitigation

PGPM improve plant tolerance to environmental stresses such as drought and salinity by modulating physiological responses (Liu et al., 2025).

Biological Disease Control

Some microbes suppress pathogens through antibiotic production and Siderophore release, improving plant health (Glick, 2014).

5. Industrialization and Its Impact on Soil Microflora

Palghar district has experienced rapid industrial growth, including steel, chemical, and textile industries. While industrialization supports economic development, it has contributed to:

- conversion of agricultural land
- contamination from industrial effluents
- accumulation of heavy metals
- changes in soil chemical properties



Industrial pollutants can disrupt microbial communities and reduce beneficial microbial populations (Iqbal et al., 2024). Changes in soil pH, contamination levels, and organic matter content may significantly affect microbial activity and soil fertility (Li et al., 2024).

6. Need for Conservation of Indigenous PGPM

Preserving native plant growth promoting microbes is essential for maintaining soil productivity and ecological balance. Indigenous microbes are adapted to local environmental conditions and support sustainable agriculture (Maciel-Rodríguez et al., 2025).

Conservation Strategies

Microbial Isolation and Preservation

Isolation and characterization of native strains for research and agricultural application.

Biofertilizer Development

Utilization of native beneficial microbes to develop eco-friendly fertilizers (Shahzad et al., 2025).

Sustainable Soil Management

-Promoting organic amendments, reduced chemical inputs, and crop diversification.

Soil Health Monitoring

Regular monitoring of biological indicators to detect changes in microbial diversity.

Farmer Awareness Programs

Encouraging awareness of soil microbial health and sustainable practices.

7. Significance for Sustainable Agriculture

Conserving microbial diversity offers ecological and agricultural benefits, including improved soil fertility, enhanced crop productivity, reduced dependence on chemical fertilizers, and strengthened resilience to climate variability (Etesami, 2025).

In industrializing regions, preserving soil microbial biodiversity is critical for long-term food security and environmental sustainability.

8. Conclusion

Paddy soils of Palghar district harbor diverse plant growth promoting microbial communities essential for soil fertility and crop productivity. Cropping diversity and seasonal variations contribute to microbial functional richness. However, rapid industrialization poses potential threats through land-use changes and environmental contamination.

The conservation and utilization of indigenous PGPM are vital for sustaining soil health and promoting eco-friendly agriculture. Adoption of sustainable farming practices and development of microbial biofertilizers can help preserve beneficial soil biodiversity and ensure long-term agricultural sustainability.

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