

Smart Nanomaterials Technology

Sezai Erciřli · S. Rakesh ·
Rahul Datta · Deepranjan Sarkar ·
Sachidanand Singh *Editors*

Nanotechnology Applications in Soil Science



Springer

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Preface

Soil security is crucial for harnessing soil ecosystem services and maintaining agricultural productivity, biodiversity conservation, and environmental health. Global soil deterioration due to mismanagement is a critical issue that threatens food security and ecosystem health. Nanotechnology represents an emerging revolution with extensive applications in the field of soil science. It employs a smart delivery system that enhances nutrient use efficiency and crop growth and minimizes nutrient losses and environmental impact. Our book emphasizes how we can leverage the benefits of nanotechnology to enhance soil health, improve plant nutrition, and ensure environmental safety, thereby advancing the understanding and practice of soil science.

Recent advancements in the synthesis, characterization, and use of nanomaterials in agriculture have revolutionized farming practices, enabling more efficient nutrient delivery and enhanced crop resilience against environmental stresses. The synthesis of nanomaterials, particularly through eco-friendly approaches, offers innovative solutions to persistent agro-environmental challenges. In addition to soil fertility management, nano-enabled products are utilized for enhancing plant growth, development, and protection; they also play a significant role in climate mitigation. The effects of nanomaterials on soil properties (physical, chemical, and biological) have been discussed in the book. Soil amendments such as nanobiochar further contribute to improved soil health and climate change mitigation. One of the chapters delves into the complexities of metal-based nanoparticles and their interactions with soil microbes. Another chapter highlights the use of nano-sensors to monitor heavy metal contamination in soils and plants. Studying the fate and transport of nanoparticles in soil systems is crucial for understanding their environmental impact and potential risks, including those to human health. Nanotechnology offers promising solutions for eliminating contaminants in soil and water, utilizing engineered nanomaterials. Nanomaterials have emerged as a suitable strategy for addressing environmental pollution and promoting sustainable agriculture, offering transformative solutions across various domains.

The chapters have been compiled with outstanding contributions from a diverse range of authors. We are thankful to all the contributors and mentors associated with the project. We hope this book serves as a valuable resource for enhancing the understanding of students, scientists, program coordinators, decision-makers, and anyone interested in the subject. Additionally, it provides a forum for plant and soil scientists to address the challenges of soil management and food production.

Erzurum, Türkiye
Hyderabad, India
Brno, Czech Republic
Khlung Luang, Thailand
Gandhinagar, India

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Nanomaterials in Action: Transformative Applications for Environmental Pollution Mitigation and Sustainable Agriculture



Arshya Hashim, Faria Fatima, P. Smriti Rao,
and Mohammad Haris Siddiqui

Abstract Nanomaterials have emerged as innovative and versatile tools for addressing environmental pollution. They are excellent in adsorbing organic pollutants and toxic substances from soil and water because of their high surface area and adjustable qualities. They also increase the performance of membrane technologies and purification systems, enhancing the efficiency of contaminant removal. By dissolving harmful substances, nanoparticles can improve soil health during remediation. In air filtration systems, nanomaterials help to trap particulate matter and volatile organic compounds, which further enhances air quality through the application of nanotechnology. These innovations contribute to environmental sustainability by promoting cleaner ecosystems. However, to ensure their safe and ethical usage, the effects of nanomaterials on the environment and human health must be carefully assessed. This chapter provides a comprehensive overview of their applications in remediating various environmental pollutants, focusing on their unique properties, synthesis methods, and uses in mitigating air, water, and soil pollution. The discussion includes the diverse types of nanomaterials and their exceptional characteristics, delving into the challenges and considerations associated with the environmental and health impacts of nanomaterials, highlighting the importance of their responsible and sustainable use.

Keywords Pollutants · Removal methods · Metal-based nanomaterials · Purifiers · Environmental remediation

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