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## Environmental Nanotechnological Applications for Sustainable Agriculture

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Agriculture and society are intertwined. Agriculture is necessary for human survival and social sustainability in India. Eco-friendly agriculture practices nurture ecosystems to solve current societal issues. Indian ecosystems are marred by pollution, imbalance, climate changes, food crisis, various diseases, and malnourishment continue as a major concern. The traditional environmental remedial strategies appear relatively ineffective in the ever-expanding use of pollutants that pervade the water, air, and soil environment. Nanotechnology provides an efficient, environmental friendly, and cost-effective solutions to the global sustainability challenges that society is facing. Nanotechnology utilizes nanomaterials that have remarkable physical and chemical features to make smart functional materials for developing sustainable technologies. Nanotechnology seems to be very promising in sustainable environment development, sustainable agriculture, renewable and economically energy alternative through use of nanomaterials for detection, prevention, and removing pollutants. The development of nanotechnology in India has huge potential to address the challenges like providing drinking water, healthcare, nano-based industry, and sustainable agriculture. This review highlights the recent nanotechnology applications to meet the global challenges in providing clean energy technology, water purification, and greenhouse gases management. In addition, effort has been made to analyse the opportunities and limitations in engineered nanomaterials safety, solid waste management, reducing pollution of air water and soil.

Keywords: Environmental nanotechnology, Nanomaterials, Nanotoxicology, Sustainable environment

## Introduction

Sustainable agriculture is the method to implement farming techniques that protect ecosystems, environment, and human health, and simultaneously produce adequate amount of agriculture products for social welfare<sup>1</sup>. Population growth and rapidly changing lifestyle are causing environmental implications such as increasing solid waste, air pollution, and contamination of surface and ground water across the world. The major environmental challenges of 21<sup>st</sup> century are global warming, water and air pollution, and reduced energy supplies. Nanotechnology, a novel branch of science of dealing with the design, synthesis, characterization, and application of nano molecules could help in dealing with the pernicious effects of these challenges on the Nanomaterials environment. display significant physico-chemical assets that make them predominantly smart functional materials for creating sustainable technologies. Nanomaterials exhibit much larger and more reactive surface area when compared to bulk

material which can be easily functionalized with the help of several chemical moieties that enhance their affinity toward a given molecule even in gases and dissolved solutes. The surface functionalization helps them to selectively target the key biochemical components and facilitate metabolic pathways as well as signalling networks of water-borne viruses and bacteria. Nanomaterials provide extraordinarv opportunities to improve the activity of functional nanomaterials as they exhibit improved optical. electronic, magnetic, and catalytic properties. These innovative functional materials can be administered into numerous forms such as water-soluble particles, supramolecular hosts, particles, membranes, and fibres. In the past decade, this field of science has gained global attention and there has been an exponential increase in the global market of nanoparticle-based products with the market value expected to exceed \$3 trillion by the end of the decade. Indian innovators and industries too developing nano-based products which will make our country a global leader in this area. It has applications in diverse fields including medicine, production, textiles, food production, energy sustainable agriculture and packaging, electronics, cosmetics, bioremediation etc.

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