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# Nanotechnology: An Innovative Approach for Smart Agriculture

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## ABSTRACT

Nanotechnology is an interdisciplinary research field. In recent past efforts have been made to improve agricultural yield through exhaustive research in nanotechnology. The green revolution resulted in blind usage of pesticides and chemical fertilizers which caused loss of soil biodiversity and developed resistance against pathogens and pests as well. Nanoparticle-mediated material delivery to plants and advanced biosensors for precision farming are possible only by nanoparticles or nanochips. Nanoencapsulated conventional fertilizers, pesticides and herbicides helps in slow and sustained release of nutrients and agrochemicals resulting in precise dosage to the plants. Nanotechnology based plant viral disease detection kits are also becoming popular and are useful in speedy and early detection of viral diseases. In this article, the potential uses and benefits of nanotechnology in precision agriculture are discussed. The modern nanotechnology based tools and techniques have the potential to address the various problems of conventional agriculture and can revolutionize this sector.

***KEYWORDS:*** *nanotechnology, biodiversity, smart, agriculture, revolutionize, plants, modern*

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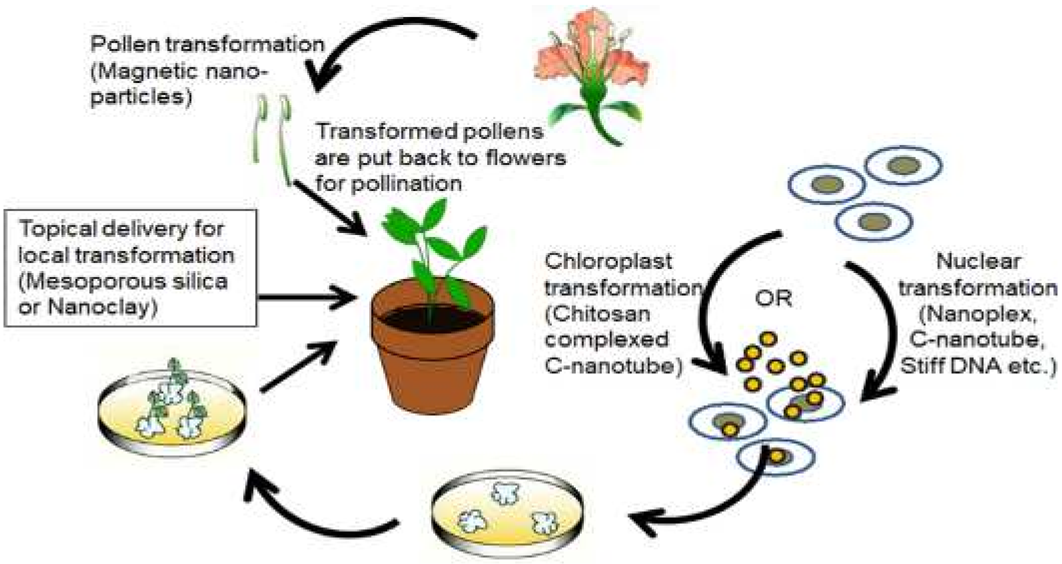
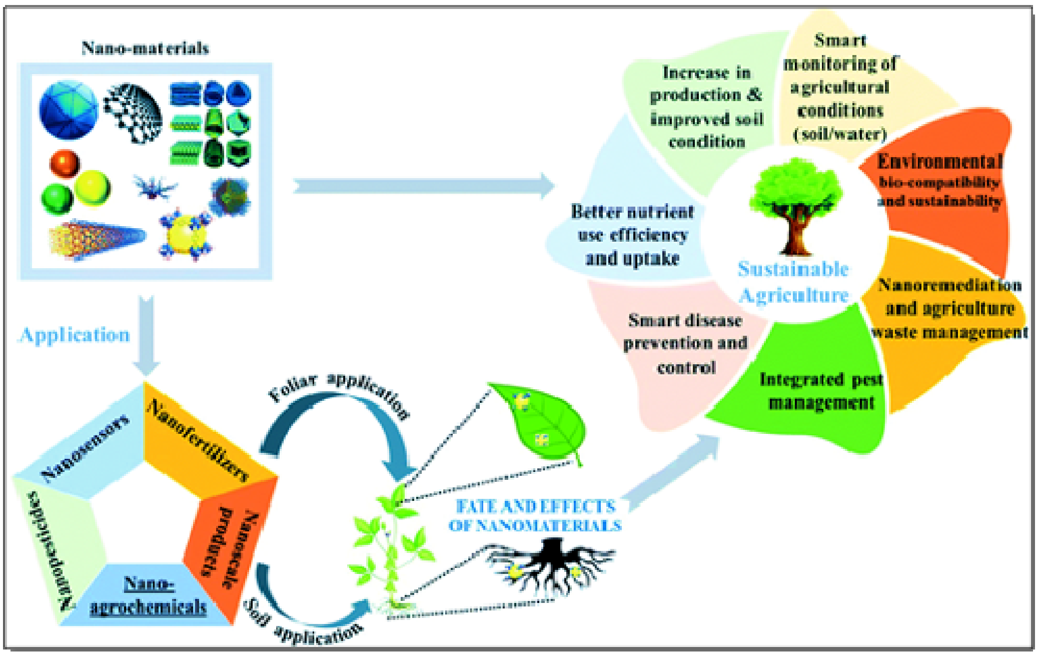
## INTRODUCTION

Recent scientific data indicate that nanotechnology has the potential to positively impact the agrifood sector, minimizing adverse problems of agricultural practices on environment and human health, improving food security and productivity (as required by the predicted rise in global population), while promoting social and economic equity. In this context, we select and report on recent trends in nanomaterial-based systems and nanodevices that could provide benefits on the food supply chain specifically on sustainable intensification, and management of soil and waste. Among others, nanomaterials for controlled-release of nutrients, pesticides and fertilizers in crops are described as well as nanosensors for agricultural practices, food quality and safety. In this context, nanosensors represent a powerful tool with advanced and improved features, compared to existing analytical sensors and biosensors. Nanosensors are defined as analytical devices having at least one sensing dimension no greater than 100 nm, fabricated for monitoring physico-chemical properties in places otherwise[1] difficult to reach. Nanotubes, nanowires, nanoparticles, or nanocrystals are often used to optimize the signal transduction deriving by sensing elements in response to exposure to biological and chemical analytes having similar size. They have unique surface chemistry, distinct thermal, electrical and optical properties, useful to enhance sensitivities, reduce response times, and improve detection limits, and can be used in multiplexed systems




Specifically, nanosensor systems can be developed to monitor the presence of pests, pathogens or pesticides in order to better tune the amount of insecticides to be employed for crop productivity management, since they show higher sensitivity and specificity compared to the "traditional" sensors. For example, controlled release mechanisms via nanoscale carriers monitored by nanosensors integrated in platforms employing wireless signals, will avoid overdose of agricultural chemicals and minimize inputs of fertilizers and pesticides during the course of cultivations, improving productivity, and reducing waste. Networks of nanosensors located throughout cultivated fields will assure a real time and comprehensive monitoring of the crop growth, furnishing effective high quality data for best management practices.[2]

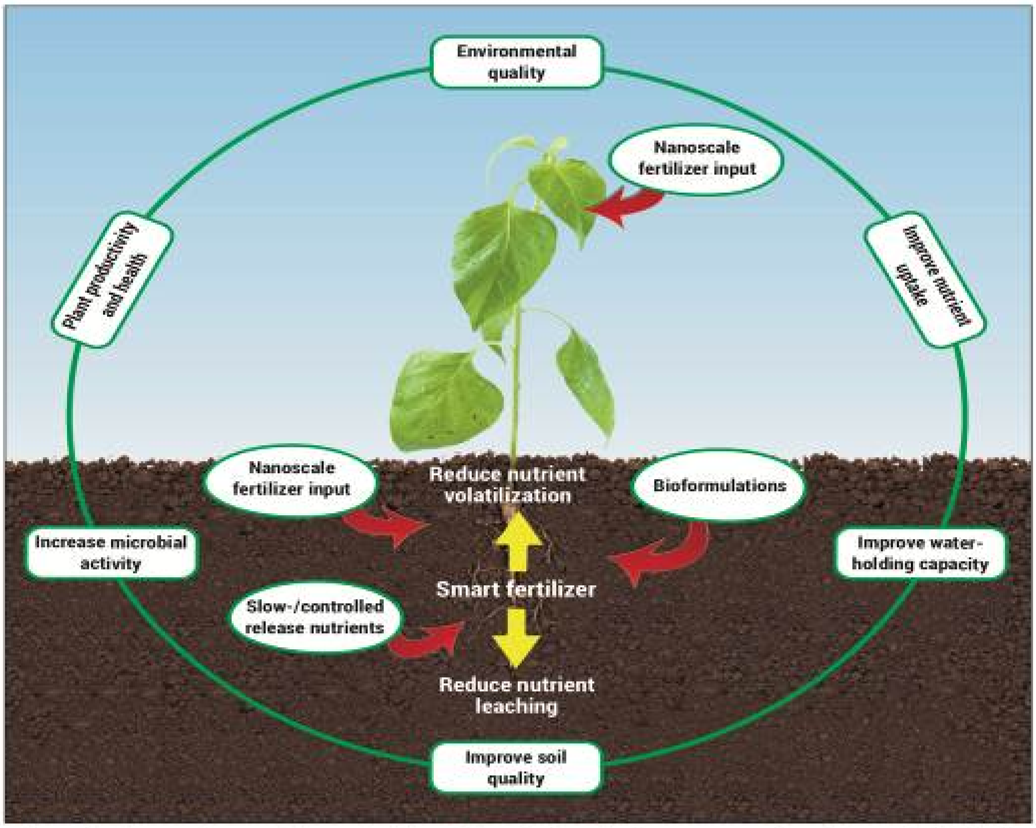
Furthermore, nanosensors find also application in fast, sensitive, and cost-effective detection of different targets to ensure food quality, safety, freshness, authenticity, and traceability along the entire food supply chain. Surely, nanosensors represent one of the emerging technologies challenging the assessment of food quality and safety, being able to provide smart monitoring of food components (e.g., sugars, amino acid, alcohol, vitamins, and minerals) and contaminants (e.g., pesticides, heavy metals, toxins, and food additives). Food quality and food safety control represents a crucial effort not only to obtain a healthy food, but also to avoid huge waste of food products. The potential of nanosensor can also be demonstrated by the last trends on intelligent or smart packaging to monitor the freshness properties of food, and check the integrity of the packages during transport, storage, and display in markets. In fact, the efficient use of fertilizers and pesticides can be enhanced by the use of nanoscale carriers and compounds, reducing the amount to be applied without impairing productivity. Nanotechnologies can also have an impact on the reduction of waste, both contributing to a more efficient production as well as to the reuse of waste, while nanosensors technology can encourage the diffusion of precision agriculture, for an efficient management of resources, including energy. [3]



**Discussion**

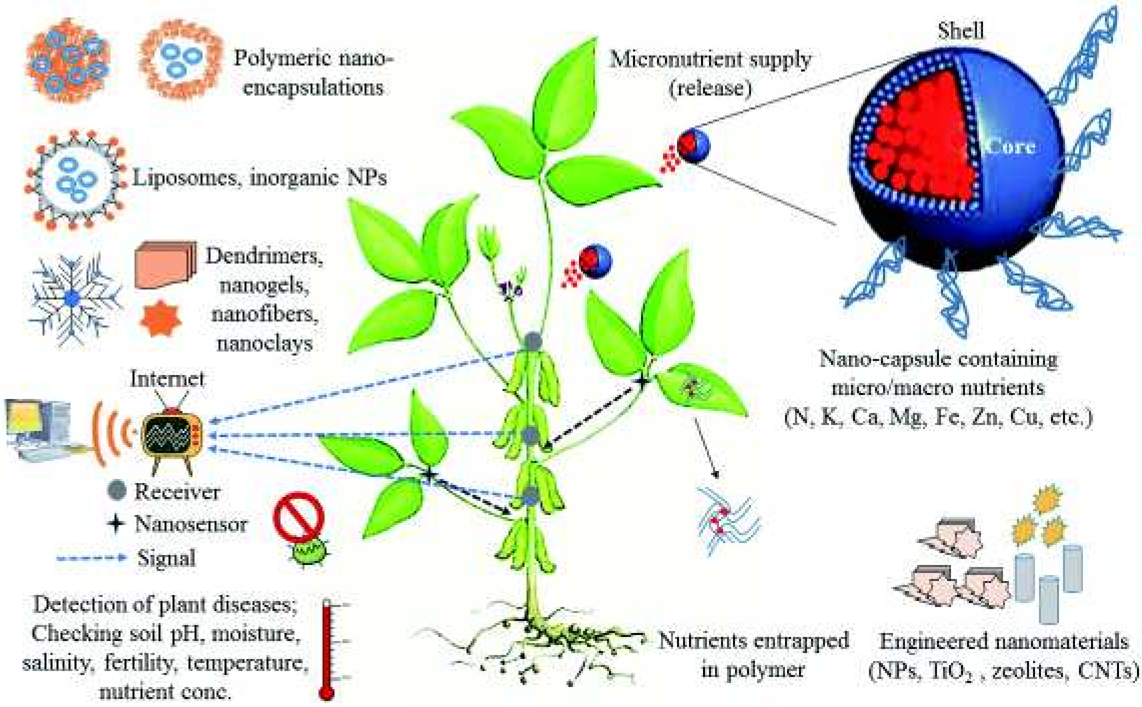
Ever since mankind embraced technology, the largest number of inventions have been aimed at agricultural improvement, more than any other sectors where technology is used. Nonetheless, today we are struggling to meet the ever increasing hunger of a growing world population. We have almost exhausted the supply of traditional technological ammunitions in the arsenal of agricultural science. The only way forward is to embrace smart agricultural practice in a sustainable manner. Use of modern electronics and material science to increase production, without further increasing fertilizer or pesticide input, can be referred to as smart and sustainable agriculture. Scientists have made giant leaps in the field of 'biology at nanoscale' during the first decade of the present century. Nanoparticles and nanosensors have huge potential in agricultural advancements, if used wisely with proper caution. Nanoparticles can be used for getting higher yield and for crop protection. Nanoparticles can also aid in the rate limiting process of gene delivery during genetic improvement of crop species. [4] Nanobiosensors can contribute to smart farming by growth monitoring, real time detection of pests, and continuous monitoring of local environment.

Most of the early uses of nanotechnology have come from material sciences, although applications in agriculture are still expanding.




Schematic diagram of potential smart fertilizer effects in the soil-plant system. Adapted from Calabi-Floody et al. 2017.

Due to a few comprehensive reviews, we described application of nanomaterials along with their fate in soil and interaction with soil and plant system. From synthesis to metabolism, nano-fertilizers like zinc, silver, selenium, titanium oxide have enhanced the physio-chemical characteristics of crop plants in every manner conceivable. On the other hand, it has the potential to minimize pesticide use by boosting reactivity and surface area of nanoparticles. Nanotechnology in pesticides will, without a doubt, replace the current way of pesticide application because of its efficacy. Nano-based approaches can readily overcome the constraints of conventional soil remediation technologies. While soil nanomaterials mobility has been investigated in a limited number of research studies, it's likely the most critical gap in knowing the real risk of their transport. As well as enhancing plant nutrient absorption, nanomaterials may also be used to regulate soil microbial activity and stimulate plant defenses. When it comes to shipping food, nanotechnology has made things easier by extending the shelf life of most foods. While it offers tremendous potential for agricultural applications, the health effects of nanoparticles on plants, animals, and humans must be thoroughly investigated.[5] Nanotechnology is a significant research strategy which enables easy understanding of technology for the modern world. From the enormous efficiency of nanotechnology pesticide based on nanoparticles, encapsulation of nanoparticles or nanoparticle-based DNA transfer to enhance the pest resistant are some examples of smart and precision farming [6].

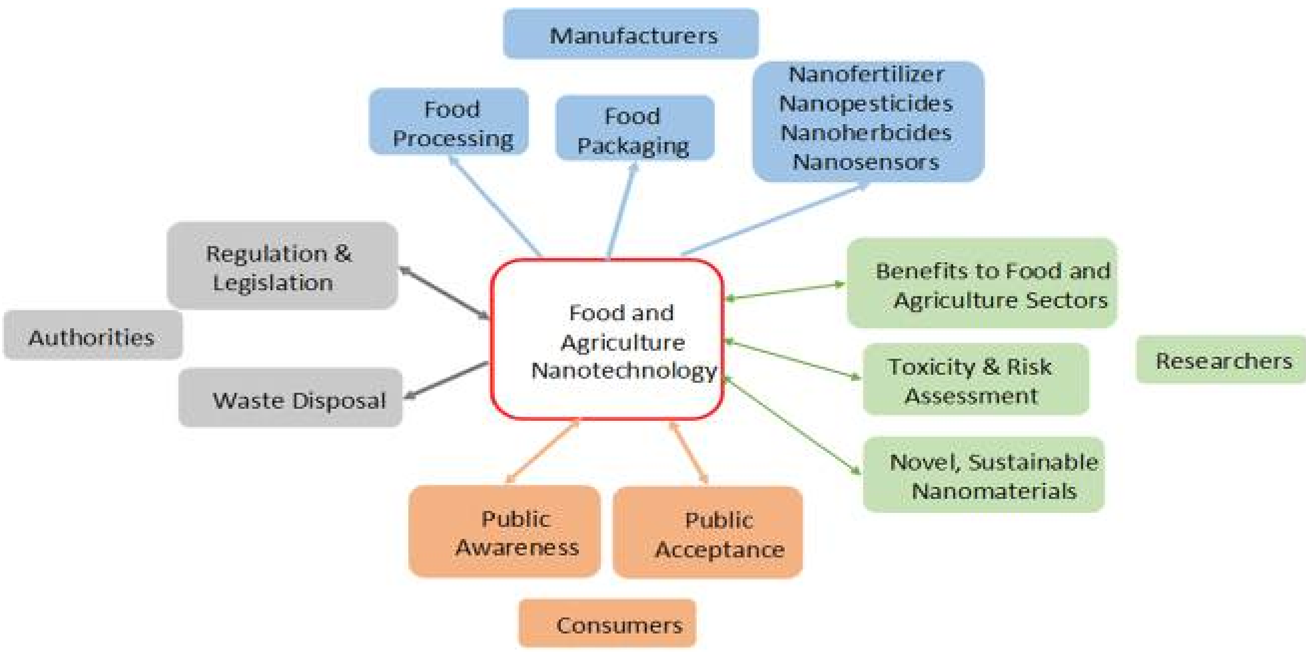



**Results**

POPs that can be remediated effectively with nanomaterials' help. For example, nano-based materials can be used to convert heavy metals to their less toxic forms, pesticide degradation, and bioremediation of contaminated soil. Besides, nano-based sensors are useful components for detecting harmful pesticide residue in the soil, like detecting Mn impurities with grapheme nanoribbon [6]

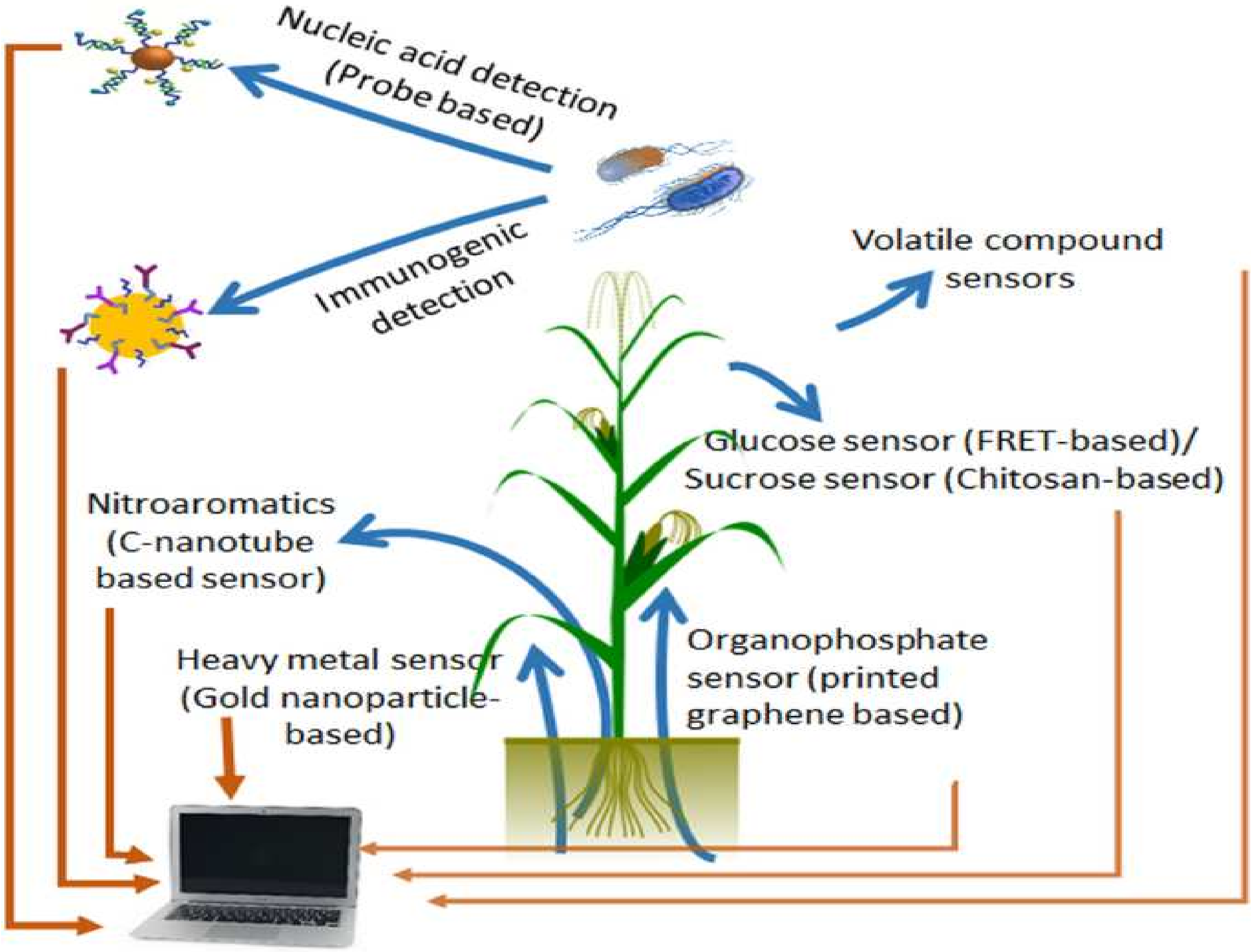
For soil remediation, conventional physical and chemical methods are available, but there is a risk of secondary contamination due to these remediating agents' high quantity uses.

Nanoparticles possess various mechanisms such as redox reactions, adsorption, ion exchange, surface complexation, and electrostatic interaction, which are useful for the adsorption and degradation of pollutants [7]. Moreover, other features include lower temperature modification, shorter interparticle diffusion distance, and multiple surface chemistry that make these materials appropriate catalysts for the remission of the concerned soil pollutants [8]. Nanoparticles are very much fruitful for the degradation of common industrial contaminants such as chlorinated organic compounds, petroleum nano aromatics, nitrates, heavy metals (arsenic (As) lead (Pb), copper (Cu), zinc (Zn), nickel (Ni), cadmium (Cd)), insecticides, and dyes [8]. For instance, specific organic and inorganic compounds such as natural short-ordered aluminosilicate, the surface of titanium oxide, and humic acids can be coupled with Ni through a multiwalled carbon nanotube. These components are effective nano-bioremediation for the sustainable agricultural system [10].



Nano-scale zero-valent iron (nZVI), titanium dioxide (TiO2), zinc oxide (ZnO), multiwalled carbon nanotubes (MWCNTs), fullerenes, bimetallic nanoparticles are widely used NPs for soil remediation because of their large surface area, high reactivity, and reduction capability [9]. Surface-modified nano-scale carbon black can reduce the bioavailability of Cu and Zn; also, nanometer hydroxyapatite can remove Cd pollution from the soil, which promotes plant growth [7]. On the other hand, nanometer zeolite can remove Cu and Pb; both are organic and heavy metal pollutants of soil [6]. Some researchers [8] showed that Cd and Zn pollution could be repaired with the help of a ferric tetroxide nanometer.

Apart from all positive impacts, nanomaterials caused toxic effects on organisms dependent on soil [7]. For instance, copper nanoparticles negatively impact rats, as copper's toxicity is related to the particle size [8]. Again, some heavy metal ions can be dissolved with metal nanomaterials, which is toxic for the ecology. Nano-TiO2 and its byproducts affected the antioxidant system and oxidative stress reaction of earthworms, one of the essential soil organisms [10]. For this reason, we should pay more to keep an eye on the biological toxicity of nanomaterials used in soil remediation. Though the development of the appropriate use of nanotechnology for remediation of polluted soils is essential with the help of numerous uses of nanomaterials, we also need a comprehensive understanding of the human and environmental risk–benefit balance by using these nanomaterials [10].




## Conclusion

The nanotechnology market is expanding very rapidly. Due to increasing scientific activities and increasing demand for nanotechnology in every field, there has been a need for tremendous expansion in this field in the last few years. So far, most of the nanotech related work in India is being imported. Although the research work is going on fast in the country, but till now the country has not been able to become self-sufficient in this field. In such a situation, there is a lot of potential for development in the country in the coming time. Due to the continuous development in the field of nanotechnology, immense possibilities will arise for the youth in this field. At present, there is a great demand for good and knowledgeable nanotechnologists in the country as well as abroad. This is an interdisciplinary area, so the youth coming to this area will get physics, chemistry, It is important to be good in subjects like biology and maths. Due to continuous research and development, it can be said that the time to come is of nanotechnology. [10]

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