Application and Threats of Nanotechnology in Agriculture

Ganesh Datt Bhatt, Department Of Agriculture
Galgotias University, Yamuna Expressway Greater Noida, Uttar Pradesh
E-mail id - ganeshdattbhatt@gmail.com

ABSTRACT:In many fields, nanotechnology holds immense promise and is envisioned as a technology to lead the way in the coming years for sustainable growth of environmentalhealth. The central theme of nanotechnology is the use of nanometer-sized particles for diverse applications in the areas of medicine, cosmetics, food and agricultural technology. The advantages associated with nanotechnology involve, but are not limited to, increased yields and the efficiency of agricultural produce, enhanced beauty products, drug delivery and sensor applications.Advances in the production of nanosensors have made it simpler and more cost-effective to recognise disease-causing components, toxins and nutrients in foods and components in environmental samples. In recent decades, moreover, tremendous emphasis on nanotechnology has contributed to its unregulated production and thus considerable use of nanoparticles (NPs). It is assumed that NPs can present threat to biological systems and the ecosystem. It has also become apparent that nanomaterials, like graphene/graphene oxide with gold NPs, carbon and carbon nitride nanotubes, have various effect on plant growth and the atmosphere in terms of scale, composition and form.Long-term life cycle tests are also necessary to determine the effects of NPs. This study provides a brief summary of the agricultural applications of nanomaterials and addresses the positive and negative aspects of nanomaterials in the agricultural sector. This study suggests that the future advancement of nanotechnology has to be focused on empirical estimates of the long-term advantages and risks associated with it.

KEYWORDS: Agricultural,Fertilizer, Nanomaterial, Nanotechnology, Pest, Sensors.

INTRODUCTION

Nanotechnology is an umbrella word used in real-world implementations to describe inventions operating on nanoscales. Atomic or molecular aggregates of variable sizes varying from 1 and 100 nm are nanoparticles (NPs). The physicochemical properties of nanoparticles differ from the substance of their native mass. Nanoparticles can originate from natural causes, like volcanic eruptions, weathering, meteoric dust, and microbial influences on soil organic matter. Anthropogenic origins include the development of engineered nanoparticles with the aid of microbes for a variety of applications by physicochemical or biological methods.It is possible to classify the engineered NPs into 4 groups: carbon-based materials (single-walled carbon nanotubes), metal-based nanoparticles (quantum dots, nano gold, nano silver, etc.), dendrites (nano-sized polymers consisting of branched units synthesised for particular chemical functions) and composites (made of two or more substances). Two methods are typically used for the production of nanomaterials: the 'top-down' approach and the 'bottom-up' approach. Nanomaterials are built from larger entities without atomic level regulation in a top-down strategy.This technique is long, costly and not sufficient for large-scale development. Milling, scraping and grinding are the top-down techniques most widely employed. The bottom-up method begins with molecular components that, using the concept of molecular recognition, chemically arrange themselves to create nanostructures. This technique is acceptable because it is low-cost and produces less material flaws as well. Wielding and riveting are the most widely employed bottom-up procedures[1][2].

Application of Nanomaterial in Agriculture

Soil nutrient shortage (Zn, Se, S, etc.) and the proliferation of a number of pests are major agricultural challenges that need to be solved in order to ensure high crop yields and efficiency. In addition, macronutrients such as N, K, and P are needed by plants in large quantities, but their bioavailability is usually poor. Therefore, the agricultural sector uses a range of chemicals (pesticides, fertilisers) in vast quantities to achieve high-quality crop production that avoids any pest attack. In order to achieve greater productivity in plant breeding systems, nanotechnology will also lead the way to successful transmission of genes or sequence molecules[3][4].

Pest control

In some areas, such as weed control and nutrient supply, the use of nanotechnology may be realised through adding pesticides and fertilisers as efficient and less contaminating nanoformulations. They are harmful for the environment because of the carcinogenic and cytotoxic nature of conventional pesticides. The latest creation of nanosensor devices like nanocomposite platinum NPs/carbon nitride nanotubes for atrazine identification and hexagonal boron nitride nanosheets of the core-shell type NPs/2D for cypermethrin determination has provided a simplified and more cost-effective approach for detecting pesticides. In order to fight against pathogens, nanosilver was researched for agricultural use[5].

Fertilizer

In agriculture, the use of nanofertilizers for the distribution of micronutrients (Zn, Se, etc.) is evolving rapidly. In addition, nanotechnology-driven nanosensing devices can be built in order to understand real-time data on the supply of water and nutrients and crop growth. In the distribution of desired chemicals to plants and crops, carbon nanotubes (CNT) and mesoporous silica nanoparticles (MSNs) have been added. A large surface size, pore depth and closely ordered pores are their principal characteristics. Another research goal is to improve nanofertilizers in such a way that nutrients can be released "in quantity and at time" when and when plants need them[6].

Plant growth regulator

The thesis would consider the mechanistic aspects of root or leaf ingestion of NPs, root to shoot and shoot to root transport and delivery to different tissues. This will pave the way for nanoformulation, fertiliser or pesticide, suitably in soil or as foliar spray, to be used. Nanoparticles may be used or inserted into a matrix as a suspension (clay, zeolite, chitosan). The impact of NPs on organisms and the environment depend on the scale of NPs, their form (aggregation), chemical properties (element(s) of NPs), environmental mobility, consideration of plant species, length of exposure, mode of exposure and environmental conditions.The plant's uptake of NPs and plant mobility depend on the shapes and scale of NPs, and also on their chemical properties. Within plants, NPs cause many changes that lead to positive changes in plant physiology and development. Stress-responsive gene expression is modified and the metabolic pathway and enzymatic activities are tuned according to the availability of NPs. In the existence of Ag NPs, there are reports of synthesis changes and ethylene functions that have contributed to either positive (improvement of growth) or negative (altered plant-microbe interaction) changes.In order to enhance the application of NPs such as Au, CuO and TiO2, the water permeability of seeds and other membranes within the plants has been identified. TiO2 NPs have been noted to enhance the functioning of nitrogen metabolism and photosynthesis, contributing to increased growth of the plants examined. While the use of NPs in the agriculture sector is gradually growing, more and more research is going on that will further expand this use. The fate and actions of NPs in the ecosystem, their contact with seeds, microbes and humans, their eventual passage across the food chain and their ultimate impact on animals and humans can, nevertheless, be assessed in detail[7].

Threats of nanotechnology

The use of nanoparticles in diverse fields is envisaged and, as a result, the manufacture of NPs has developed tremendously. However, this is notwithstanding the fact that knowledge on the potential fate of NPs is still not completely elucidated after implementation. It is generally understood that the current degree of pollution of NPs is not risky. The current average production of NPs is 270,000 metric tons/year (SiO2, TiO2, FeO2, AlO2, ZnO2, and CeO2). Even, it should not be forgotten that concentrations of NPs can very soon go beyond acceptable limits.Nanotechnology has its own pros and cons. Since NPs are very different from their ordinary counterparts, it is not possible to infer their negative impacts from the known toxicity of the macro-sized material. This raises critical concerns for addressing the effect of free nanoparticles on health and the environment. In the climate, the presence of NPs is both attributable to natural sources and to anthropogenic activity. Via atmospheric deposition and rain, and through direct supply to agricultural fields, nanoparticles enter the soil. Owing to the poor mobility of NPs in the soil, NPs keep building up in the soil, which is why NPs are found in higher soil concentrations than in air and water.NP-based nanofertilizers can serve as a source of soil, water and air pollution by NPs. The soil NPs are taken up by plants and microbes may also enter them. NPs pass through plants inside the plants to reach up to shoot and to several organs and tissues. NPs continue to move through the food chain via microbes and plants through protozoans, fish and insects, etc., and will ultimately enter humans. Increased development of ROS, Damage to DNA, genotoxic effects, damage to human organs and tissues, impacts on crop production, and negative effects on advantageous bacterial species are hazards and threats for nanoparticles.Before being actively advertised, the possible impact of nanoparticles on people's wellbeing and the atmosphere should be assessed[8][9].

People's possible health risks should be fully understood. There are several possible entry routes into the body for NPs. They may be inhaled, swallowed, ingested by the skin or, during surgical operations, purposefully injected. One of the major problems that must be solved is the action of NPs within the organism. The scale, shape and surface reactivity of nanoparticles with the surrounding tissue are a result of this action. Cytotoxicity could be caused by dangerous or poisonous materials contaminating the particles. When nanoparticles are processed on a wide scale, the risks of such pollution are rising.

They are naturally produced or end up in the ecosystem because of the constant development of NPs over the last few decades. Nevertheless, little is understood about the possible environmental implications of NPs, although chemical structure, shapes and scale have been found to contribute to the toxicological consequences of some instances. Researchers also observed that, with potential harmful effects, silver nanoparticles used in socks only to minimise foot odour are emitted in the bath. Silver nanoparticles, that are bacteriostatic, can then kill beneficial bacteria that are essential in waste treatment plants or farms for breaking down organic matter[10].

CONCLUSION

Despite many studies available on the fate and actions of NPs and their toxic effects, there is a significant lack of holistic expertise on the subject. Micro- and nanoplastics are emerging as large-scale environmental pollutants with a prevalence in nearly every environmental matrices. There is a need to research the fate and behaviour of nanoplastics. Further research should concentrate on the use of different exposure concentrations, durations and types of exposure, applying artificial field conditions or carrying out real-field trials. To determine the toxic effects of different NPs on various crops and under differing environmental conditions, a standard set of criteria must be specified.Researchers have proposed the use of certain representative animal species at various tropical levels to execute a standard collection of tests in order to collect the necessary evidence in the future, so that legal standards can be developed and that the use of NPs can be tracked and supervised safely.

The costs of NPs must be kept beyond the control of the general population, in particular in the case of NPs for use in the agricultural sector. It can be expensive and affordable for the medical sector to have NPs. Nonetheless, NP prices should be reduced to a minimum for large-scale agricultural use by poor farmers.Future studies should concentrate on reaping the advantages of technology, taking into account cost pressures and specifications. Therefore, considerable emphasis has currently moved to the production of NPs by natural processes or from natural products such as chitosan and chitin from exoskeleton and alginate crustaceans (from brown algae).

REFERENCES

[1] A. Kumar, K. Gupta, S. Dixit, K. Mishra, and S. Srivastava, “A review on positive and negative impacts of nanotechnology in agriculture,” *International Journal of Environmental Science and Technology*. 2019, doi: 10.1007/s13762-018-2119-7.

[2] M. Calabi-Floody *et al.*, “Smart Fertilizers as a Strategy for Sustainable Agriculture,” in *Advances in Agronomy*, 2018.

[3] X. He, H. Deng, and H. min Hwang, “The current application of nanotechnology in food and agriculture,” *Journal of Food and Drug Analysis*. 2019, doi: 10.1016/j.jfda.2018.12.002.

[4] P. Zhang, Z. Guo, Z. Zhang, H. Fu, J. C. White, and I. Lynch, “Nanomaterial Transformation in the Soil–Plant System: Implications for Food Safety and Application in Agriculture,” *Small*. 2020, doi: 10.1002/smll.202000705.

[5] J. Yasur and P. U. Rani, “Environmental effects of nanosilver: Impact on castor seed germination, seedling growth, and plant physiology,” *Environ. Sci. Pollut. Res.*, 2013, doi: 10.1007/s11356-013-1798-3.

[6] H. Chhipa, “Nanofertilizers and nanopesticides for agriculture,” *Environmental Chemistry Letters*. 2017, doi: 10.1007/s10311-016-0600-4.

[7] C. Kole, D. S. Kumar, and M. V. Khodakovskaya, *Plant nanotechnology: Principles and practices*. 2016.

[8] J. Hong, J. R. Peralta-Videa, and J. L. Gardea-Torresdey, “Nanomaterials in agricultural production: Benefits and possible threats?,” *ACS Symp. Ser.*, 2013, doi: 10.1021/bk-2013-1124.ch005.

[9] R. Roy, S. Kumar, A. Tripathi, M. Das, and P. D. Dwivedi, “Interactive threats of nanoparticles to the biological system,” *Immunology Letters*. 2014, doi: 10.1016/j.imlet.2013.11.019.

[10] J. Besley, “Current research on public perceptions of nanotechnology,” *Emerg. Health Threats J.*, 2010, doi: 10.3402/ehtj.v3i0.7098.

- P. Lavanya, R. Meena, R. Vijayalakshmi, Prof. M. Sowmiya, Prof. S. Balamurugan , " A Novel Object Oriented Perspective Design for Automated BookBank Management System", International Journal of Innovative Research in Computer and Communication Engineering, Vol.3, Issue 2, February 2015.
- P.Andrew , J.Anishkumar , Prof.S.Balamurugan , S.Charanyaa, " A Survey on Strategies Developed for Mining Functional Dependencies", International Journal of Innovative Research in Computer and Communication Engineering, Vol.3, Issue 2, February 2015.
- SV AmridhVarshini, R Kaarthi, N Monica, M Sowmiya, S Balamurugan, "Entity Relationship Modeling of Automated Passport Management System", International Journal of Innovative Research in Science, Engineering and Technology , Vol. 4, Issue 2, February 2015
- RS Venkatesh, PK Reejeesh, S Balamurugan, S Charanyaa, "Further More Investigations on Evolution of Approaches for Cloud Security", International Journal of Innovative Research in Computer and Communication Engineering , Vol. 3, Issue 1, January 2015
- K Deepika, N Naveen Prasad, S Balamurugan, S Charanyaa, "Survey on Security on Cloud Computing by Trusted Computer Strategy", International Journal of Innovative Research in Computer and Communication Engineering, 2015
- P Durga, S Jeevitha, A Poomalai, M Sowmiya, S Balamurugan, "Aspect Oriented Strategy to model the Examination Management Systems", International Journal of Innovative Research in Science, Engineering and Technology , Vol. 4, Issue 2, February 2015