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Nanotechnology Use In Agriculture: Present And Future

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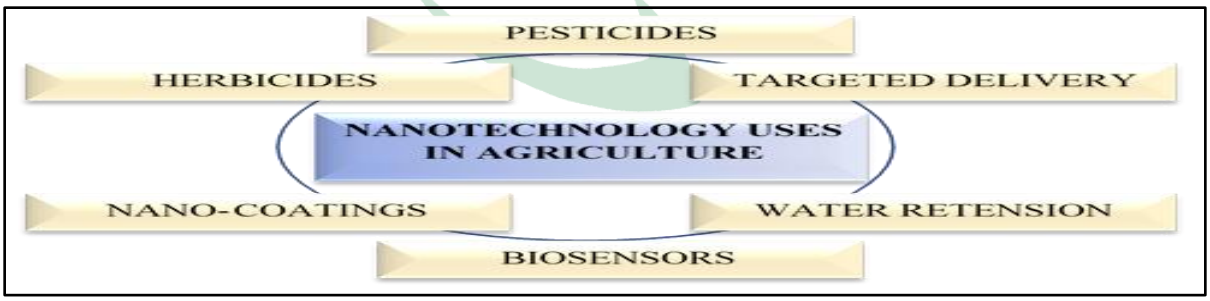
Introduction

"Nano" which is known as one billionth usually used as prefix in the metric system. In a scientific world nano-prefix is used before technology. The science of nano-technology presented to the world by renowned physicist Richard Feynman and commonly attributed as the father of nanotechnology. Nanotechnology is the branch of science whicha deals with the manipulations like designing, synthesis and applications of the nanomaterials which are the new emerging face of all the fields like life sciences, medicine, electronics. Nanomaterials, on the basis of dimensions, can be classified into zero dimensional (where all dimensions are of range 1-100 nm, these are the nanoparticles), one dimensional (rod shaped), two dimensional (ultrathin films) or three dimensional (any shape). These nanomaterials also naturally occur in the environment, the main sources are- volcanic ashes, forest-fire ashes, ocean sprays etc. Nanotechnology applications in recent years provided many promising results towards the betterment of agriculture from crop-nourishment, protection, growth factors, packaging etc. The general property of nanoparticles like the large surface area, more absorbing and reactivity are highly exploited. The advised use of nano-pesticides, fertilizers etc. to the crops benefits the farmers as well as environment as the amount to be used will be much lesser and the amount of the chemical releasing in environment will also be reduced.



Nanotechnology uses not only limited to the plant world but also play very important role in animal related fields of agriculture like improving the nutrition, feeding efficiency,

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zoonotic disease control, reproduction, quality of product (meat, milk) and the waste management. The availability of these resources is limited today and seems to get highly usable in coming years.

Present day agriculture is highly prone to various types of unwanted events which occur naturally or are manmade- the climate change like disturbances in the natural raining pattern, prolonged drought; deficiency of macro and micro nutrients due to extensive agriculture; occurrence of heavy metals due to various reasons etc. Nanotechnology will transform agriculture and food-based business such as in of farming tech-systems, enhancing the capability of plants to captivate nutrients, disease finding, control pests and withstanding in adverse conditions. Despite substantial advances in recognizing likely applications of nano-technology in agriculture, several questions remain to be fixed in the future before this technology takes momentum in the area of agriculture. Risk related to nano-materials and life-cycle of nanomaterials like nanopesticides, nanofertilizers is of major concern. The effects on non-targeted pest-pathogens or toxic effects on plants is also one of the concerns.

Some Facts

Study of nanoparticles is not new, Richard Zsigmondy, a Nobel prize Laureate in chemistry was the first scientist who proposed the concept of nanometre. Norio Taniguchi was the first who coined the term nanotechnology and describes the semiconductor processes that occur at nanoscale. Increased interest towards nanotechnology actually starts at the beginning of 21st century. Nanotechnology is a very young and rapidly emerging field which allows inter-disciplinary collaboration of biologist, physicist, engineers and material scientists Within very few years, approximately in half a century, nanotechnology has become the bedrock of industrial application. In Pharmaceutical industry nanobiotechnology plays an important role in imaging probes, drug delivery systems, and diagnostic biosensors. Nanoparticles are also excessively used in food and cosmetics industry. Zinc oxide quantum dot nanoparticles act as biosensor for checking food quality and safety. In the field of medical sciences, nanoparticles are extensively used to improved drug delivery, antibacterial coatings of medical devices, reduced inflammation, better surgical tissue healing, and detection of circulating cancer cells.

Processing

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The basis of nanotechnology is the nanomaterial used in this field. So, it is important to understand the synthesis and uniqueness of nanomaterials. Nanomaterial synthesis may take place by different methods viz. physical, chemical or biological. Nanomaterials can be basically synthesized using two approaches: top down and bottom up approach.

- **Top down approach:** This method uses a set of technologies in which larger bulk materials are fabricated to formulate nanoparticles, directing their assembly.
- **Bottom up approach:** A base substrate, at the molecular level, is used in this method. These are used to form larger and more complex substances while maintaining their molecular structure Due to their unique properties mainly large surface area to volume ratio, nanomaterials have found an irreplaceable place in the field of science.

Following this, nanotechnology has paved way into different areas such as biology, physics, chemistry, material science, medicine and engineering. Nanomaterials occur naturally in various forms in the environment such as products of bacteria, clay and minerals. They exhibit various properties not shown by their bulk sample which include several aspects like thermal, optical, electrical and surface properties. Nanomaterials, being zero valent metals engineered synthetically, due to their characteristics such as high capability of adsorption and strong reducibility can also be exploited for processes such as environmental remediation and antimicrobial effect.

In agriculture:

Failure of conventional farming technologies in increasing productivity any further and also their lack in restoring the environment damaged by earlier technologies has attributed to the need to increase usage of nanotechnology in agriculture. Bad agricultural practices like excessive use of pesticides, insecticides and chemical fertilizers have degraded the soil quality to a very high extent. Many approaches have been introduced to replenish the soil quality and increase productivity. Nanomaterials may be used in agricultural applications such as nanofertilizers, growth stimulators, nanopesticides, agents which can improve soil or in agricultural fields as sensors which monitors different parameters and in the food industry. Nanotechnology is emerging as a promising approach in agriculture.

Advantages

- Nanosensors can be used to monitor plant growth regulators and soil conditions

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- Nano-encapsulated slow release nutrients and fertilizers are better choice to avoid excessive dosage
- Nanobiosensors for detection of biotic and abiotic stress and contamination in the soil
- Clay nanomaterials can be used to detoxify harmful pollutants for example heavy metal and pesticides.
- Nanotech based smart chemical and micronutrients delivery system in controlled and targeted manner
- Due to their antimicrobial properties, nanomaterials can also be used in plant disease control system
- Nanoherbicides and nanotech based organic farming are other such promising approaches

Safety Assessment of Nanomaterials

Nanotoxicology is the study of ill effects of nanoparticles on human health, it also emerges as a new field to observe the toxicity of using nanoparticles at a large scale. UK Nanotechnology Research Coordination Group and the US National Nanotechnology Characterization Laboratory initiated to provide the reference material to test the nanotoxicity. An idea of High throughput screening of nanoparticles was also proposed by US National Research Council. Walker and Bucher, who study health hazard of nanomaterial, described why assessment of nanomaterial is different from conventional methods: their different surface properties which affect dosimetry, small size of nanoparticles leads to its exposure to new cellular portals, modern commercial application of nanomaterial may lead to some unseen toxicities, expression of nanomaterial dose in terms of mass may give false results due to its size dependent property. Scientists are doing research in this direction for further development of methods for safety evaluation of nanomaterial.

Some industries, which use nanomaterials on a large scale, make way for them to be released out in the environment. There can be direct or indirect modes of nanomaterials accumulation in the terrestrial ecosystem, can be either natural or anthropogenic, in nature, may be found in air, water, sediment or soil, and hence gets accumulated in the environment with time. Human activities include combustion of fossil fuels, waste incineration or biomass burning, environmental remediation methods which uses zero valent metals and photocatalysis processes also causes accumulation of nanomaterials in the environment.

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Conclusion

Today human life revolves around nanotechnology because of its diverse benefits in different fields. Although even after sufficient development of the roots of Nanotechnology, some questions still arise which must be answered to extend this technology beyond laboratory which is lacking because of health and environmental risks. Lot of studies has been done to check the advantages of using nanoparticles in different industry but very little is known about the cons of using nanoparticles so this field requires further investigation. With the increasing use of nanomaterials, their toxicity in plants have been studied by many researchers now. According to them, plants can tolerate the nanomaterial stress but only upto an extent, above that, they hamper their growth. Being a revolutionary technology, we cannot afford to completely discard it, but its usage and impact on environment needs to be monitored very closely. Since there is no such internationally accepted standard protocol developed to test the toxicity level of nanoparticles, it becomes very hazardous to use them without considering their negative impacts on environment and ultimately human health.

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