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# Nanotechnology And Nano-Food- A Promising Choice For Future Food Security

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**Abstract:**

Nanotechnology concerns with the manipulation of materials at the nano scale. It paves a way for the novel approach in sustainable farming to enhance food production. Nano-food is the one that is cultivated, produced, processed and packaged using nanotechnology. Nanotechnology helps to maintain healthy soil-plant system fostered with the usage of nano fertilizers. Nanoengineering addresses the scarcity of water resources, soil erosion and pest management. Nanoparticle carriers increase the soil fertility, plant growth and yield production. Nanosensors help the plants to absorb optimum quantity of fertilizers, water, sunlight, resulting to a huge harvest. Nanoparticles of metal oxides like ZnO2, Alumina Silicates play the role of intelligent biocides for effective pest control with less damage to the soil fertility. DNA sequencing using nanotechnology with nanoparticles like *3nm mesophorous silica nano particles*, *graphene nanoribbons* for crop improvement. The nanoparticles like Ag, Zn, Cu and Silica particles are effectively used for crop protection. *Smart Dust* nanosensors works for precision agriculture. Nano Graphene used in food packaging increases the shell life of food product and protects the nutrient quality. The efficient use of nanotechnology in cultivating, harvesting, processing and packaging agricultural goods ensures the quality and durability of nano food. This paper outlines the applications of nanotechnology in cultivating and producing nano-based food. This paper discusses the challenges of nanotechnology and the accumulation of nanoparticles in soil, water, and plants. So, nanotechnology and nano-food can be the best promising choice for future food security.

Keywords: Nanotechnology, nano-food, nano engineering, nano sensors.

## INTRODUCTION:

Nanotechnology monitors and manipulates matter at the nano level to perform a wide range of operations in various fields, ranging from drug delivery to cosmetics, architecture to construction, farming to harvesting, food preparation to food packaging, automobiles to missiles, and many more. Nano-based food is prepared using nanotechnology from cultivating to processing nano food. Nanoscience engineering with nanotechnology has created it's indelible mark from ancient ages with uniqueness in properties and applications of the materials to provide healthier, nutritious food with more shelf life. Nanocoatings of the recommended size can be used in bakery products, meat, dairy products, fresh farm fruits and vegetables to sustain the colour, nutrients, and their liveliness [1]. The quality of the nanofood depends on the pre-harvest of a healthy soil-plant system and the post-harvest of the crop.

### Nanotechnology – Healthy soil -plant system:

A healthy soil-plant system is maintained and sustained by the soil structure & fertility, conservation of soil nutrients, removal of soil contaminants, soil remediation, hydraulic conductivity of soil, plant growth, crop protection with pest management and crop harvesting.

- **Sustainment of soil structure and soil fertility:** Soil structure can be sustained with the nanotechnology-aided *nanozeolites.* Zeolites are a family of minerals with a corner sharing tetrahedral atoms like tectosilicates, hydrated crystalline aluminosilicates. The empirical formula of a zeolite is of the type: M2/nO Al2O3 xSiO2 yH2O, where n is the valence charge on that element; M is an alkali or alkaline earth element, and y is a number from 2 to 7 [2]. *Nanozeolites and nanofertilizers* strengthen the growth of soil-friendly microorganisms. "*Clinoptilite*" is a natural zeolite that is used in agriculture to enhance the nitrogen nutrients in soil [3].
- **Conservation of soil nutrients**: The nutrients of the soil can be preserved with the optimum usage of nano fertilisers. Nanoparticles of N, P, K, Zn act as nanofertilisers to help in the slow release of nutrients to enhance soil conservation. Porous nanomaterials like zeolites, clay or chitosan regulate the slow release of nitrogen to enhance the plant growth [4].The zeolites composed of ammonia can increase the solubility of phosphorus in the soil and help the roots to absorb it. Graphene oxide nano films reduce the loss of leaching by prolonging the release of potassium nitrate to the plants[5-6].
- **Removal of soil contaminants**: The contaminants produced by the air and water pollution can be detected by the ***nanosensors*** and can be removed with the aid of nanotechnology. Heavy metals like mercury, cadmium, arsenic, lead and selenium are accumulated on the top layer of the soil. Nanozeolites have high potential for hydration and dehydration of water and this aids to the removal of soil contaminants[7].
- **Hydraulic conductivity of the soil:** Hydraulic conductivity is the ability of the soil to have easy water movements. The soil moisture and the water-absorbing capacity of the soil can be monitored with the ***nanosensors***. The hydraulic conductivity of the soil can be increased by the sustenance of

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soil structure. This can be attained with the removal of soil contaminants that were accumulated on the top layer of the soil and allowing the free flow of air through the pores of the soil. Zeolites can be used as soil conditioners to promote the hydraulic conductivity [8]. It has been reported that the usage of the Brazilian zeolitic sedimentary rocks had increased the hydraulic conductivity of the soil,which significantly increased the yields of lettuce, tomato, and rice[9].

- **Soil Remediation:** The soil can be healed, restored in structure by conserving the optimum hydraulic conductivity, soil fertility, free air flow and absorbing capacity of nutrients. *Nanoparticles like Iron Oxide and biochar* produce biomass which breaks down and cleans the contaminants on the top layer of the soil [10]. The use of "control loss fertilizers" enhances the retention of nitrogen and reduces the soil leaching[11].
- **Plant growth and crop improvement:** The plant growth is assured by the good fertile soil with a good hydraulic conductivity.The plant growth and crop production is enhanced by the biofortification with the usage of *nano zeolites, nanofertilizers* such as nanoMn, nanoZn, nanoFe [12]. These nanoparticles triggers the growth and capacity of blooming and fruit formation. Crop improvement can be achieved through the DNA sequencing using nanotechnology with nanoparticles like *3nm mesophorous silica nano particles*, *graphene nanoribbon, and Arginine gold nanoparticles [13].*

  **Crop protection with pest management:** Pest management plays a key role in maintaining healthy crops in achieving good yields. Silver nanoparticles (AgNPs), Copper nanoparticles (CuNPs), and Zinc nanoparticles (ZnNPs) can be used as nanopesticides, nanofungicides for the best pest management [10].The nanoparticles of CdS,and $TiO_2$ showed excellent potential in suppressing *Spodoptera litura larvae* which is destroying the cotton, maize, corn and tomato crops [14].
- **Crop harvesting with Nanotechnology**: The nanotechnological methods and devices with inbuilt nanosensors and real time monitoring system used for crop harvesting increase the nutrient quality and life time of the food grain. SmartDust nanosensors are used for precision agriculture. Potato Harvestor, Groundnut Harvestor are used to separate potatoes and groundnuts from the soil without damage, Automatic row weeder, Carrot Harvester and separator, Robotic lettuce harvester, Drones to monitor the farm, Nanosensors and nanobiosensors to monitor the moisture and sense the defeciency of nutrients, Harvesting Robots, Autonomous mobile robots for shifting goods from the farm to the warehouses[15].

**Nanofood:** The yield of the food that is produced by the nano methods and nano approaches from cultivation to harvesting of crop can be considered as nano-based food or nanofood. The potential applications of nanotechnology can be used to detect the bacteria in processing and packaging of food [16].

**Nanofood processing:**Nanoparticles are used as **anticaking agents** to prevent lump formation in preparing cookies, cakes, confectioneries and many other baking products.NanoCa, Nano Mg and Nano Zn are used

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as **gelating agents** to improve texture in the preparation of chocolate wafers, gelly cookies, gems, gelly cakes. **Nanoadditives and neutraceuticals** are used in protein and food supplements to improve the nutritional value of food. **Nanocapsulation** is adopted to protect aroma, flavour in preparation of tea and coffee powders[17].

**Nanofood packaging**: *Nanomaterials* made from transition metals like Ag, Fe, alkaline earth metals like Ca, Mg and other non-metals like Se and other silicates are used in food packaging for more freshness, preservation of nutrients and shell life.Foodpackaging material manufactured with the *nanosensors* made up of carbon nanoparticles, nano-sized metal oxides and polymeric resins enhances the degradation of ethylene gas and reduces the harmful enzymes which are unsafe and unrecommended for human consumption [18].Nanocomposite films composed of *silicate nanoparticles* like *Durethan* from Bayer polymers , U.S.A reduces the entry of Oxygen and reduces the exit of moisture to conserve the nutrients of the food [19]. *Bio active nanopolymer* such as niacin composed of nanoparticles exhibit excellent potential of immediate antimicrobial activity in destroying the bacteria like E-coli [20]. Protein supplements like Women's Horlicks, Ensure powders are updated with nanoparticle powders to recommend the better absorption of nutrients. Ag, ZnO,$TiO_2$ nanoparticles are used in orange juice to reduce the formation of yeast and molds and used in apples to enhance freshness and to reduce browning when they are sliced [21].

**Nano food as future food security:** Nano-based food can become as a future food security fostered with the adoption of nano-cultivational and harvesting techniques using nano particles, nano zeolites and nanosensors. Nanobased food can be preserved with the food packaging aided with nanotechnology-based nanoparticles, nano biopolymers and nanocomposite films.

**Challenges and limitations:**

**Ecological balance:** Disposal and leaching of the overdosage of nanoparticles from the nanofertilizers, nanobiosensors, nanopesticides, nanoherbicides lead to the percolation of nanowaste in to the deeper layers of earth causing it to loose it's natural fertileness [22].The wild animals and the birds eating the fruits and crops grown from the nanopolluted soil may accumulate toxic nanoparticles and develop mutational changes. Seafood produced from the nanocontiminated aquaspheres may contain the toxic Hg nanoparticles which may be harmful to the human digestive system.The nanoanpolluted dairy and the aquatic products when consumed by humans may serious and chronic health issues regarding liver and pancreatic cancers. So, there should be a specific method to process the nanowaste without causing much damage to the Mother Earth.

**Accumulation of nanoparticles in soil and water:**Nanoparticles like Fe, Al, Cu, Au, Ag,Si,Ni,ZnO,$TiO_2$ used in cosmetic products will be accumulated in soil,water especially when washed off. Sunscreen lotions, Hair dyes made up of nanoparticles are causing aquatic pollution[23].

**Safety of Nanofood:** Uncertainty of safety in the effective delivery of nanofood without leaching of the toxic nanomaterials into the nanofood.This raises an alarm in the adoption of nanotechnology in the food processing and food packaging[21].

**Harmful to Human beings:** Hyper activity of nanoparticles regarding adsorption, ionisation may harm the brain, liver and create imbalance of gut health in people with sensitive human body.Overdosage of TiO2 nanoparticles may accumulate in brain causing it's improper functioning [24,25].

**Conclusion:** Nanotechnology has brought a remarkable change in the fields of medicine, agriculture, electronics, food industry, military and telecommunications. It has created it's indelible mark in the food industry beginning from the crop cultivation to the nanofood processing and packaging. Nanoparticles used as preservatives to conserve flavour and texture, and also to increase the shelf life. With the increase in population and it's large demand for rich nutritious food, nanotechnology and nanofood serve as the best promising choice for the future food security.

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