A review on nanotechnology and its applications on Fluid Flow in agriculture and water resources

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Abstract
Nanotechnology is a very effective field of study with the potential to drastically change how we observe and create change in the field of agriculture, biomedicine, chemical, mass transfer and water management amongst others. The technology derived from the name, Nano, works with particles that can be observed on a nano scale. By working on this scale, unique problems can be solved creatively with more success. For example, fertilizer efficiency can be improved by using Nano-clays and zeolites to restore soil quality and fertility. Work on smart seeds scheduled for germination with Nano-polymer coating under favourable conditions is encouraging. Under precision farming inputs, crops are usually classified based on the nutrient requirements and with the assistance of a Nano-biosensor and a satellite system, the delivery of nutrients can be delivered precisely and can be monitored more accurately than existing methods. This also brings to attention the development of Nano-herbicides to tackle weed management. There exist studies that demonstrate the effectiveness of Nano-fertilizers to improve the productivity and efficiency of the nutrients, decrease soli toxicity, and minimize possible contamination related issues. The potential of nanotechnology for sustainable agriculture is therefore strong, especially in developing countries.

Keywords: Nanotechnology, mass transfer, water resources, Fluid Flow, zeolite.

1. Introduction
Indian national policymakers allocate 4 percent annual growth in agriculture to Ensure national food security with limited access to land and water supplies. Demand can only be met by increasing productivity and income per area for limited natural resources through the efficient use of advanced technologies. This requires a continuous flow in the industrial sector, and therefore information, biotechnology and nanotechnology have recently taken the lead in the development era [1- 4]. Nano fertilizers are economically cheaper and are needed in lower amounts as compared to the demand and price of chemical fertilizers. Farmers have found for years that absorption of nitrogen is the main reason for an inadequate yield. When testing a specific soil sample that causes disturbance in the soil, sensors give accurate results but have a drawback in terms of time consumption and also high-performance costs. Sensors provide better results with live images and conditions of the field and they can track changes
caused by different pesticides, fertilizers, and herbicides, as well as the physical conditions of
the soil such as pH [5]. Agriculture is not an exception and meeting the changing needs and
domains are under constant development [2, 6]. It is claimed that nanotechnology (NT)
israpidly advancing and evolving with the potential to revolutionize food production
processes and provide new and improved approaches to many of the major challenges facing
agriculture today and society in the future. "Nano" means a billion, therefore it is concerned
with materials measured in one billionth of a meter. A nano meter is 1/80,000th of a human
hair diameter or about ten wide atoms of hydrogen; the science of very small things is
nanotechnology. Nanotechnology is a science that is multidisciplinary as it extends from
biology, physics, chemistry, etc. Josep and Morrison (2006) defines Nanotechnology as the
controlled assembly of carefully structured molecules formed from atoms that are able to
alter the material properties. Nanotechnology collects Nano-scale atom data, taking into
account physical, catalytic, magnetic and optical Characteristics [7, 8]. Fertilizers are applied
to soil, crops or even aquatic ecosystems in many ways; these inorganic fertilizers are
supplied in equal proportions with three major components, nitrogen, phosphorus and
potassium [9].

2. Nano-farming: a new frontier in the development of agriculture
Although ' nanotechnology ' has been used in many fields for a long time, the development of
nano particles can also be applied to the field of agriculture and warrants more interest as it is
a relatively new breakthrough [10]. Due to modern developments and the ability to tune the
size and shape of the particles and in turn control the properties of the material, prospective
fields have opened up such as in the field of agriculture, medicine and environmental
sciences as well. These innovations can certainly help the field of agriculture and can help
tackle difficult challenges such as lower quality yields due to the abiotic and biotic stress impacts.
Other factors that can also be considered are nutrient deficiency, environment and air pollution.
Further development of nanotechnology can help counter and eliminate these effects and allow for
precise farming methods. (Figure 1) Over the past few years, precision agriculture/farming has
become more popular as well as the production of wireless networking and sensor miniaturization to
track, analyse and regulate agricultural practices. Particularly, specific site management policies can
be applied to both pre and post agricultural production aspects [11]. New developments in tissue
engineering such as CRISPR/CAS mRNA and sgRNA can have significant effects and can be
proven scientifically.
Figure 1: Nanotechnology applications in agriculture.

The controlled delivery of Nano-fertilizers can be used to enhance its efficiency, which can improve the crop yield. This will eventually lead to a boost in the quality of the crops produced, additionally, Nano-pesticides can also improve the health of the crop grown. When combined with Nano sensors and computerised control systems, precision farming can yield very positive results. The use of additional nanomaterials can also help improve soil quality and increase its resistance to contamination and external stresses.

3. Properties of the nanoparticles
Two major factors allow the properties of nanomaterials to differ substantially from other materials; increased relative surface area and quantum effects. Morphology-aspect ratio / size, hydrophobicity, toxic material solubility release, surface area / ruggedness, contamination / adsorption of surface species during synthesis / history, important reactive properties of nanoparticles with oxygen species (ROS) O2/H2O, ROS production capacity, structure / composition, competitive receptor binding sites and dispersion / aggregation are properties which can be altered and modified as needed [12-17].

4. Nano-Agriculture
In December 2002, the Department of Agriculture (USDA) in USA drafted the first "roadmap" of the world to apply nanotechnology to agriculture and food. A large group of policy makers met at Cornell University (New York, USA) with land grant participants from universities and corporate scientists to discuss their dream of how to rehabilitate farming using nanotechnology. In general, to be compatible with Nanotechnology and take advantage of its subsequent benefits, agriculture will need to be more structured to bring it up to industrial automated levels. The farm will be a major bio factory region in our molecular future that can be monitored and controlled from a laptop. The body is supplied effectively with food and calories and Nano-biotechnology can increase the potential of farming for industrial processes to produce feed stocks. Meanwhile, in a modern "flexible matter" nano economy, tropical agricultural commodities such as rubber, cocoa, coffee and cotton grown by small-scale farmers will become quaint and insignificant. It is possible to adjust nanoparticles to produce better, "smarter" alternatives. Just as GM agriculture has led to new rates of corporate control throughout the food chain, patented nano innovation implemented from seed to mouth, genome to gullet, the agribusiness grasp on global food and agriculture will broaden at all stages. Scientists have been controlling food and farming at the molecular level for two decades. In the industrial food chain, agro-nano connects the dots and goes one step further. GM crops are atomically transformed plants with new nanoscale techniques for combining and harnessing genes. Pesticides can be packaged more precisely so that they can be unpackaged to please the palate. The food and the agricultural industries can be revolutionized using Nano technology and this modern innovation can be used to treat and reduce the development and spread of diseases [18,45].

5. Precision farming

Precision agriculture was a long-awaited target of optimizing production while reducing input (i.e. fertilizers, pesticides, herbicides, etc.) by monitoring and coordinating intervention of environmental variables. Precision farming uses computers, global satellite positioning systems, and remote sensing devices to measure highly localized environmental conditions such as total efficiency or correct detection of problem type and location. By using centralized data to determine soil and plant conditions growth, the use of seeds, fertilizers, chemicals and water can be fine-tuned to reduce production costs and potentially increase yield, all of which favour the farmer. New farming methodologies can be created by using nanotechnology capable sensors and monitoring systems which can improve precision faming with a GPS system that can help improve real time tracking [46-50]. In order to track soil conditions and plant growth, these Nano sensors could be spread across the field. In parts of the United States and Australia, remote detectors are already being used. For example, improved use of autonomous sensors linked to a GPS system for real-time tracking is one of the major roles of nanotechnology-enabled devices. Approximately seven billion USD are expected to be spent by 2010. The amalgamation of Nanotechnology and biotechnology can lead to creation of very sensitive equipment enabling faster and effective responses to change in external stimuli [12].

6. Nano-Sensors

Nanotechnology applications can be implemented to improve the soil quality and fertility and improve crop yields; it can also be used to create advanced monitoring systems to analyse crop and animal health. These applications can also be developed into a software/computerised system known as “Lab on a chip” to provide cheap and effective systems in developing countries. A new concept such as magnetic Nano particles can be used in the soil to actively remove contaminants [18, 19, 52-55].
7. Food systems and nanotechnology
Food systems consist of using resources, availability and access, therefore agricultural production-consumption systems must be included in the scope of nanotechnology applications to enhance food safety. The rapidly fast growth nature of the world economy is largely dictated by energy use and availability, impacting food resource production and consumption. This will primarily be driven by the rural or local income and supply chains can be a primary source in the food chain network [2, 20]. In doing so, nanotechnology should be seen as complementary enabling technology along with Biotechnology and conventional technologies [21]. From the food safety point of view, nanotechnology should not be applied limited to the level of agricultural production but also applied to all subsequent and dependent links in the overall productivity and the significant impact is only realised due to specific environmental and social policies [22-25, 56].

8. Nanoparticles based smart delivery systems: Applications and advantages
Nanoscale machines are capable of detecting and treating diseases, monitoring and curing nutrient deficiencies and also shed more light on other health issues which can be identified due to the incredible capacity of these machines to identify changes of chemicals in the system. Intelligent delivery systems are capable of tracking the effects of medication, nutraceutical, nutrient delivery, food supplements, bioactive compounds, vaccinations, probiotics, chemicals, and insecticides. Agricultural delivery systems are critical for the use pesticides and fertilizers as well as genetically modified plant quality improvement techniques. The software implemented should primarily focus not only on the efficacy of the delivered chemicals but also to minimize other issues such as spray drift when fertilizers are faced with problems with soil chelation, over-use and run-off bioavailability. The system for delivering fertilizers and pesticides areviable alternatives to solving and eradicating these issues. The methodology of guided distribution was designed to track the release over a period of time are necessary, delivering sufficient amounts of agrochemicals, achieving maximum biological effectiveness and minimizing harmful effects [26]. Particulate matter was investigated as vehicles for agrochemical delivery. Nano particle have a larger surface area, fast attachment and rapid transfer of mass compared to micro particles (b 1000 nm), the powerful charging (b 1000 nm) provide an advantage. The controlled release of active ingredient bonding of nano materials, products of components and the conditions of the climate. When taking into account genetic materials, the delivery systems face a multitude of obstacles, i.e., host duration limitation, nuclei transfer and transportation of materials across the cell membrane. However, through Assisted Transmission, the genetical materials are being examined to develop a higher resistance to insects. For example, as bullets in the 'gene gun' system, DNA-coated gold NPs are used to achieve the transferring of genes by bombarding the plant cells and tissues [27].

8.1. Pesticide/biopesticide delivery
Nanotechnology can deliver pesticides which have both a biological and chemical nature which can make use of prepared agrochemical formulations effectively. Due to the increased effectiveness and availability of the larger surface area and the solubility, the larger volume of the smaller particles, lower toxicity and higher mobility, nano particle pesticide delivery plays a major role in improving the overall quality and efficacy of the process. However, nano particles face challenges due to the distribution of pesticides and bio pesticides and brings into question the cost effectiveness. Traditionally, the total surface of the crops is sprayed with pesticides for easy and quick applications and are generally easy to spray and are more cost effective. Since, Nano-pesticide delivery requires careful preparation and their higher cost to volume ratio brings additional challenges. These managed nanoparticulate
distribution very systems would involve a concentrated delivery approach based on life-cycle information and pathogen or pest behaviour [27, 28].

8.2. Delivery of fertilizers
Nanomaterials have potential contributions in slow fertilizer release. Coatings of nanomaterials on fertilizer particles keep the substance tighter than typical surfaces because of higher surface pressures from the plants. Nano coating’s also provide surface coverage for larger particles [28]. The use of large amounts of fertilizer in a localized area can be harmful due to the formation of nitrate or phosphate compounds, urea and ammonia salts, however a large volume of fertilizers are not necessarily delivered effectively due to leaching or run off due to rain and other factors [29]. Nano-coated fertilizers with a coating of sulphur about 100nm in thickness are more useful for soils containing higher amounts of sulphur have a reduced fertilizer dissolution allowing a more stable release of the fertilizer. Besides Nanocoating’s of sulphur Yet encapsulation and release of urea and phosphate should help meet the demands of soil and plants. Other potential applications of nanomaterials include biocompatible NPs for kaolin and polymers used for controlled applications release of NPK fertilizer sources such as urea calcium phosphate and potassium chloride [10, 29].

8.3. Nano-pesticides and fertilizers in the field
The manner in which pesticides and fertilizers are applied influences their efficacy and impact on the environment [30-32]. Current pesticide spraying requires larger supply droplets in the range of 9-66 ìm. Controlled application of smaller droplets (3-28 ìm) reduce splashes or ultra-light volume spray drift. The droplet size limit can be solved by the use of NP encapsulated or nano-sized pesticides resulting in a more effective spray and disposal of splash and spray drift. Other problems that arise in the field include is the settling of the formulation of chemicals in the spray tank and its components. Nano-sized fertilizers (~100 nm, BannerM AXX, Syngent) stopped spray tank alters from clogging, assmaller particles do not need mixing [33]. Due to the smaller particles, they are not easily removed by water even after a year of use and require little to no agitation unlike larger particles. Proper method of application of optimum fertilizer quantities maximize the absorption of nutrients and reduce pollution. Choosing the method of application of fertilizer depends mainly on soil, plant, type of irrigation and the nutrient used. Current practices involving due to breakdown of soil moisture and leaching, banding, side dressing and dusting face run-off problems. Fertilizers in large quantities close to the soil and the seeds resulted in a higher reduction in moisture primarily caused by grain damage. Various application methods of nitrogen fertilizers on algae and the resulting oxidation was monitored on wetland rice soil. In one particular case, the nitrogen oxidation was limited in the broadcast system whereas other applications such as green algae and urea application were preferred. In another method, the placing of 1-2 g of urea granules did not suppress or limit the growth of blue green algae, as the nano particle coated fertilized released the fertilizer more slowly and consistently therefore preventing both environment damage and run off/dissolution [33].

9. Conventional fertilizers v/s Nano-fertilizers
Generally, traditional fertilizers are spread by spraying or transmitting on the crops however the bottom-line is the amount of fertilizer that is actually absorbed by the plant which will help determine which method of application is best suited. This will take into considerations other factors such as soil moisture, leaching, run off, precipitation, microbial and photolytic degradation. It can be estimated that about 40-70 % of applied nitrogen, 80-90 % of applied phosphorus and 50-90% applied potassium is lost to the environment and are therefore not entering the plants or the crop causing economic loss as well [34, 35]. Due to the wide, large
and relatively uncontrolled applications of pesticide and fertilizers, degradation of naturally occurring flora and fauna has taken place [36]. As explained before, nano-fertilizers make use of nano particles that is able to supply crops and plants with nutrition, pesticides and fertilizers more effectively. For example, nano material encapsulation coated particles provide additional protection and the all the other benefits [37].

10. Nanotechnology in crop nutrition

During the Green Revolution era, fertilizers had a major impact on the crop production levels around in the world, especially grain production in India after the availability of higher yields of fertilizer responsive crops. Many crop yields have started to stagnate due to excess and uncontrolled use of fertilizers leading to a sharp decrease in the naturally occurring soil nutrient density. The excess use of nitrogen rich fertilizers has an effect on groundwater and in aquatic ecosystems Is also responsible for eutrophication. A disturbing fact is that in terms of nitrogen, the efficiency of fertilizer use is 20-25 % and 10-25% in terms of phosphorus. Alternatives to conventional fertilizers include nano-fertilizers, therefore it is possible to eliminate nutrient build-up in soils and thus eutrophication and contamination of drinking water. In fact, nanotechnology has created new opportunities for improving the efficiency of nutrient use and minimizing environmental protection costs. Recent findings have helped to reveal that plant roots and microorganisms may lift nutrient ions directly out of the solid mineral phase. Slow release of nano-fertilizers and nanocomposites is an optimal alternative to soluble fertilizers. Nutrients are released at a slower rate during crop growth; plants can take up most of them the nutrients are not wasted. Zeolites are a naturally occurring mineral which allow the slow release of nutrients into the ecosystem through their uniquely layered honeycomb structure. It can fill the network of nitrogen and potassium interconnected tunnels and cages in conjunction with other gradually dissolving tunnels. Materials include ammonia, calcium and total range of nutrients. Zeolite is a reserve that releases nutrients as required, therefore the particles of the fertilizer can be supplemented with Nano sized membranes that allow a controlled release of the desired nutrients. Nano-fertilizers were highly innovative but scarcely reported in literature. Nano-fertilizer technology in the literature is very innovative but scarcely reported. Some of the reports and patents, however, strongly suggest that there is ample scope for Nano-fertilizer formulation [38-40]. Significant yield increases are observed as a result of foliar application of Nano particles Nano phosphorus yielded 80 kg ha-1 P of cluster bean and pearl millet equivalent yield under arid conditions as a fertilizer 640 mg ha-1 foliar application (40 ppm concentrate). Nano composites are currently in development to deliver the ideal or desired amount of essential nutrients [40].

11. Nano structured formulation reduce nutrients loss into soil by leaching and/or leaking

Several patents have been reviewed and confirmed that China is registered with the highest number of patents worldwide. The products patented include the Nano encapsulated products In conjunction with other slowly dissolving materials, including phosphorus. The linked tunnel and cage network which can be filled with calcium, potassium, and nitrogen amongst other traceable nutrients. As presented before, since zeolites allow gradual and controlled release of the desired Rahale nutrients [41]. The very small scale of the delivery structure and network, allows very highly efficient agronomic applications as they are able to sustain a more desirable outcome when taking into account the degradation of the environment [42]. In China, since the beginning of this century, the development of Nano based slow or controlled release fertilizers has been actively implemented and supported by the National High-Tech R&D Program. Particularly on film-coating urea and granular compound fertilizers, significant progress has been made. There were some nano-based agrochemicals
commercialized. Nanosized or nano structured processing has significantly improved the solubility and dispersion of insoluble mineral micronutrients; phosphate fertilizers Kalpana Shastry et al. (2011) [23].

12. Use of nanotechnology in seed science

Seeds are a naturally self-sustaining mass that can adapt to the environment given enough time. Use of nanotechnology to unlock the full potential of the seed. In particular in wind-pollinated crops, seed production is a tedious process. The identification of pollen that causes pollution is a sure way of ensuring genetic purity the movement of pollen is determined by the air of the plant. Temperature, moisture, velocity, and production of pollen. The use of pollen-specific bio nano sensors can help to prevent possible contamination and thus mitigate contamination the same approach can also be used to avoid the contamination of field crops from Genetically modified crops. New genes are integrated in/ seeds and the company was closed. Tracking sold seeds could be achieved using Encodable, reliable, low-micron taggers which are readable by computers. Disease spreads through seeds and diseases destroy seeds several times stored. Seed nano-coating with basic forms of Zn, Mn, Pa, Pt, Au, Ag Not only will seeds be covered, but they It's going to be used in much less quantities than Su and Li do today (2004). Developed a technique called quantum dots (QDs) in combination with immunomagnetic separation for E coli 0157:H7. Helps distinguish unviable seeds and the seeds are infected. Technologies such as encapsulation and controlled methods of releasing pesticides have revolutionized use Seeds can also be impregnated with specific bacterial strain nanoencapsulations called smart seeds. Therefore, it will the seed level, ensure the correct standing of the field and boost crop quality A smart seed can be engineered to germinate if there is enough moisture that can be distributed over a mountain range of reforestation [2] and nano-membrane seeds that are sensitive The availability of water and the ability to absorb seeds only when the Time to germinate, aerial transmission of seeds embedded with magnetic particles, identification of moisture content during processing of suitable damage reduction measures and the use of bioanalytic Nano sensors to determine seed ageing are some future research areas. To improve germination, a team of researchers are developing a metal-oxide and carbon nanotube by improving moisture to permeate easily [43]. The carbon nanotubes otherwise known as CNTs, allow water to permeate more usually through the pores on the surface. This creates a channel or passage for the water to flow to the seeds.

13. Nano pesticide

Reducing the population of insects to lower economic levels and sustain that level of control over a considerable period of time can be achieved by having pesticides that are more persistent. Surface treatment using active ingredients is still a viable and cost effect option and added to this is the flexibility of various methods of pest control. Nano-encapsulation is a technique which can be taken advantage of to limit environment damage as well as protect the valuable active ingredients to enhance its life. Nano encapsulation consists of nano-sized particles that are enclosed Nano encapsulation of insecticides, fungicides or nematicides by A shell or thin-walled container (protective covering) can help to create a solution that provides active pest control while avoiding residue accumulation in soil. The controlled and sustained release of the active ingredient can enhance its durability and enhance its resistance to degradation due to various stresses. Can be used to enhance the potency of the formulation, which can significantly reduce the production of pesticides and related environmental hazards. Nano-pesticides should minimize the application level because the active quantity of the drug is at least 10-15 times lower than that used in traditional formulations Hence the
need for much better and prolonged management could be much smaller than the normal amount [44]. Pesticides which contain nanoparticles can be modified to respond to external stimuli such as moisture, light and temperature changes. Whether these pesticides will be available on the market in the short term is uncertain. Clay nano tubes (halloysite) were developed for extended release and better communication as a low-cost carrier of pesticides with plants. Pesticide concentrations are decreased by 70-80 percent, thereby lowering pesticide prices with minimal impact on water flows.

14. Food packaging
As food and safety standards are being raised worldwide along with customers demanding food that has longer shelf life, the field of food science is now more important than ever. This can include the food packaging itself which plays an important role to make sure food is protected from external elements. A ‘hybrid system’ which has been developed by Bayer, is an airtight packaging that keeps the nutrients locked. For example, certain Nano particles which have anti-microbial properties such as titanium dioxide, zinc oxide and magnesium oxide has been researched by food scientists at Leeds University. These Nano particles are very effective in eradicating microorganisms and because of the airtight packaging, the oxygen is not allowed to react with the outside environment thus improving shelf life. It can also be noted that by incorporating nano particles of clay can be used to provide a barrier by inserting them into an alcohol copolymer and poly biopolymer shell. These ultimately improve the protection to the gas as well as having higher mechanical strength and thermal stability. The nano clay-nylon coating and silicon barriers are usually present in glass bottles [41, 56-61].

15. Conclusion
Not only the topsoil, groundwater and meat has been polluted by the intensive use of agrochemicals in the new agricultural sector to boost agricultural production. It is necessary to increase agricultural productivity, but bear in mind the biodiversity damage It must be taken into consideration. Nanotechnology is growing in importance in the field of agriculture as it can be used to develop pesticides, fertilizers and genetic material. There are already promising results and applications The use of nano materials It is expected that the dosage of pesticides and fertilizers will be reduced and controlled slow delivery will be ensured. Nano particles can used to reduce environmental damage and hazard as they are able to safely control bio control systems and preparations. A major obstacle to removing harmful ûeld That was costly for conventional methods. Nano sensors have an incredible capacity to detect very small amounts of pathogens, on a scale of parts per billion and can be used to aid to reduce persistent chemicals which cause food and crop degradation. nanotechnology also has solutions. Agricultural engineering should use the strong nanotechnology methods to remove pollutants from the soil in the good of humanity Nanotechnology techniques can be used to tackle the urgent ecological and the problems of pollution. Nanotechnology would aim to provide and streamline current technologies for environmental detection, sensing and remediation.

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