Nanobiotechnology: Application and Fate

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Abstract:

Nanosciences emerges as new dimensions in each and every field of basic and applied sciences. Nanotechnology has the prospective to significantly involve environmental protection through understanding and control of emissions from various sources, development of new tools and technologies that reduce the production of adverse byproducts, and remediation of existing waste sites and polluted water reservoirs. Nanobiotechnologyis biotechnology at the nanoscale. It includes tools and processes of nanotechnology to study and manipulate biological systems. This involves main thrusts of research like nano scales, tools and techniques for Nanoparticles, nanomaterials, and applied nanobiotechnology. In nanobiotechnology, many discoveries has been invented so far and more will be needed for better future. Applications of nanoparticles in the field of medical drug delivery are showing enormous potential for benefit of mankind. Meanwhile lack of information on the fate of nanoparticles (NP) prevents an accurate assessment of their environmental risks. The various types of NP with regard to their fate in aquatic systems and their effects on aquatic organisms and regarding toxicological effects of engineered nanomaterials on humans and the environment is reviewed.

Keywords:
Nanobiotechnology, nanoparticles, drug delivery.

Introduction:

Nano is a prefix that means "one-billionth." The nanometer is one-billionth of a meter - much too small to see with the naked eye or even with a conventional light microscope. Nanotechnologyinvolves creating and manipulating materials at the nano scale. This is a relatively new area for researchers, with rapidly growing commercial applications. The term 'nanotechnology' can be traced back to 1974. It was first used by Norio Taniguchi in a paper entitled "On the Basic Concept of 'Nano-Technology' (Taniguchi N., 1974)" In this paper, Taniguchi described nanotechnology as the technology that engineers materials at the nanometer level. The origins of nanotechnology are traced back to a speech given by Richard Feynman at the California Institute of Technology in December 1959 called "There's Plenty of Room at the Bottom" (Feynman, 1992). In this talk, Feynman spoke about the principles of miniaturization and atomic-level precision and how these concepts do not violate any known law of physics (Fritz, 2010). Nanotechnology, the engineering and art of manipulating matter at the nanoscale (1–100 nm), offers the potential of novel nanomaterials for treatment of surface water, groundwater, and wastewater contaminated by toxic metal ions, organic and inorganic solutes, and microorganisms. Due to their unique activity toward recalcitrant contaminants and application flexibility, many nanomaterials are under active research and development. Accordingly, literature about current research on different nanomaterials (nanostructured catalytic membranes, nanosorbents, nanocatalysts, and bioactive nanoparticles) and their application in water treatment, purification and disinfection are reviewed in many articles.

Nanobiotechnology

Nanobiotechnology is biotechnology at the nano scale, and it has exciting applications in drug delivery systems, diagnostic medical tests and regenerative medicine (Filipponi, 2010).The application of nanoscience to "practical" devices is called nanotechnologies. Nanotechnologies are based on the manipulation, control and integration of atoms and molecules to form materials, structures, components, devices and systems at the nanoscale. Nanotechnologies are the application of nanoscience especially to industrial and commercial objectives. All industrial sectors rely on materials and devices made of atoms and molecules, thus in all materials can be enhanced with nanomaterials and all industries can benefit from nanotechnologies (Fig.2).

Widespread dissemination of nanotechnology in water treatment will require overcoming the relatively high costs of manufactured nanomaterials (e.g., by enabling their reuse and avoiding diminishing returns of ultra-high material purity) and mitigating unintended risks to the public and environmental health (e.g., by immobilizing nanoparticles to minimize unintended release). (ALVAREZ, 2012) Nanotechnology can enable sustainable solutions for clean water by both enhancing the performance of existing treatment processes and developing new practices (Fig.3).

For microbial control, the overarching goal is to develop antimicrobial systems that sense and selectively target waterborne pathogens for safer water disinfection, diagnosis of pathogenic disease, and improvement of bio-corrosion in a manner that is eco-responsible, broadly accessible, and practical. Nanoscientists use scanning probe microscopes to explore the surface of Nanoparticles. The scanning probe microscope (SPM) scans the surface of the particle in a given pattern. One specific type of SFM is an Atomic Force Microscope, which uses forces such as electrostatic, magnetic, chemical bonds and others. Materials composed of the same atoms and molecules may have different properties depending on their arrangement at the nanoscale (Fig.4) (Nanobiotechnology Reference: Unit IV-3.5).

Degradation of Nanoparticles:

One of the side effects of wide utilization of nanotechnology is the release of nanomaterials to the environment. Since industrial centers used nanotechnology, it becomes responsible for the production of waste containing residue NPs. Therefore, the usage of NPs by industry increased intensively

(Bystrzejewska-Piotrowska, 2009). Nanoparticles are induced into the soil as a result of human activities including application of fertilizers or pesticides in agriculture, soil and water remediation technology or water and sewage sludge applied to the landfill, as well as NPs may be released in the form of aerosols to the atmosphere, soil and surface water (Bystrzejewska-Piotrowska,2009). The fate of NPs released to environment is depending upon the chemical and physical properties of the NPs. NPs are small enough to fit into smaller spaces between soil particles or can be strongly bound with soil organic matter. The sorption strength and transportation rate of NPs to soil will be dependent on its size, charge, chemistry, and application conditions (Brar, 2010).

Fate of Nano-biotechnology are involved bio-accumulation and bio-magnification of various types of nanoparticles release in the environment. Bioaccumulationis the buildup of a chemical in the tissue of organisms because they take it in faster than they can get rid of it. Bio-magnificationis the process in which the concentration of a contaminant increases as it passes up the food chain. Nanotechnology has the potential to remove the finest contaminants from water supplies and air as well as continuously measure and mitigate pollutants in the environment. However, nanotechnology may pose risks to the environment and human health, and these risks should be examined as the technology progresses.

One of the destinations of NPs in soil is bounding with soil organic matter and immobilization by soil microorganisms. According to many reports there is a positive correlation between organic C content and NPs sorption potential (Ahmad,2001; Chefetz, et al., 2000). This could be due to the strong binding of C60 to soil organic matter (Tong, 2007). Due to adsorption by soil organic matter the mobility of NPs in the soil matrix is decreased and hence their influence on the microbial activities is drastically reduced. Hence, soil organic matter significantly influenced the fate of NPs in the environment. Generally microorganisms present in soil interact with NPs through passive and active mechanisms resulting from changing microbial activities (Brar, 2010). Therefore, we need to better understanding the potential hazards of NPs in natural environments (Agrawal, 2014) .Therefore, concerns have been raised about potential adverse effects of nanoparticles on biological systems and the environment such as toxicity generated by free radicals leading to lipid peroxidation and DNA damage. Under this scenario, there is a need to predict the environmental effect of these nanoparticles in the near future. Nano sensors with immobilized bio receptor probes that are selective for target analyte molecules are called nano biosensors. Their applications include detection of analytes like urea, glucose, pesticides etc., monitoring of metabolites and detection of various microorganisms/pathogens (Rai et al. 2012). Nanosensors offer the advantage of being are small, portable, sensitive with real-time monitoring, precise, quantitative, reliable, accurate, reproducible and robust and stable which can overcome the deficits of present sensors (Agrawal, 2014)

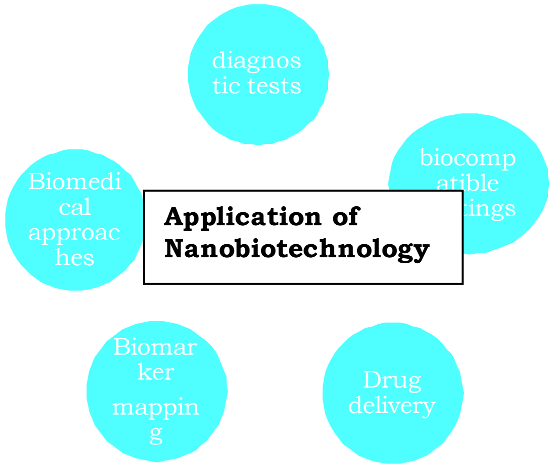

Figure 1: Figure showing application of nanobiotechnology

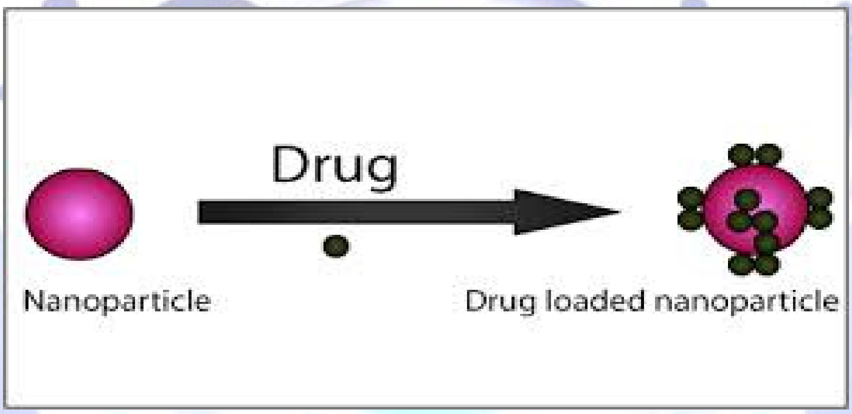

Figure 2: Figure showing diagrammatic representation of drug loaded nanoparticles (NPs)

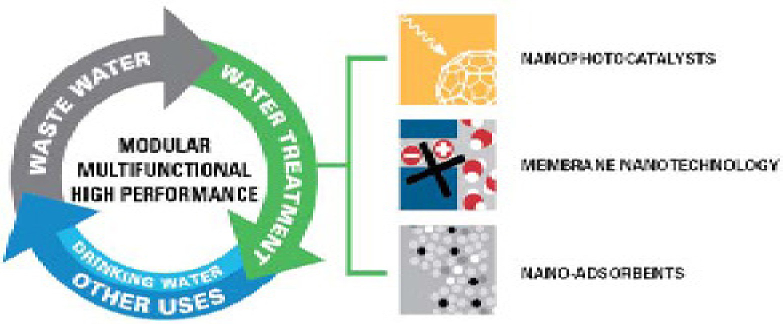

Figure 3: Nanotechnology-enabled integrated urban water management (Qu et al., 2012).

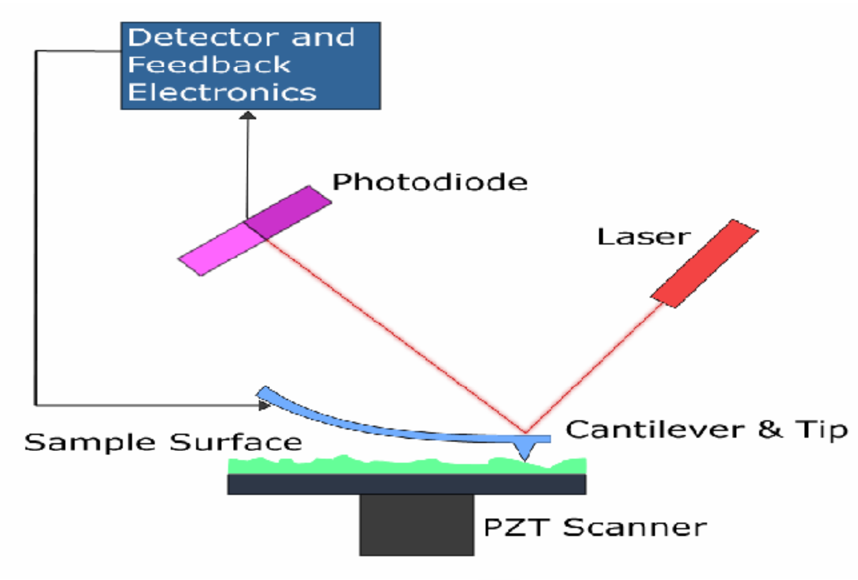

Figure 4: Atomic Force Microscope (Image Credit: Sciencenter)

Conclusion:

Apart from the potential benefits of nanotechnology in agricultural sector it also involves some risks. It cannot be claimed with certainty either those nanotechnologies are fully safe for health or that they are harmful. Risks associated with chronic exposure of farmers to nanomaterials, unknown life cycles, interactions with the biotic or abiotic environment and their possible amplified bioaccumulation effects have not been accounted for and these should be seriously considered before these applications move from laboratories to the field. The common challenges related to commercializing nanotechnology, are: high processing costs, problems in the scalability of R & D for prototype and industrial production and concerns about public perception of environment, health and safety issues. The Governments across the world should form common and strict norms and monitoring, before commercialization and bulk use of these nanomaterials (Agrawal, 2014).

Nevertheless nanoscience involves too many applications in field biological sciences but the concern should be taken that this technology do not disturbed the environment with more focus on biodegradable nanoparticles.

References:

Agrawal shewta and Pragya Rathore (2014); Nanotechnology Pros and Cons to Agriculture: A Review, Int. J. Curr. Microbiol. App. Sci ISSN: 2319-7706 Volume 3 Number 3 pp. 43-55)

Ahmad, R., R. S. Kookana, A. M. Alston, and J. O. Skjemstad. (2001). The nature of soil organic matter affects sorption of pesticides. 1. Relationships with carbon chemistry as determined by 13C CPMAS NMR spectroscopy. Environmental Science and Technology 35:878-884.,

Allhoff Fritz, Patrick Lin,and Daniel Moore (2010) What Is Nanotechnology and Why Does It Matter? From Science to Ethics;Book Blackwell Publishing).

Alvarez Pedro J. J., George R. Brown (2012) Professor and Chair of Civil and Environmental Engineering Rice University • Houston, Texas.The 2012 Clarke Prize Lecture* Convergence of Nanotechnology and Microbiology: Emerging Opportunities for Water Disinfection, Microbial Control, and Integrated Urban Water Management)

Alvarez, P. J. et al. (2009). "Research priorities to advance eco-responsible nanotechnology."*ACS Nano*, 3(7): 1616-9.

Bazgir Masoud and Javad Mirzaei, (2012) Nanotechnology in Soil Microbiology; Dept. of Water Resources, Faculty of Agriculture, Ilam University, Ilam.m.bazgir@mail.ilam.ac.ir

Brar, S. K., M. Verma, R. D. Tyagi, and R. Y. Surampalli. (2010). Engineered nanoparticles in wastewater and wastewater sludge – Evidence and impacts. Waste Management 30:504-520

Bystrzejewska - Piotrowska, G., J. Golimowski, and P. L. Urban. (2009). Nanoparticles: Their potential toxicity, waste and environmental management. Waste Management 29 : 2587-2595.

Chefetz, B., A. P. Deshmukh, P. G. Hatcher, and E. A. Guthrie. (2000). Pyrene sorption by natural organic matter. Environmental Science and Technology 34:2925-2930.).

Gil C., Mark Geppert, Carl Isaacson, Alexandra Kroll, Xiaomei Li, Ursula Lindauer, Niksa Odzak, SmithaPillai, Lena Röhder, Ahmed Tlili, Bettina Wagner and Yang Yue. ; Ecotoxicology of engineered nanoparticles http://www.nanomile.eu-vri.eu www.NWRI-USA.org http:// informahealthcare.com/doi/abs/10.1080/10408410701710442%20

Norio Taniguchi (1974), "On the Basic Concept of Nanotechnology," Proceedings of the International Conference of Production Engineering, London, Part II. British Society of Precision Engineering, Nanobiotechnology Reference: Unit IV-3.5).

Qu, X., et al., (2012). "Nanotechnology for a Safe and Sustainable WaterSupply: Enabling Integrated Water Treatment and Reuse." *Acc Chem Res.* Filipponi Luisa and Duncan Sutherland, Interdisciplinary Nanoscience Center (iNANO) Aarhus University, Denmark , September 2010

Rai V., Acharya S. and Dey N. (2012) Implications of Nanobiosensors in Agriculture. J. Biomaterilas Nanobiotechnology 3: 315 324.

Richard P. Feynman (1992), "There's Plenty of Room at the Bottom," Journal of Microelectromechanical Systems 1: 60–6

Tong, Z. H., M. Bischoff, L. Nies, B. Applegate, and R. F. Turco. (2007). Impact of fullerene (C60) on a soil microbial community. Environ. Sci. Technol. 41.