Journal of Advances and Scholarly Researches in Allied Education
Vol. 16, Issue No. 5, April-2019, ISSN 2230-7540

Toxicity and Environmental Risks of Nano materials: Challenges and Future Needs

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Abstract – Nanotechnology has developed a great deal of interest in several fields including agriculture, manufacturing, medicine sector and public health, due to the demands and applications of nano materials. Increasing use of nano materials has resulted in concerns about environmental impacts in every field of society. Environmental exposure to nano materials is unavoidable as nano materials become part of our everyday lives, and as a result, research into nano toxicity is gaining interest. This study provided an overview of recent research efforts on existence, actions and toxicity of various groups of environmental nano materials.

Keywords: Nano Materials, Environmental Impact, Toxicity, Metal Oxides.

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INTRODUCTION

Nano materials (NMs) show unique properties due to their small size and composition which have diverse applications in many fields such as biomedicine, electronics, agriculture, cosmetics, environmental and engineering industries. The spectrum of nanotechnology applications since the last decade is massive and growing. While nanotechnology is developing as a multidisciplinary science for the introduction of new products through engineered NMs and many benefits are required from on-going nanotechnology research, serious concerns are being raised about the potential environmental, ecosystem and human health hazards that nanoparticles (NPs) may raise. [1]

Nanotechnology helps us to build usable materials, devices and systems by manipulating matters at the molecular and atomic scales [2]. Significantly smaller scale, lower weight, more manageable power requirements, higher sensitivity and improved specificity are just a few of the changes that we're seeing in sensor design. Nano science and nano technology are among the fastest-growing fields of research and technology. In our everyday lives engineered nano materials are used in the form of food packaging, drug delivery systems, cosmetics, therapies, biosensors and others [3].

CHALLENGES IN NANO TOXICOLOGY RESEARCH

- Because of the new study on nanoparticles toxicity, several researchers discussed the functional issues and problems that need to be taken into consideration in nanoparticles toxicity studies. Physiochemical properties like size, shape, charge, composition, aggregation and etc. are essential to be characterized in detail at all the stages of nano toxicity testing, since these factors are playing major roles in interaction with biological system. [4]
- It is also very difficult to establish an exact dose concentration due to various factors such as surface area, structure, mass, dimension and aggregation.
- Inhalation, oral, dermal and injection routes are some of the appropriate exposure routes which must be selected to human exposures.
- Cellular absorption, trafficking and exclusion play a crucial role in nano toxicity. Therefore, consideration should be given to the size , shape , surface chemistry and charge with in cells and also to the interaction of nanoparticles with the target cells.[5]
- With biological particles, interactions of nanoparticles such as protein, carbohydrate and DNA can change the biological distribution, physiochemical properties, immune response, and metabolism of nanoparticles that interfere

with absorption, wrapping, and entanglement.

- Due to the smaller particle size and less aggregation, quantitative measurements of nanoparticles in the target organ and tissues are difficult.[6]

NANO TOXICITY MECHANISMS

Nanoparticles' peculiar properties are the explanation with their many beneficial results, and the same for their toxic effects. In recent years of scientific research into the biological and toxic effects of nanoparticles, few mechanisms have been described; [7-11]

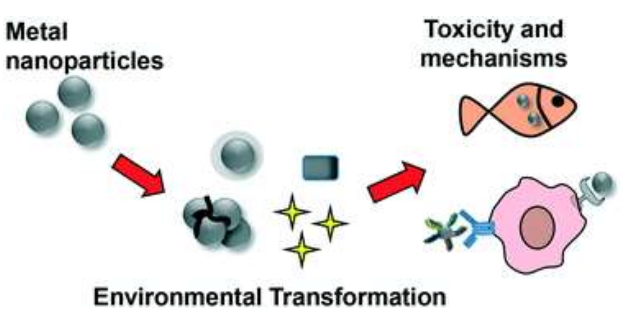
- Formation of free radicals in response to phagocytic cells as well as in the transition metals' presence; the free radical induction of oxidative stress resulted in diseases namely hypertension, diabetes and heart disease.

- Oxidative stress also oxidizes the DNA, lipids and protein, resulting in cell function and toxicity deteriorating. Owing to imbalances between protective antioxidants and damaging oxidants, oxidative stress was induced.

- Oxidative stress can regulate inflammatory factors such as NF-kB, protein-1 activator and kinases, resulting in inflammatory reactions.

- Nanoparticles can interfere with the cell and disrupt the cell wall, enter the nucleus and can cause DNA damage, interrupt the cell cycle and apoptosis.

- Induce hepatotoxicity and immune toxicity by-products produced during nanoparticles; Nanoparticle interactions with blood components induce haemolysis and thrombosis.



The tremendous advancement of nanotechnology, coupled with intensive nano-based consumer products, has resulted in the omnipresence of Engineered Nano materials (ENMs) in the biosphere [12]. While exposure to ENMs through inhalation has been reported to cause adverse health effects, [13, 14] airborne nanoparticles are still not seen as an significant public health issue. However, their rapid growth and human accessibility call for urgent exploration of the activities of airborne nanoparticles in the atmosphere and their biological effects as a result. Atmospheric nanoparticles are derived primarily from anthropogenic activities, including the production, processing, transportation and disposal of particles and their commercial applications [15]. Aerosolized nanoparticles appear to agglomerate / accumulate after release into the air environment [16, 17] or undergo redox reaction, primarily based on the properties of nanoparticles of pristine metal (MNPs). For example, airborne nanoalumina (nAl_2O_3) with primary particle size distributions from 27 to 56 nm, after drying overnight, may form agglomerates with a nominal size of 200 Nm. [18]

BEHAVIOUR OF NANO MATERIALS IN THE ENVIRONMENT

Ecological research on the behaviour of ENPs can depend on multiple geoscience studies that examined the behaviour of the environmentally induced nanoparticles. However, in some ways the ENPs vary from those that naturally occur. While the natural nanoparticles are randomly shaped and dispersed diffusely in the atmosphere, the suspensions or powders created by industry contain pure nano materials of very uniform shape, size and structure. These nano-materials have unique properties such as the high tensile strength of CNTs or nano-TiO_2 photo-catalytic action, which makes them valuable for new products and applications. The following account summarizes briefly our present state of awareness on the nature and actions of ENPs based on the study in the environmental compartments air , water , soil, and sediment.

Water: The basic rule is that water-distributed nanoparticles behave more like colloids, which are well represented in the chemical literature. Colloids are droplets or particles that are finely dispersed in a medium; they are highly unstable since they bind easily to each other due to attractive electrostatic forces, and then fall caused by gravity. Natural bodies of water usually contain materials dissolved or dispersed like natural nano materials. Synthetic nano materials which join a natural body of water attach themselves to certain natural materials as predicted. However, the fate and behaviour of nano materials in the water is also determined by parameters such as pH, salinity (ionic strength), and organic material presence.

Air: As nanoparticles reach the atmosphere, they shift from high-concentration areas to lower-concentration (diffusion) regions. Air currents are fast to disperse the particles; these may move wide distances from their original source. Nanoparticles however tend to accumulate into larger structures (agglomeration). It is very difficult to detect nanoparticles in the air, since simple size distribution measurements can hardly differentiate such agglomerates from natural particulates. The velocity of deposition of particles in the atmosphere on the ground, in the water or on plants (deposition) depends on the diameter of the particles. Because of their smaller diameters, nanoparticles from the air are released much slower than bigger particles.

Soil and sediment: The data in this environmental compartment are sadly inadequate to draw definite conclusions. For this sector considerably less studies are available than for air or water. However, there is extensive literature on the mobility of natural colloids in surface and groundwater, which helps draw any conclusions about the behaviour of nano materials. Accordingly, nano materials are known to bind to solids in the soil and in sediments.

CONCLUSION

In the present research, we highlighted the significance of MNP's transformation-related toxicological effects with the objective of better evaluating MNP's EHS in the natural environment. The current report discussed the fate, behaviour, and toxicity of various classes of environmental nano materials. Although toxic effects of nano materials have been found by several research groups, the causes for toxicity are often unknown. There are still wide gaps in information about the existence of nanoparticles communicating with the environment system. Advanced studies are required to fully characterize the opportunities for human exposure to the nanostructured materials of commercially available products, as well as future products. While several studies have studied the processes of transformation of MNPs in environments and their effect on toxicity, numerous gaps in knowledge and challenges persisted when evaluating MNPs' EHS on environmental exposure. Toxicity analysis on nanoparticles using different cell lines and incubation times is progressively being published, but due to the large range of concentrations of nanoparticles, the variety of cell lines and the conditions of cultivation, and lack of understanding of the mechanism, it is very difficult to determine whether the toxicity observed is physiologically relevant.

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