Is Nanotechnology-related Pollution a Threat to Environment?

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Have you ever thought about drinking water we consume, whether it is safe from all emerging contaminants (i.e., new and unknown types of contaminants, such as pharmaceutical compounds, nanoparticles (NPs), personal care products) or not? If not, then it's time to think about it, as we only think about removal of bacteria, viruses, organics, ions from water, whereas more subtle constituents, such as hazardous NPs(one dimension <100nm) might also be present in our water. Sources of these particles are multiple, for instance, discharge from chemicals industries, nanopesticides from fertilizer industries, medicine from pharmaceutical industries and others. These substances have been shown to damage cells of human body and pose risks to environment.

The aim of this brief essay is to highlight information about NPs, its sources, and possibility of removal in treatment plant so that proper action can be taken to reduce chances of exposures to humans.

We all know the benefits of nanotechnology and how it has made our life easy. However, we might have never thought about the emerging threat which it might pose to environment and human health. Nanoparticle has become a part of day- to- day life due to its increasing usage in the fields of medicine, electronics, and personal care products. Examples of NPs include fullerenes (C60), single and multi-walled carbon nanotubes, silver NPs, metal oxide NPs, i.e., zinc oxide, titanium dioxide, copper oxide. Because of a variety of applications, NPs can enter the environment through many pathways. The NPs are released during various stages of production, use and disposal from product and will ultimately find its way to air, water, soil and plant environment (Figure 1).

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* Ms. Tanushree Parsai, Ph.D. Scholar from Indian Institute of Technology, Delhi, is pursuing her research on "Fate of Nanoparticles in Different Environmental Matrices." Her popular science story entitled "Is Nanotechnology-Related Pollution a Threat to Environment?" has been selected for AWSAR Award.

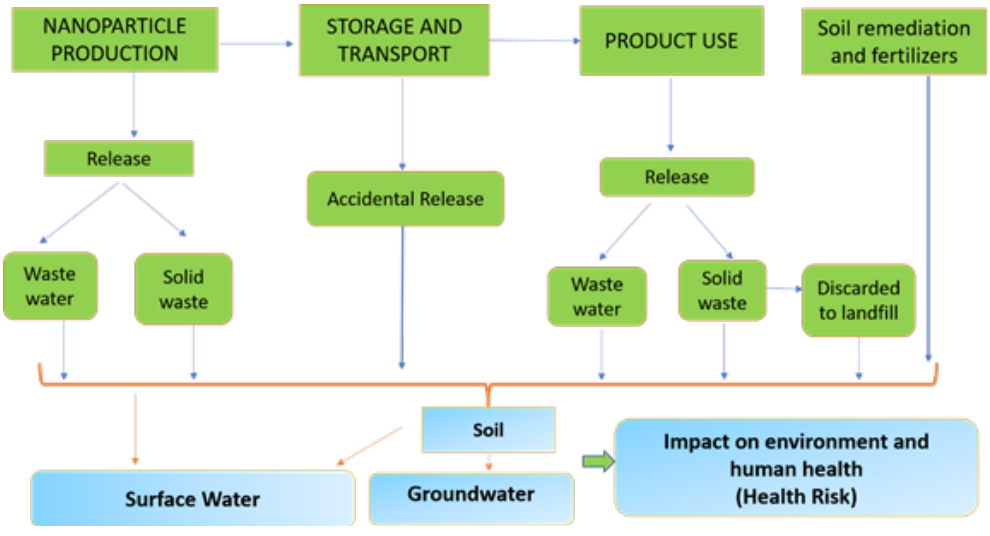

Fig 1. Sources of nanoparticles in different environmental media

River water, we use for drinking, may contain NPs which may reach the water treatment plant and to human population, if not removed from water. Similarly, NPs released from various products may reach the wastewater treatment plant and if not removed may end up in the aquatic system and affect aquatic life. If not given attention now, the problems posed by these small sized particles can aggravate in the future.

Toxicity of NPs depends on its shape, size and reactivity. It can directly affect human health or indirectly through contaminated environment. These products can enter human body through various routes of inhalation, oral or through skin. The effect depends on concentration of these NPs in varied products. Similarly, these small NPs can be ingested through water contaminated with NPs we drink, through ingestion of plants grown in soil contaminated with NPs. Researchers have reported harmful effects of NPs on animals and human as well. NPs entering into aquatic systems, such as lake, river, ocean, might pose harmful effects on aquatic ecology, thus disturbing ecosystem balance. NPs are extremely slow degradable contaminants and hence, have long persistence in any matrices, creating the worse situation.

There has been a lot of development to treat suspended solids present in water or wastewater in treatment plants. But, at present time, no one has thought much about the need for removing nanoparticles from water treatment plants. Here lies the question whether removal of NPs from water is worth exploring with regards to its reported harmful effects to aquatic species and human and impacts on environment. This area needs to be explored much more to answer question. Behaviour of these NPs is very different from that of micro- sized particles present in water. They undergo various chemical processes in suspension, like aggregation (i.e., formation of bigger flocs by combination of two NPs), dissolution (i.e., release of ions), and transformation (i.e., change of

shape and properties). Even, the filters available for removing suspended solids are not economical to remove these NPs from water for potable purposes. Hence, if we think of removing these particles on a large -scale, we might need to carry out research and understand processes taking place in a water suspension.

In India, very few scientists are working on understanding issues and challenges in removing NPs from water. In this regard, the researchers at IIT Delhi (Er.Tanushree Parsai, Research Scholar, Civil Engineering, Indian Institute of Technology (IIT) Delhi; Supervisor: Prof. Arun Kumar, Associate Professor) have been trying to understand what exactly happens to NPs in different water matrices. During doctoral research at IIT Delhi, the author, mentioned above, have been experimenting to understand settling and change in size of mixture of zinc oxide and copper oxide NPs. These NPs were chosen due to their usage in various industries of medicine, personal care products, etc. The study of mixture of more than one types of NPs is important as it represents a realistic condition of contamination of a water body. Earlier, there has been lot of studies for understanding what happens to single type of nanoparticle in water, but, there has been scarce information on behaviour and fate of mixture of NPs in a water body. The research is ongoing to determine whether these NPs have settling capacity to settle down easily or have properties to remain in suspension for a long period of time under environmentally-relevant conditions (such as river water matrix or lake water matrix). The initial findings of ongoing research indicate that the presence of more than one types of NPs have the ability to increase the removal of NPs by sedimentation than that in a single nanoparticle-type system (Figure 2). Hence, such study gives us an insight on how mixture of NPs might behave once they are discharged to river water or in a standing water body. It could also help in understanding what design improvement can be done to treat water containing multiple NPs in a sedimentation tank.

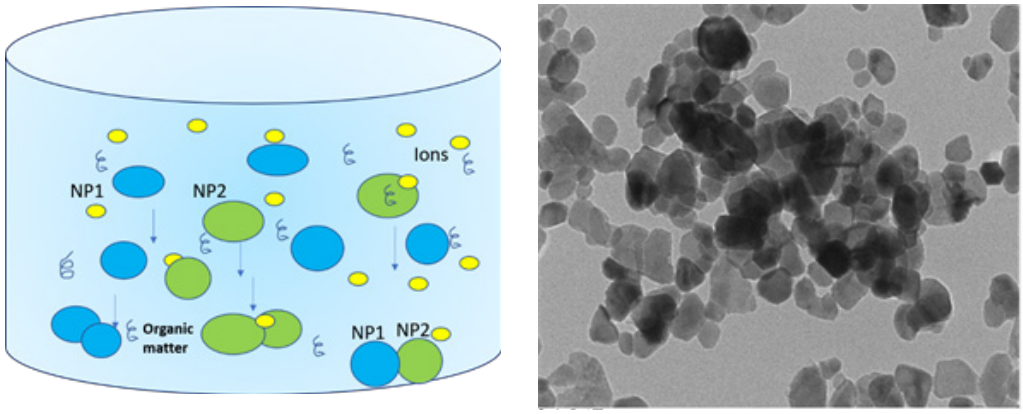

Fig 2. (A) *Suspension showing settling and aggregation of single and mixture of nanoparticles (B) Transmission electron microscopy image for mixture of zinc oxide and copper oxide nanoparticles*

Through my doctoral work, I am trying to obtain more information on NPs presence/ behaviour in water system and also in other environmental systems like soil, which might ultimately create groundwater pollution. There may be less knowledge available as of now on potential risk, what nanotechnology might pose on humans or environment; however, it requires research to ascertain different aspects with scientific evidence and to inform public, regulators and manufacturers. We are trying to provide solutions to treat wastewater containing NPs, which in the coming future, may lead to a threat in safety of both environment and its community.

Research team includes: Er. Tanushree Parsai, Research Scholar, Department of Civil Engineering, IIT Delhi, and Dr. Arun Kumar, Associate Professor, Department of Civil Engineering, IIT Delhi. The research team has published an article and submitted a paper related to this work.

Parsai T. and Kumar A. (2017). Nanotechnology-related waste management: Issues and Challenges ahead. *Water digest,* Vol. XI, Issue IV, p.54

ParsaiT.and Kumar A. 'Understanding effect of solution chemistry on Heteroaggregation of Zinc Oxide and Copper Oxide Nanoparticles using a 2^{4-1} factorial approach"- (Submitted)