INTERACTION OF NANOPARTICLES ON THE ENVIRONMENT AND POLLUTION FROM NANO MATERIALS

Mrs. Shabana K

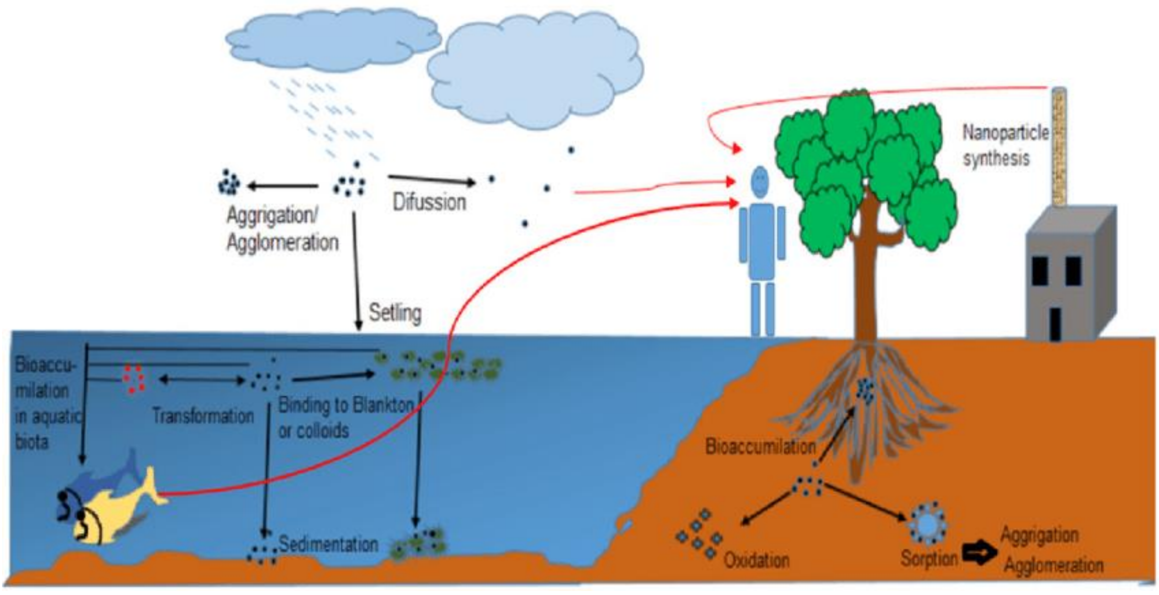
Assistant Professor (Ad hoc), PG Department of Chemistry, KAHM Unity Women's College, Manjeri, Kerala-676122, India

E-mail: shabshabana@gmail.com

INTRODUCTION

Nanoparticles have existed for millions of years on the Earth, and they have been used by humans for thousands of years. In recent years, due to the increased human capacity to make synthetic nanoparticles, much attention has been focused on this type of material. Today, nanoparticles are used in different areas, such as the electronics industry, medical applications, pharmaceuticals, cosmetics, and environmental processes. Due to the significant potential of this technology, investments in the applications of nanotechnology are a growing trend worldwide

The available information on the current uses and the production rate of nanoparticles is inadequate. According to estimates of the production rate of nanoparticles, about 2,000 tons were produced in 2004, and it is expected that the production rate will increase to 58,000 tons by 2020. Due to the exponential increase in the production and use of nanoparticles, environmental and human exposures also will increase.



The fate and behavior of nanoparticles in the environment. This behavior of nanoparticles in agroecosystems includes the positive and the negative effects as well as the release, transport and toxicity of engineered nanoparticles in the terrestrial environments.

EFFECTS OF NANOPARTICLES ON ORGANISMS

Absorption and toxicity

All nanoparticles, on exposure to tissues and fluids of the body, will immediately adsorb on to their surface some of the macromolecules that they encounter at their portal of entry. The

ISBN 978-93-5396-526-6

specific features of this adsorption process will depend on the surface characteristics of the particles, including surface chemistry and surface energy, and may be modulated by intentional modification or functionalization of the surfaces. This is well demonstrated through the use of specific bio molecular linkers that are anchored on the surface of nanoparticles or within vesicles and liposomes. In this way the affinity of a nanoparticle can be shaped to fit to a particular protein, and thus target a specific bio molecular assembly on a membrane, or within a specific organelle or cell surface. The specificity of such surface layers is used for analytical purposes, for optical labeling of biomolecules in molecular libraries and for drug or gene delivery to cells. Thus, both the existence of passive surface layers and surface active agents compromise the risk evaluation of nanoparticles by mere chemical composition. In agreement with bulk surface chemistry, metallic nanoparticles are of considerable chemical reactivity while ionic crystal nanoparticles have been observed to accumulate protein layers when exposed to the cytoplasm or in the lymphatic fluid. This protein layer is possibly involved in the interaction of the nanoparticle by the cellular system.

The Effects of Size, Shape, Surface and Bulk Composition

The interaction of nanoparticles with living systems is also affected by the characteristic dimensions. Nanoparticles, of a few nm in size, may reach well inside biomolecules, a situation not possible for larger particles. It has been reported that inhaled nanoparticles reach the blood and may reach other target sites such as the liver, heart or blood cells.Nanoparticles may translocate through membranes. There is little evidence for an intact cellular or sub-cellular protection mechanism. For humans, inhalation is the most frequent route of access, and therefore the process of aggregation of the nanoparticles in the inhaled air has to be taken into account.

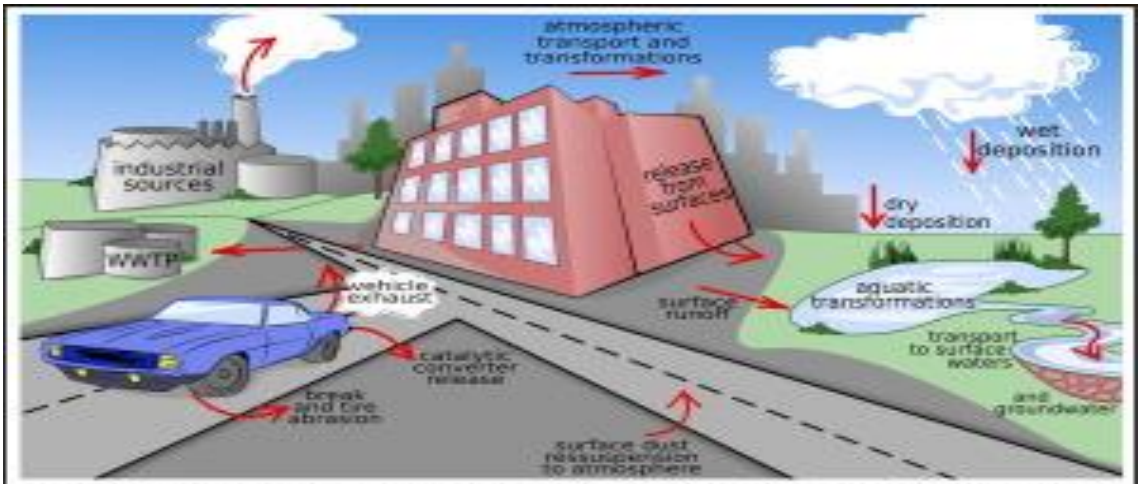
In order to understand and categorize the mechanisms for nanoparticle toxicity, information is needed on the response of living systems to the presence of nanoparticles of varying size, shape, surface and bulk chemical composition, as well as the temporal fate of the nanoparticles that are subject to translocation and degradation processes. The typical path within the organ and / or cell, which may be the result of either diffusion or active intracellular transportation, is also of relevance. Very little information on these aspects is presently available and this implies that there is an urgent need for toxic kinetic data for nanoparticles.

Solubility and Persistence

In view of the active functionalization and the possible interaction of nanoparticles with bio-molecular structures, it is important to consider the dose and dose rate of the particulate agent, its ability to spread within the body and ecosystem, the decay of number concentration and the erosion of individual particles. Many nanoparticles will have considerable solubility. For these materials the interaction with living systems remains close enough to the bulk chemical agent to justify the use of well-established toxicological testing procedures and approaches. For biodegradable particles, the particle composition and degradation products will influence their biological effects. On the other hand, materials with very low solubility or degradability could accumulate within biological systems and persist there for long durations. It is with nanoparticles of this character that the greatest concerns must arise, and attention will have to be paid to the comparison of the persistence of the particles and the time constants of the metabolic and cellular activities within the target host.

ISBN 978-93-5396-526-6

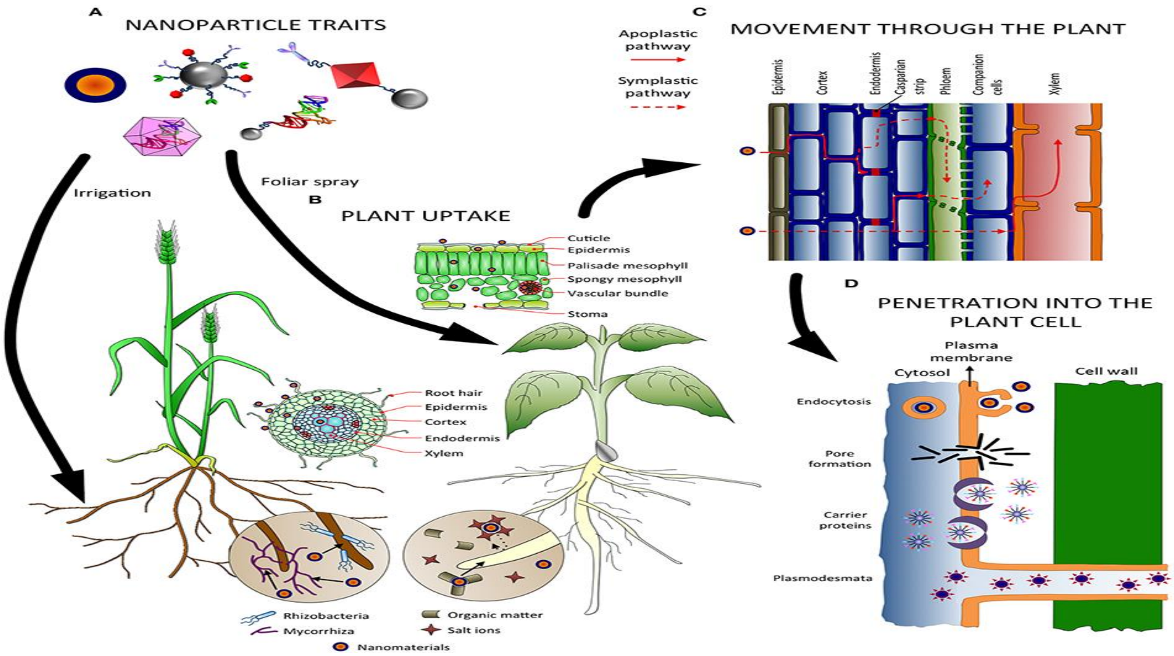
NANOPARTICLES IN OUTDOOR SPACES



- Sources and pathways of outdoor urban nanomaterials in the environment -

Many natural and manmade processes lead to the release of nanoparticles in indoor and outdoor spaces. Some construction workers, gas and petroleum transmission pipeline workers, members of police forces, farmers, and workers in many other jobs spend their work time in outdoor environments. Few studies have been conducted on the effects of the exposure of such workers to nanoparticles; however, the limited research that is available suggests that such people are subject to increased risk of adverse health effects caused by their exposure to nanoparticles. In some cases, the penetration of nanoparticles from indoor places into the outdoor environment is likely. For example, the nanoparticles that pass through a filtration system can enter the outdoor spaces through ventilation ducts and affect the workers outside. Due to their special physical and chemical properties, nanoparticles readily enter indoor and outdoor workplaces and are distributed throughout these spaces. They can cause biochemical damage by creating some reactions in the cells of the human body. Today, many researchers are measuring the concentrations of various nanoparticles in indoor and outdoor workplaces in order to determine the workers' levels of exposure.

INTERACTION OF NANOPARTICLES WITH PLANTS



ISBN 978-93-5396-526-6

In a study of the impact of aluminum oxide nanoparticles on the growth of plants' roots, a slight reduction was seen in the growth of roots in the presence of uncoated alumina nanoparticles, but no reduction was observed when the nanoparticles were coated with phenanthrene. The surface properties of alumina have an important role in its toxicity. Several papers have shown that a positive effect on the growth of spinach occurred when the spinach seeds were smeared with titanium dioxide nanoparticles or the leaves were sprayed with these nanoparticles. Titanium dioxide nanoparticles, unlike larger samples of titanium dioxide, can enhance enzymatic activity, increase the absorption of nitrates, and accelerate the conversion of inorganic nitrogen to organic nitrogen. There is some limited information that suggests that nanoparticles of inorganic oxides can interact with plants' cells and with green algae that have cell walls similar to those of other plants.

Nanoparticles can interact with plants' roots by being absorbed from the surface of the roots, entering the cell wall, and being absorbed into the roots' cells. It also is possible that nanoparticles enter the intercellular space where they can be absorbed by the membranes. The surfaces of plants' cells have a negative charge, which allows the entry of negatively-charged species into the intercellular space of the roots' bark. Nanoparticles can find their way into the woody tissue of the plant by entering this space.

The interaction of nanoparticles with toxic materials and organic compounds can either increase or reduce their toxicity. Thus, even though nanoparticles can have harmful environmental effects, they also can be helpful for the environment. The contaminants may be absorbed by nanoparticles, thereby reducing the concentrations of the free molecules of pollutants around the cells and reducing the toxic effects of the pollutants. However, if the nanoparticle and its combination with the pollutant would not be toxic, no toxic effects may be seen.

ENVIRONMENTAL RISK ASSESSMENT OF NANOPARTICLES

The environmental impacts of nanoparticles depend on how they are used in the workplace, how they are separated into different media (e.g., water and air), their mobility in each of these media, and their stability. Colvin's discussion on the potential impact of engineered materials demonstrates the lack of data on the exposure and effects of nanoparticles. To date, only a few studies have been carried out with species used for ecotoxicological testing. Oberdörster showed the 48 hours LC_{50} in *Daphnia magna* for uncoated water soluble fullerenes nC_{60} is 800 ppb. E. Oberdörster demonstrated a significant increase of lipid peroxidation in the brain and glutathione depletion in the gill of juvenile largemouth bass (*Micropterussalmoides*) after exposure for 48 hours to 0.5 ppm of fullerenes nC_{60}., but the increase was not significant at 1 ppm. In their follow-up studies, Oberdörster G *et al.* report the possible molecular mechanism of these observations. The bactericidal properties of fullerenes have been reported by Yamakoshi *et al*. However, considering that a large number of the above cited human toxicology studies have examined the uptake and effects of nanoparticles at a cellular level, it can be hypothesized that these observations may also hold for species other than humans. As such the reports may be useful for the assessment of the effects on environmental species. Work to support this hypothesis is needed. Careful examination and interpretation of existing data and careful planning of new research is, however, required if we are to establish the true ecotoxicity of nanoparticles, and the differences with conventional forms of the substances.

ISBN 978-93-5396-526-6

POLLUTION FROM NANOMATERIALS

Air pollution by nanoparticles linkedto brain cancer for first time

Nano pollution is a generic name for waste generated by Nano devices or during the nanomaterial manufacturing process. Nano waste is mainly the group of particles that are released into the environment, or the particles that are thrown away when still on their products. The thrown away nanoparticles are usually still functioning how they are supposed to (still have their individual properties), they are just not being properly used anymore. Most of the time, they are lost due to contact with different environments. Silver nanoparticles, for example, they are used a lot in clothes to control odor; those particles are lost when washing them.The fact that they are still functioning and are so small is what makes Nano waste a concern. It can float in the air and might easily penetrate animal and plant cells causing unknown effects. Due to its small size, nanoparticles can have different properties than their own material when on a bigger size, and they are also functioning more efficiently because of its greater surface area. Most human-made nanoparticles do not appear in nature, so living organisms may not have appropriate means to deal with Nano waste. New research has linked air pollution nanoparticles to brain cancer for the first time. The ultra-fine particles (UFPs) are produced by fuel burning, particularly in diesel vehicles, and higher exposures significantly increase people's chances of getting the deadly cancer. Previous work has shown that nanoparticles can get into the brain and that they can carry carcinogenic chemicals. Brain cancers are rare, and the scientists have calculated that an increase in pollution exposure roughly equivalent to moving from a quiet city street to a busy one leads to one extra case of brain cancer for every 100,000 people exposed.

The discovery of abundant toxic nanoparticles from air pollution in human brains was made in 2016. A comprehensive global review earlier in 2019 concluded that air pollution may be damaging every organ and virtually every cell in the human body. Toxic air has been linked to other effects on the brain, including huge reductions in intelligence, dementia and mental health problems in both adults and children. The World Health Organization says air pollution is a "silent public health emergency".

The new study, published in the journal Epidemiology, found that a one-year increase in pollution exposure of 10,000 nanoparticles per cubic centimeter – the approximate difference between quiet and busy city streets – increased the risk of brain cancer by more than 10%.The pollution levels in the cities studied – Toronto and Montreal – ranged from 6,000/cm3 to 97,000/cm3. *Weichenthal* said people living with pollution of 50,000/cm^3 have a 50% higher risk of brain cancer than those living with 15,000/cm^3.

ISBN 978-93-5396-526-6

CONCLUSION

In recent years, rapid advances in nanotechnology have brought major developments in the areas of the environment, medicine, agriculture, industry, and other sciences. The nanoparticle technology has made an important contribution to the field and provided a basis for the development of nanotechnologies. Despite the fact that the major effect of particle size on materials' toxicities has been specified in the past, the effect of particle size on the behavior and reactivity of nanoparticles remains unclear. New issues and ideas about nanoparticles require the development of appropriate laboratory methods. Currently, there are several uses of nanoparticles in the environment, including the removal of contaminants from water, sewage, and air. Also, they have been used in environmental instruments, such as sensors, green nanotechnology, and the reduction of greenhouse gases. However, apart from the usefulness of nanoparticles, they can cause some hazards for the environment from their production to their disposal.

As a result, environmental risk assessments of nanoparticles during their lifecycles are essential. It is worth noting that the study of the effects of nanoparticles on industrial and non-industrial workplaces also is very important. Also, the measurement of exposures of workers in outdoor workplaces to nanoparticles released from various sources is essential. It is recommended that additional information be gathered on the characteristics of various nanoparticles, especially their toxicological properties, and placed in databases that can be made readily available to researchers. In plants that deal with engineered nanoparticles, safety measures should be considered to minimize occupational exposure. Also, some guidelines should be established concerning the safe handling and use of nanoparticles in research laboratories. Finally, while promoting the benefits of the use of nanoparticles in various fields, we should ensure that no adverse effects result from their use.

REFERENCES

1. Guzman KAD, Taylor MR, Banfield JF. Environmental risks of nanotechnology: national nanotechnology initiative funding, 2000–2004. Environ. Sci. Technol. 2006; 40:1401–1407.
2. Nowack B, Bucheli TD. Occurrence, behavior and effectsof nanoparticles in the environment. Environmental Pollution. 2007;150:5–22].
3. Buffle J. The key role of environmental colloids/nanoparticles for the sustainability of life. Environ. Chem. 2006;3:155–158.
4. Dai HJ. Carbon nanotubes: synthesis, integration, and properties. Acc. Chem. Res. 2002;35:1035–1044.
5. Koziara JM, Lockman PR, Allen DD, Mumper RJ.In situ bloodebrain barrier transport of nanoparticles. Pharm. Res. 2003;20:1772–1778.
6. Nowack B. Pollution prevention and treatment using nanotechnology. In: Krug HF, editor. Nanotechnology. Springer; in press.
7. Nel A, Xia T, Mädler L, Li N. Toxic potential of materials at the nanolevel. Science. 2006; 311:622–627.
8. Sondi I, Salopek-Sondi B. Silver nanoparticles as antimicrobial agent: a case study on E. coli as a model for Gram-negative bacteria. Colloid Interface Sci. 2004;275:177–182.
9. Casuccio G, Ogle R, Bunker K, Rickabaugh K, et al. Worker and Environmental Assessment of Potential Unbound Engineered Nanoparticle Releases, Phase III Final Report: validation of preliminary control band assignments. Ernest Orlando Lawrence Berkeley National Laboratory and RJ Lee Group, Inc; canada: 2010.
10. Reijnders L. Cleaner nanotechnology and hazard reduction of manufactured nanoparticles. Clean. Prod. 2006; 14:124–133.

 ISBN 978-93-5396-526-6