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ENVIRONMENTAL RISKS OF NANOMATERIALS

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ABSTRACT:

Nanomaterials are generally defined as materials that are less than 100 nm (<100nm) on at least one dimension. Nanomaterials can be 3 dimension (3D) particles of any shape or size, they can be thin films (2D) like or fine rods (1D) type. Engineered nanomaterials are almost tenth the size of human cell and are widely being used in almost every sector of human life including electronics, engineering, medicines, space, etc. Their behaviour and nature basically depends upon their small size, which translates into a large surface area, and this provides greater opportunity to interact and integrate with the environment Thus toxicity varies directly with the size. Nowadays nanomaterials are considered as emerging environmental pollutants and contaminants. Physiochemical and biological transformations makes them vulnerable to interact with environmental pollutants, which can cause high risk to the biodiversity. Fullerenes and carbon nanotubes (CNTs) are used in plastics, batteries, fuel cells, water purifiers, sensors, and in many other fields and are found to be highly hazardous to the human health and habitat. Another class of nanomaterials composed of metal oxides like TiO_2, ZnO, CrO_2, MoO_2, Bi_2O_3 etc. which have great application in cosmetics and automobile industry are found to be highly dangerous for the environment. However, a number of methods like chromatography, spectroscopy, centrifugation, filtration are available to determine their concentration, size distribution and characterisation in the environment with the help of which their emission can be detected and controlled. Today we are at the optimal level to study the impact of nanomaterials on the human health and environment. The proliferation of nanotechnology has evoked discussions over the safety of these materials to the biodiversity and environment.

Keywords: *nanomaterials, environment, potential risk, characterisation, analysis*

INTRODUCTION:

In today's era nanotechnology is considered as the most potent and futuristic technology. It is ready to revolutionize a diverse range of industries as many smart and efficient devices are ready to replace the conventional ones. These modern devices and tools are much efficient, superior, and smarter in comparison to their bulk counterparts. There is no doubt that this technique is going to be the integral part in the production of different materials ranging from household items to space sails. It is the fastest growing research and development area and gained a great deal of public interest. This technology is proving its utility in many areas of human endeavours including agriculture, industry, business, medicine, public health, energy and many more.

Moreover, nanotechnology is distinguished by innovative options it offers in manufacturing and quality. These include in particular improved control possibilities in the manufacturing process and self-organisation of nano size materials. In self-organisation or arrangement, nanoparticles systematically combine together to form new structures with innovative geometries. The most striking feature of nano materials lies in the combination of a top bottom approach, with a bottom up approach. In top bottom approach, the nanostructures are obtained by means of progressive miniaturization, while bottom up approach consists the scheme of combining individual nanoparticles. Nanomaterials are both of natural origin and artificially engineered. The properties already known with respect to atoms and molecules such as electrical and thermal conductivity, magnetism, colour, catalytic behaviour, brittleness, durability are inherited in them depending upon their size and geometry, ie. Cadmiun Telluride [CdTe] particles, fluoresces in different colours depending upon the size of the nanoparticles (2nm-

5nm). Nanomaterials which are currently being synthesized all along the globe mainly consists of nano powder which includes, metals, oxides, carbides, sulphides, nitrides, silica and silicon carbides. These nano powders are used in the manufacturing of wide range of products such as Titanium [Ti] and Zinc Oxide [ZnO] are used in cosmetics and sunscreen, Teflon and polymeric nanofibres are used in textile industry, Titanium Oxide [TiO] and graphene are used for coatings , carbon nanotubes [CNT] and nano clay particles are used for the manufacturing of tennis racquets and balls. There are other numerous examples which shows the use of nanoparticles for the synthesis and manufacturing of different products and devices.

Developed nations are spending huge amount of money and time in the research and development of nanotechnology. It is estimated that in between 2000 to 2015 nearly $10billion have been invested on the study of this novel technique. According to the National Nanotechnology Research Institute (USA), thousands of tonnes of silica, alumina and ceramic, in the form of ultra fine particles are used in the slurries for polishing of silicone wafers and glasses. The Carbon Nanotechnology Research Institute (Japan) is planning to expand its production of silica and alumina nanoparticles to 150 tons / year. Within the next 5 years the world wide production of single wall carbon nanotubes (SWCNT) and multi wall carbon nanotubes (MWCNT) is estimated to be about 2000 tons.

The tremendous increase in the manufacturing of nanomaterials and nanodevices has highlighted the potential risk to humans and ecosystem as these particles are contaminating the environment. By product contaminants and fumes emission during the process of combustion, fire and pollution are also creating a alarming situation for the ecosystem. Thus the exposure of environment towards nanoparticles continues to increase as their application expands. Despite of numerous benefits of this technology, there are many open questions about how the nanoparticles should be used in day to day life, so that their concentration remains in the saturation limit and less harm is done to the environment.

To prevent this complex situation many researches across the globe is going on to study, analyse and combat the negative impact of nanomaterials.

Some research priorities to decrease the risk of nanomaterials are:

- There should be fundamental concept about the material i.e,it's properties and characterization should be figured out.

- Analysis of current knowledge and techniques must be done to control the situation
- Smart models must be prepared to perform in depth analysis
- Innovative tools for research should be outlined
- Database monitoring of environment should be planned
- The level of nanoparticles must be controlled

One of the crucial issues that have to be confronted in the future, before the mass level production of these materials, is there toxicity to humans and the environment. There are many queries regarding how the novel properties at the nano scale could lead to adverse biological effects, with the probability to cause high degree of toxicity. One needs to understand that when nanomaterials will undergo degradation in the environment then what will be the response of biodiversity whether it will sustain or will react negatively towards the same. Hence it is the call of the time for the scientists and nanotoxicologist, to uncover and analyse how nanomaterials are going to influence the environment.

Exposure towards nanomaterials.

Current studies indicates that exposure to nanoparticles can occur through inhalation or by skin contact. The inhalation in substantial amount may pose possible concern both medically and environmentally. The exact magnitude of damage that may cause is exactly not known but they can prove to be fatal due to their high toxic nature. This toxicity can be related with their large surface area, which makes them highly reactive and catalytic. It has been proved that nanoparticles can enter the body through several ways. Accidental or involuntary contact during production or excessive exposure towards them are the main cause .The inhalation is most likely to happen through lungs from where a rapid translocation occurs through the blood stream is possible to other vital organs. On the cellular level the ability to act as a gene vector has also been identified. Carbon black nanoparticles and carbon nanotubes [CNT] have been found to be every dangerous as they effects the cell signalling mechanism of the brain. Animal studies have shown that some nanoparticles belonging to the category of metal oxides can penetrate through cells and tissues to enter into the body, and may cause serious damage to brain and biological system.

However the nanoparticles suspended in nature quickly gets agglomerated to change there nano state and didn't posemuch threat to organisms and biological system. Nature mother itself presents variety of nanomaterials towards which organisms have developed considerable immunity. i.e., salt particulates from water bodies, aerosols, and terpenes from plants, fine impurities and contaminants present in atmosphere etc.

Toxicity of nanomaterials

Today's burning topic on nano research is that how toxic and harmful are these nanomaterials and at what optimal concentrations they might be used. In a related information it has been reported that the magnitude of their toxic effects is related to their configuration, composition and contours. In toxicity studies of nanomaterials with different cells line sat different temperatures and incubation periods have revealed that the cytotoxicity is physiologically highly relevant. In one research it is found that citrate capped gold nano sphere's are found to be cytotoxic to kidney and human liver. Exposure to high levels of silver [Ag] over a long period of time can result in breathing problems, lung and throat infections. The effect titanium oxide [TiO] and silver oxide [AgO] can cause a condition called argyria (blue-gray discoloration of skin) as nano silver leads to the formation of free radicals in the cells which is highly reactive and sensitive towards the skin cells.

Metal chalcogenides nanoparticles are important raw materials widely used for the preparation of cosmetics, pharmaceuticals and food colorants and are found to be hazardous for human health as long term exposure can lead to paralysis and neurological problems. Copper oxide [CuO] nanoparticles are the most potent regarding cytotoxicity and DNA damage. Zinc oxide [ZnO] showed effects on cell viability, which can lead to some changes in genetic factors. Carbon nanotubes [CNT] are also found to have significant toxic effects on human health and environment due to their complex structure. The studies have revealed that carbon nanotubes [CNT] exhibit substantial cytotoxicity in vitro, including including induction of oxidative stress, inhibiting the cellular prohibition and induction of apoptosis/ necrosis. The results indicates that the single wall carbon nanotubes [SWCNT] coiled together in bundles can produce pulmonary inflammations. The results have shown that cytotoxicity increases by as much as 42% when the concentration of this nanoparticle increases by $0.12 mg/cm^2$., which may lead to alveolitis, fibrosis and gene toxicity in epithelial cells. Another important much used nanomaterial is Quantum Dots which can cause much damage to human health leading to disorders like Alzheimer's and Parkinson's. Each individual type of Quantum Dot possess its unique physiological characteristic, which in turn determines its toxicity ie, when QD655 and QD565 coated with acidic functional group-(COOH) studied for 10 and 24 hours in flow through diffusion cells the skin penetration was well below the upper most stratum of intact skin. Pollutant particles such as diesel exhaust particulates (DEP) are very much responsible for causing pulmonary inflammation. Moreover intratracheal inhalation of DEP promotes femoral venous and arterial thrombosis. Many experimental datas indicate that inhaled particles can trigger cardiovascular complexities and after the passage in the circulatory system can play a direct role in thrombogenesis. An increase in plasma concentration fibrinogen and C-reactive protein has been found in samples of adults who have been exposed with these nano particulates.

Nanoparticles can enter the environment directly or indirectly through emissions, waste water treatment plants, landfills, by products of industries, chemicals and contaminants. The nanoparticles in the environment undergoes ageing processes such as aggregation, chemical transformation, pH change. The interplay between these processes and the nanoparticle transmission determines the fate and ecotoxicological effects of nanoparticles. Drastic transformation in chemical properties like dissolution, degradation and pH as well as considerable change in surface area by adsorption or desorption have been under scrutiny for their potential adverse effects on aquatic and soil ecosystem. Moreover nanoparticles have the severe harmful effects in biota by the formation of reactive oxygen species (ROS) that could effect the biological strata and eco levels. Global estimation of nanoparticle emission indicates that landfills and soil's receives the largest share of about 70% and 20% respectively whereas the remaining 10% is received by aquatic environment and air. However it is unfortunate that there is no exact mechanism of toxicity for all the nanoparticles and therefore there action on different biological species is hard to understand.

Occupational hazards of nanoparticles

There are many workplaces which raises the risk of exposure to nanoparticles. Some of them are

- Workers who deals with nanoparticles in liquid media without adequate protection.
- During the pouring and mixing operations where high degree of agitation is involved.
- During the synthesization of nano powders which involves the risk of aerosolization.
- IT Industries where the nanomaterials are formed in abundance.
- Health care where some specific diagnostic tools are used.

Prevention of nanoparticle exposure

Most of the measures adopted are up to standard lab practices regarding the use of hazardous chemicals and gases. In addition some more precautions include.

- Laboratory protection and hygiene
- Proper hand washing
- Standard Penn safety glasses
- Respirators and ventilators for proper inhalation.
- Safe handling of dry nanoparticles using fume hood, biological safety cabinet, and glove boxes.
- Dry and tightly packed containers should be used to contain nanomaterials.
- Aerosols producing activity may not be conducted in open.
- Spills of nanoparticles must be cleaned with HEPA and EHRS vacuum methods.
- All solutions and solid by products must be disposed according to security guidelines.

CONCLUSION:

The behaviour, toxicity and fate of nanomaterials in the environment have been critically discussed above. Still lot has to be done to primarily study the interaction of nanoparticles with the environmental system. Much more studies are needed to analyse the stability of these matrices in variety of test systems to fully diagnose and evaluate the negative impact of nanomaterials. The pharmacokinetics behaviour of different types of nanoparticles requires detailed analysis and a database of health risks associated with them should be planned. However there are some techniques like chromatography, spectroscopy, tunneling and scanning to name the few with the help of which the magnitude of interaction of nanoparticles with the environment can be studied.

With a broad potential for societal, environmental and economic benefits it is unlikely that the nanotechnology industry will ever slow down. So, the need of the hour is the sensible use of nanomaterials without hurting the ecosystem. In the words of OECD, there is a need for a responsible and coordinated approach to ensure that potential safety issues are being addressed at the same time as the technology is developing. Thus closing the gap between nanotech and scientists ability to understand its impact is going to be crucial and deciding for the sustainability of industry and avoidance of unintended consequences. Nanoscience and nanotechnology holds great potential for the mankind and ecosystemif implemented properly and sensibly and is ready to trigger the breakthroughs of tomorrow. Thus the bottom line of the future should be:

Nano in the environment, nano for the environment.

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