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1. Nanotechnology for the Environment and Medicine

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ABSTRACT

Nanotechnology encompasses the production and applications of physical, chemical, and biological systems at scales ranging from individual atoms or molecules to around 100 nanometres, as well as the integration of the resulting nanostructures into larger systems. Nanomaterials differ from bulk materials for their relatively larger surface-area-to-mass ratio, consequently they become more chemically reactive and can show different optical, magnetic and electrical behaviours. In recent years, engineered nanomaterials have gained a particular attention in some fields such as environmental protection (soil, air and water remediation/treatment) and medicine (bio-sensing, imaging, and drug delivery).

Nanoparticles can be used to monitor in real-time some pollutants (including heavy metal ions, organic compounds, microbiological pathogens, etc.) present even at extremely low concentrations in different environments. The use of nanomaterials for waste remediation/treatment results in a technology more cost-effective and rapid than current conventional approaches thanks to their enhanced surface area, transport properties, and sequestration characteristics.

In addition, the integration of molecular biology and medicine with nanotechnology has resulted in new active nanostructures able to interact with biological systems. Nanocarriers based on carbon nanotubes, fumed silica (SiO2), titanium dioxide (TiO2), and magnetite and maghemite (Fe3O4, and γ-Fe2O3) nanoparticles have a distinct advantage over other drug carriers as they can be opportunely designed to reach the desired targets. As a consequence, such nanostructures can represent an important platform for enhanced medical imaging and controlled drug delivery. Here, some applications of nanomaterials as water purifying agents and drug delivery systems are reported.

KEYWORDS:

Nanotechnology, Nanoparticles, Environmental impacts, Environment, EVS, Medicine, Nanomaterials.

1. Introduction:

The emerging field of Nanotechnology is leading to a technological revolution in the new millennium. It could revolutionize the way our society manufactures goods, generates energy and cures diseases. Nano scale materials are currently being used in consumer goods, computers, electronics, information and biotechnology, aerospace, defense, energy, medicine and many other sectors of our economy. Areas producing the greatest revenue for Nanotechnology applications are chemical-mechanical polishing, magnetic recording tapes, sunscreen, automotive catalyst, bio-labeling, electro-conductive coatings and fiber optics.

Nanotechnology has direct beneficial applications for medicine and the environment, but like all technologies that may have unintended effects that can adversely impact the environment, both within the human body and within the natural ecosystem. While taking advantage of this new technology for health environmental and sustainability benefits, science needs to examine the environmental and health implications. The impact of nanotechnology extends from its medical, ethical, mental, legal, and environmental applications to fields such as engineering, biology, chemistry, computing, material science, military applications, and communications.

Advances in nanotechnology could also be ready to provide more sensitive detection systems for air and water quality monitoring, allowing the simultaneous measurement of multiple parameters in real time response capability. Metal oxide nano catalysts are being developed for the prevention of pollution thanks to industrial emissions and therefore the photocatalytic properties of titanium oxide nanoparticles are often exploited to make self-cleaning surfaces that reduce existing pollution.

However, while nanotechnology might provide solutions surely environmental problems, relatively little is understood at the present about the environmental impact of nanoparticles, though in some cases chemical composition, size and shape are shown to contribute to toxicological effects.

Nanotechnology can assist resource saving through the utilization of lightweight, high strength materials supported carbon nanotubes and metal oxide frameworks as hydrogen storage materials. Other energy related applications include nanostructured electrode materials for improving the performance of lithium-ion batteries and non-porous silicon and titanium oxide in advanced photovoltaic cells. It is important to develop an efficient strategy for the recycling and recovery of nano materials and methods are needed to assess whether the potential benefits of nanotechnology outweigh the risks. Lifecycle analyses are going to be a useful gizmo for assessing truth environmental impacts. The potential positive and negative effects of nanotechnology on the environment are discussed. Advances in nanotechnology could also be ready to provide more sensitive detection systems for air and water quality monitoring, allowing the simultaneous measurement of multiple parameters in

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2. Objectives:

a. Understand the new frontier of nanotechnology for Environment and Medicine.
b. Identify the various applications of nanomaterials for Environment and Medicine.
c. Analyze the environmental benefits of nanotechnology.

3. Review of Literature:

Riva and co-authors proposed a nanostructured cellulose-based material as a possible sorbent for the removal of organic dyes from water, demonstrating its sorbent efficiency for four different organic dyes commonly used for fabric printing. The material performance was compared with that of an activated carbon, routinely used for this application, thus highlighting the potentialities and limits of this new material together with the important issue of the regeneration and reuse of the sorbent [2]

The suitability of cellulose-based nanomaterials for the remediation of heavy metal-contaminated environments was then assessed by Guidi and colleagues. They indicated an eco-friendly cellulose-based nanosponge as a safe and effective candidate in the cadmium remediation process, being able to sequester cadmium and restore cellular damage induced by cadmium exposure in the zebra mussel, an animal model typical of freshwater environments, without altering cellular physiological activity. In particular, the authors showed the recovery of cadmium-induced DNA integrity loss, cell proliferation increase, and nuclear morphology and chromosomal alterations in zebra mussel haemocytes. The same eco-friendly nano sponges were demonstrated to be effective in the removal of zinc ions from the seawater environment, through another in vivo study. The contribution by Liberatori et al. confirmed, besides the efficacy of the Nano sponge, the recovery of the toxicological responses induced in the marine mussel. The genetic, chromosomal, cellular and tissue alterations induced by zinc ions were actually reported at control levels, supporting the environmentally safe application of cellulose-based Nano sponges for heavy metal removal from seawater. [3][4]

Mariano and colleagues demonstrated the possible use of a microalgae as a model microorganism to study silver nanoparticle toxicity, but also to protect against nanoparticle pollution. They showed that silver nanoparticles, internalized in a time- and dose-dependent manner inside large vacuoles, were not released into the medium for almost one week, without undergoing any biotransformation, confirming the role of the microalgae in environmental protection. Still within the field of remediation, Park and co-authors proposed a nanohybrid material able to detect uranyl ions spectroscopically and act as a uranyl ion absorbent in an aqueous system. The contribution has high impact because the uranyl ion, the most soluble toxic uranium species, is considered as an important index for monitoring nuclear wastewater quality. [5][6]

Two contributions faced this researchaspect, which concerns the interactions between nanostructured materials and classical pollutants. The assessment of the ecotoxicological effects of the interaction between benzo[a]pyrene and fullerene(C60) was performed by Barranger and co-authors in the marine mussel. They found antagonistic responses at the genotoxic and proteomic level, also showing a complex multi-modal response to environmental stressors in the species used. Another antagonistic interaction was reported by Santonastaso and co-workers, who assessed the in vitro effects of titanium dioxide nanoparticles and cadmium interaction in human sperm cells by investigating semen parameters, apoptotic processes, DNA integrity, genomic stability and oxidative stress.

They demonstrated that the genotoxicity induced by the co-exposure was lower if compared to single cadmium exposure, suggesting the formation of a sandwich-like structure, with cadmium in the middle, to explain the inhibition of its genotoxicity in human sperms. [7]

The biophysical effect of nanomaterials within stem cell-based therapies has been investigated by Shin and co-authors. They labeled human bone marrow-derived mesenchymal stem cells with silica-coated magnetic nanoparticles incorporating rhodamine B isothiocyanate, and found decreased cell viability, an increase in intracellular reactive oxygen species, and, most of all, a decrease in stem cell migration activity related with membrane fluidity reduction and focal adhesion impairment.

Therefore, the authors highlighted the importance of nanoparticles that are used for stem cell trafficking or clinical applications being labeled using optimal nanoparticle concentrations, so as to preserve human bone marrow-derived mesenchymal stem cells' migratory activity, thus ensuring successful outcomes following stem cell localization. Regarding another key word of the Special Issue, i.e., drug delivery, an interesting contribution came from Matsuo and co-authors, who indicated encapsulated lipid-based nanoparticles, prepared from neutral hydrogenated soybean phosphatidylcholine and dipalmitoyl phosphatidylglycerol, as an optimal way, after roll grinding and high-pressure homogenization, to prepare stable bicelles for nifedipine delivery. Cryo-transmission electron microscopy and atomic force microscopy were also performed to better understand the structure of such nifedipine-encapsulated lipid-based nanoparticles. [8,9]

4. Research Methodology:

Books, educational and development journals, government papers, and print and online reference resources were only some of the secondary sources we used to learn about the composition, use, and impacts of Nanotechnology for the Environment and Medicine. Only the qualitative analyses of questions related to potential environmental risks from nanomedicine and adequacy of the current risk framework for assessing environmental risks from nanomedicines are presented here. Since risk is constructed in specific sociotechnical contexts, both environmental hazards and exposures were explored.

5. Result and Discussion:

A. Effects of Environment with Nanotechnology:

Positive effects on environment with nanotechnology:

Nanotechnology offers potential economic, societal and environment benefits. Nanotechnology also has the potential to help reduce the human footprint on the environment by providing solutions for energy consumption, pollution, and green gas emissions. Nanotechnology offers the potential for significant environmental benefits, including:

- Cleaner, more efficient industrial processes.
- Improved abilities to detect and eliminate pollution by improving air, water, and soil quality.
- High precision manufacturing by reducing amount of waste.
- Clean abundant power viaduct more efficient solar cells.
- Removal of greenhouse gases and other pollutants from the atmosphere.
- Decreased needs for large industrial plants.
- Remediating environmental damages.

Negative effects on environment with nanotechnology:

Negative effects on environment Understanding of the environmental effects and risks associated with nanotechnology is very limited and inconsistent. The potential environmental harm through nanotechnology can be summarized as follows:

- High energy requirements for synthesizing nanoparticles causing high energy demand.
- Dissemination of toxic, persistent nano substances originating environmental harm.
- Lower recovery and recycling rates.
- Environmental implications of other lifecycle stages also not clear.
- Lacks trained engineers and workers causing further concerns.

Formations, emission, occurrence in faith of nanoparticles (np) in the environment:

Assessing the risks imposed using nanomaterials in commercial products and environmental applications requires a better understanding of their mobility, bioavailability, and toxicity. For nanomaterials to comprise a risk, there must be both a potential for exposure and a hazard that results after exposure.

Release of np may come from point sources such as production facilities, landfills, or wastewater treatment plants or from nonpoint sources such as where from materials containing np. Accidental release during production or transport is also possible in addition to the unintentional release there are also np released intentionally into the environment nzvi, for example is directly injected into groundwater polluted with chlorinated solvents. Whether the particles are released directly into water slash soil or the atmosphere they all end up in soil or water, either directly or indirectly for instance, via sewage treatment plants waste handling or aerial deposition. In the environment the formation of aggregates and therefore of larger particles that are trapped or eliminated through sedimentation effects the concentrations of free np. Humans can be either directly influenced by np through exposure to air, soil, or water or indirectly by consuming plants or animals which have accumulated np. Aggregated or adsorbed np will be less mobile, but uptake by sediment dwelling animals or filter feeders is still possible.

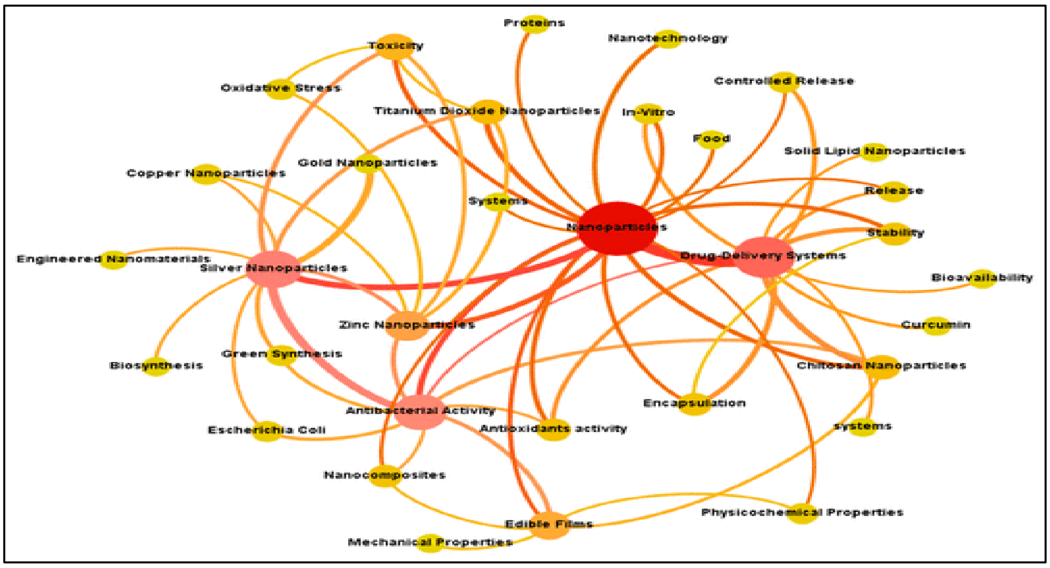

Figure 1: Formations, emission, occurrence in faith of nanoparticles (np) in the environment

Environmental Risk Assessment of NPs

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. Such basic information about the behavior and toxicity of nanoparticles is required to assess their risks; however, a realistic assessment cannot be done based exclusively on this information; rather, some data on the expected concentration of nanoparticles in environmental systems would be necessary, and, to date, there is no accurate concerning such concentrations.

As a starting point for the environmental risk assessment of nanoparticles, the resources, environmental pathways, and applications of nanoparticles, as well as the plants and animals that are sensitive to nanoparticles, must be identified. [10]

In terms of drug discovery and development, the role of nanotechnology currently lies in improving diagnostic methods, developing improved drug formulations and drug delivery systems for disease therapy.

The anticipation that treatments for diseases such as cancer will be revolutionised with the advent of nanotechnology-based products such as nanoarrays and dendrimers is stimulating research in nano-medicine. The realisation is that the nanoscale has certain properties to solve important medical challenges and to cater to unmet medical needs is a factor driving research in nano-medicine (Figure 2).

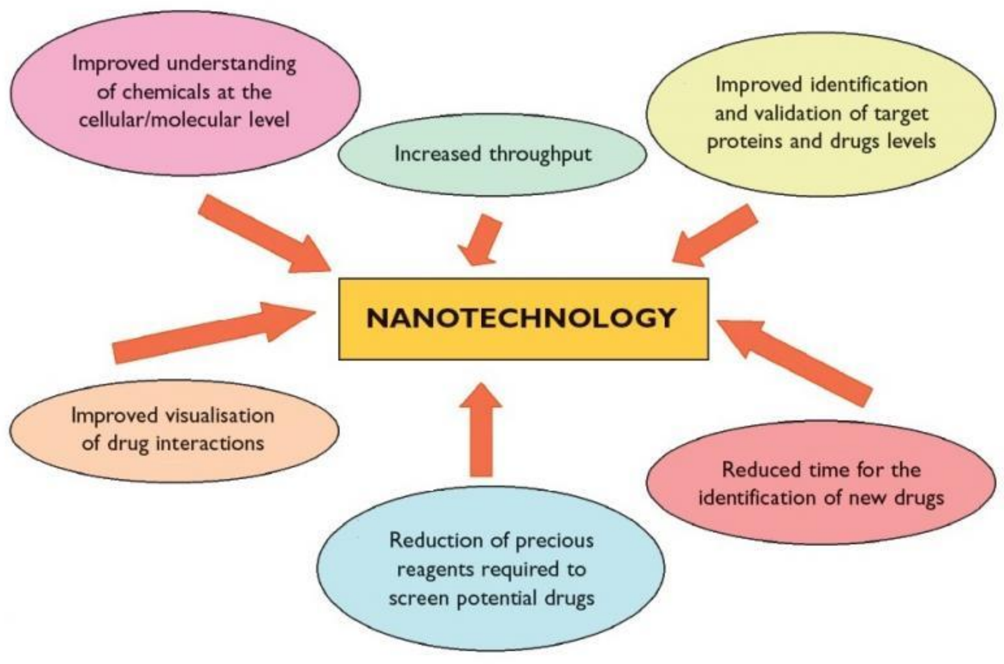

Figure 2: The Role of Nanotechnology in Drug Discovery

The breakthrough format of nanotechnology offers innovative solutions, giving researchers greater analytical capacity, improved data quality and at the same time consuming less sample volume in the storage and screening of molecular, cell and tissue libraries. The advances in the technology are now beginning to overcome the initial challenges of insufficient throughput, unreliable data and various other issues. This article will focus on the principal trends and the implications on drug discovery.

The drug discovery industry has become such a competitive market that it continually faces a challenge to find better drug discovery technologies. This industry has to discover and develop innovative medicines for a wide range of diseases in a marketplace that is likely to experience growing regulatory challenges, pricing pressures and various other bottlenecks.

Currently, nearly all pharmaceutical companies follow common technology processes for discovering drugs. These include, cloning and expressing human receptors and enzymes in formats that allow high throughput, automated screening and the application of combinatorial chemistries. The genomics and proteomics revolution has delivered massive amounts of data about life's molecular components, giving the drug discovery industry more qualified targets and leads than ever before.

Nanotechnology has the potential to prolong a disease-free lifespan. In addition, for many chronic diseases and disorders, nano-medicine offers the potential and hope for a cure. Some of the major factors driving the expansion of nanotechnology- based solutions in drug discovery include: identification of novel chemical structures, ability to manipulate and track cells on the nanoscale due to advances in microscopy, increased government funds earmarked for nanotechnology, significant and growing interest from the venture capital community, and the rapid proliferation of nanotechnology start-up companies. [11]

6. Conclusion:

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.

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