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Unraveling the Controversy: Exploring the Aquatic Toxicity of Nanoparticles

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Abstract

Nanotechnology has propelled innovation in medicine, electronics, and materials. Central to this revolution are nanoparticles. Despite their transformative potential and increasing use, concerns about nanoparticle aquatic toxicity is a current topic of discussion. In aquatic environments, nanoparticles can pose toxicity risks by disrupting cellular structures, inducing oxidative stress, and modulating immune responses. Recent studies on aquatic nanoparticle toxicity reveal diverse outcomes, underscoring the complexity of this issue. Proactive measures are imperative to address these concerns. Rigorous testing protocols and regulatory frameworks are essential to identify risks early in development. Yet, the lack of standardized testing methods and global regulations for nanoparticles poses challenges, necessitating collaborative efforts among scientists, policymakers, and industry leaders. As understanding of nanoparticle behavior expands, responsible research and development practices will ensure the realization of nanotechnology's promise without compromising human health or the environment.

Keywords: Nanoparticles; Aquatic toxicity; Nanotechnology

Introduction

Nanotechnology, the manipulation of matter on an atomic and molecular scale, has revolutionized various industries, from medicine to electronics [1]. One of the key components of nanotechnology is nanoparticles, tiny particles with dimensions ranging from 1 to 100nm. While these minuscule entities offer incredible potential for innovation, the debate surrounding their toxicity has become a prevalent topic which is being further explored by the scientific community [2].

Nanoparticles exhibit unique properties that make them invaluable in numerous applications: In medicine, they are extensively used in drug delivery since they can be engineered to deliver drugs to specific target cells or tissues, improving drug efficacy and reducing side effects. Nanoparticles are also used in medical imaging techniques, such as magnetic resonance imaging (MRI) and computed tomography (CT), to enhance contrast and improve diagnostic accuracy; and nanoparticles are being exhaustively explored for therapeutic purposes, including cancer treatment, gene therapy, and regenerative medicine [3]. In material science, nanoparticles have been proved to enhance the mechanical properties of polymers, metals, or ceramics, improving their strength, hardness and durability, or to facilitate the encapsulation of active ingredients [4]. Additionally, nanoparticles can act as efficient catalysts due to their high surface area and reactivity. They have been also extensively used in cosmetic formulations to obtain improved texture, stability, and delivery of active ingredients [5], and as nanofluids for cleaning purposes [6].

Nanoparticles come in various types, each with unique properties and applications. For example, metal nanoparticles such as gold or silver are used in medical applications. Titanium dioxide, zinc oxide and silica nanoparticles are commonly used in sunscreens, cosmetics, or drug delivery. Nanoparticles specifically designed, such as carbon-based, polymeric, ceramic, or lipid-based nanoparticles, have been investigated to be used for drug delivery, as a carrier or in medical applications. However, whereas the potential benefits and applications seem limitless, the question of their safety looms large.

The concern regarding nanoparticle toxicity arises from their ability to interact with biological systems in ways that larger particles do not. Nanoparticles can easily penetrate cell membranes, allowing them to access internal structures and potentially interfere with cellular functions. The size, surface charge, and composition of nanoparticles are crucial factors influencing their interaction with biological systems [7].

Concerns about nanoparticle toxicity extend beyond the realm of human health to environmental impacts. The release of nanoparticles into the environment, whether through industrial processes or consumer products, raises questions about their long-term effects on ecosystems. Understanding the potential harm to aquatic life, soil organisms, and plants is critical for responsible development and usage of nanotechnology.

Nanoparticles, after their use and when they are released into aquatic environments, can interact with aquatic organisms and ecosystems, leading to potential toxicity [8]. The mechanisms of nanoparticle toxicity in aquatic systems are complex and can vary based on factors such as nanoparticle composition, size, shape, surface charge, and the specific organisms involved [9]. Nanoparticles may interact directly with aquatic organisms through physical contact or adsorption onto their surfaces. This interaction can disrupt cellular membranes and structures, leading to cellular damage and dysfunction, they can generate reactive oxygen species (ROS) through processes such as photocatalysis or redox reactions. Elevated ROS levels can cause oxidative stress in aquatic organisms, leading to damage to cellular components, including lipids, proteins, and DNA, or can modulate the immune responses of aquatic organisms, affecting their ability to defend against pathogens. Immunotoxicity may compromise the overall health and survival of aquatic species. Furthermore, the presence of nanoparticles in conjunction with other pollutants (e.g., heavy metals or concerning organic pollutants) may result in synergistic effects, amplifying the overall toxicity to aquatic organisms.

In recent years, studies about the potential aquatic toxicity of nanoparticles and nanomaterials have increased markedly. The conclusions of the studies are very broad, and are strongly dependent on the type of nanoparticle, the aquatic organisms tested, or the method used [9]. Conclusions vary from non-toxic results in case of silica nanoparticles to marine bacterium *V. fischeri* [10], or that ceria nanoparticles do not induce acute aquatic toxicity nanoparticles to *Cyprinus carpio L*. [11], to very drastic negative effects to the aquatic organisms as is the case of silver nanoparticle which led to growth inhibition and morphology changes on aquatic plants or genotoxicity on aquatic vertebrates and invertebrates [12,13], or the example of fullerene C60 nanoparticles which can cause cellular damage and necrosis on aquatic vertebrates [14].

As researchers strive to unlock the full potential of nanotechnology, it is essential to address concerns about aquatic nanoparticle toxicity proactively. Establishing rigorous testing protocols and regulatory frameworks can help identify potential risks early in the development process. On the other hand, there is a lack of standardized testing methods and global regulations for nanoparticles. This makes it difficult to assess and compare the safety of different nanoparticles and regulate their use in various applications. Collaborative efforts between scientists, policymakers, and industry leaders are vital to strike a balance between innovation and safety.

The debate surrounding the aquatic toxicity of nanoparticles is complex and multi-faceted, involving considerations of human health, environmental impact, and technological advancement. While the potential benefits of nanotechnology are vast, responsible research and development practices are necessary to mitigate any potential risks. As our understanding of nanoparticle behavior expands, it is crucial to maintain a cautious and informed approach to ensure that the promise of nanotechnology is realized without compromising safety.

Conclusion

The debate surrounding the aquatic toxicity of nanoparticles is complex and multi-faceted, involving considerations of human health, environmental impact, and technological advancement. While the potential benefits of nanotechnology are vast, responsible research and development practices are necessary to mitigate any potential risks. As our understanding of nanoparticle behavior expands, it is crucial to maintain a cautious and informed approach to ensure that the promise of nanotechnology is realized without compromising safety.

References

1. A. Selmani, D Kovačević, K Bohinc (2022) Nanoparticles: From synthesis to applications and beyond. Adv Colloid Interface Sci 303: 102640.
2. Z Liu, CR Malinowski, MS Sepúlveda (2022) Emerging trends in nanoparticle toxicity and the significance of using Daphnia as a model organism. Chemosphere 291(Pt 2): 132941.
3. A Aghebati-Maleki, S Dolati, M Ahmadi, A Baghbanzhadeh, M Asadi, et al. (2020) Nanoparticles and cancer therapy: Perspectives for application of nanoparticles in the treatment of cancers. J Cell Physiol 235(3): 1962-1972.
4. I Lobato-Guarnido, G Luzón, F Ríos, M Fernández-Serrano (2023) Synthesis and Characterization of Environmentally Friendly Chitosan–Arabic Gum Nanoparticles for Encapsulation of Oregano Essential Oil in Pickering Emulsion. Nanomaterials 13(19): 2651.
5. R Włodarczyk, A Kwarciak-Kozłowska (2021) Nanoparticles from the Cosmetics and Medical Industries in Legal and Environmental Aspects. Sustainability 13(11): 5805.
6. M Lechuga, M Fernández-Serrano, F Ríos, A Fernández-Arteaga, Ramón Jiménez-Robles (2022) Environmental impact assessment of nanofluids containing mixtures of surfactants and silica nanoparticles. Environmental Science and Pollution Research 29: 84125-84136.
7. PR More, S Pandit, A De Filippis, G Franci, I Mijakovic, et al. (2023) Silver Nanoparticles: Bactericidal and Mechanistic Approach against Drug Resistant Pathogens. Microorganisms 11(2): 369.
8. H Kerin, K Nagaraj, S Kamalesu, (2023) Review on aquatic toxicity of metal oxide nanoparticles. Mater Today Proc.
9. NB Turan, HS Erkan, GO Engin, MS Bilgili (2019) Nanoparticles in the aquatic environment: Usage, properties, transformation and toxicity—A review. Process Safety and Environmental Protection 130: 238-249.

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10. F Ríos, A Fernández-Arteaga, M Fernández-Serrano, E Jurado, M Lechuga (2018) Silica micro- and nanoparticles reduce the toxicity of surfactant solutions. J Hazard Mater 353: 436-443.

11. MU Marghoob, A Noureen, A Raza, WS Khan, M Iftikhar, et al. (2022) Synthesis and toxicity assessment of environment friendly high yield ceria nanoparticles for biosafety. J Environ Chem Eng 10(1): 107029.

12. F Li, R Li, F Lu, L Xu, L Gan, et al. (2023) Adverse effects of silver nanoparticles on aquatic plants and zooplankton: A review. Chemosphere 338: 139459.

13. A Sibiya, J Jeyavani, P Santhanam, E Preetham, R Freitas, et al. (2022) Comparative evaluation on the toxic effect of silver (Ag) and zinc oxide (ZnO) nanoparticles on different trophic levels in aquatic ecosystems: A review. Journal of Applied Toxicology 42(12): 1890-1900.

14. JLR Ferreira, DM Barros, LA Geracitano, G Fillmann, CE Fossa, et al. (2012) *In vitro* exposure to fullerene C 60 influences redox state and lipid peroxidation in brain and gills from Cyprinus carpio (Cyprinidae). Environ Toxicol Chem 31(5): 961-967.