



Nano-Toxicity: A Bird's Eye View of Toxicological Aspects



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Introduction

Every technology has to face exaltation and disparagement at various levels. Strengths of a technology are readily translated into functional outcomes while the shortcomings pave way for further research and breakthroughs. Nanotechnology is not an exception from this clause. With the growing prominence this technology is facing major setbacks. One such setback is associated toxicity. In this paper, we confine ourselves to present potential toxic effects of nanoparticles. The bird's eye view of this problem may help develop strategies for using these materials in various applications.

Nanomaterials have changed our approach towards research and development expanding the horizons of frontiers in science and technology (Figure 1). Many argue on the threat that nanoparticles could possibly confer on humans and ecosystems [1]. Though this argument has some experimental evidence, it is possible that

such arguments are often farfetched assumptions. As enquiry and evidence form basis for empirical science, a thorough investigation on the probable negative implications of nanomaterials on humans and ecosystems may provide guidance for technology development using these materials. Tiny size of nanoparticles (NPs) may facilitate their easy entry into the human, animal and plant bodies. It has been reported that the size of the NPs are proportional to the toxicity they cause [2,3]. The aluminium oxide NPs are widely used in several clinical applications [4]. Recent studies report DNA toxicity of aluminium oxide NPs without any mutagenic effects [3]. Copper NPs cause liver, spleen and kidney impairment [3]. Under controlled experimental conditions Copper oxide NPs also caused gill lesions to common carp (*Cyprinus carpio L.*) leading to reduced survival rates [5]. Similarly, phytotoxicity of Copper oxide NPs has been observed in *Phaseolus radiatus* and *Triticum aestivum* [1].

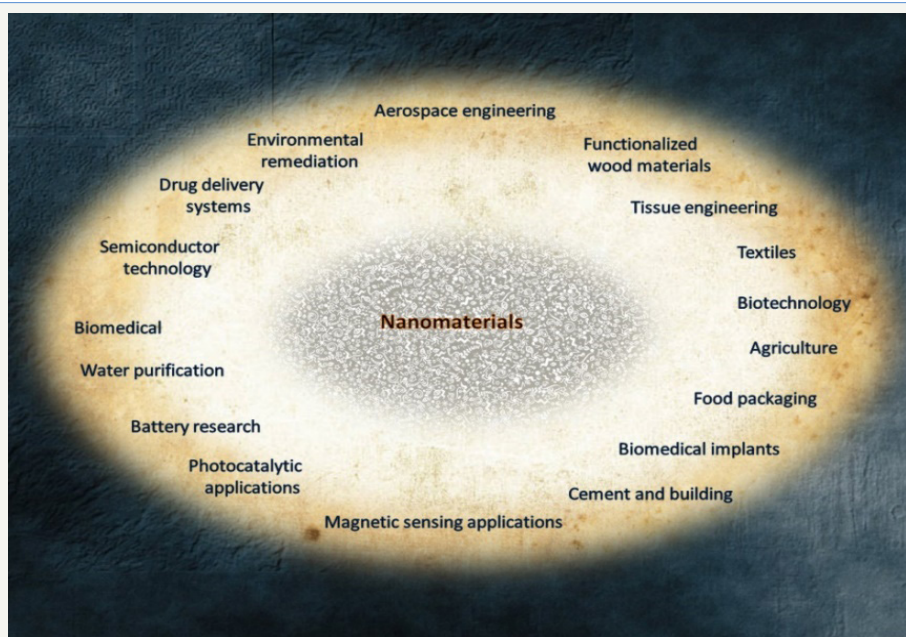


Figure 1: Application of nanomaterials in the research and development.

However, the toxic properties associated with copper NPs are used in developing antimicrobial agents [6]. Silver NPs elicit cytotoxicity leading to reduced cell viability, increased generation of reactive oxygen species and lactase dehydrogenase [3]. Additionally, Silver NPs oxidize intermediary metabolites and damage cell membrane, disrupt ATP production and DNA replication [7]. Toxic effect of mannitol- modified silver NPs at the concentration of 50mgL⁻¹ has been reported in *Drosophila melanogaster* [7]. Silver NPs pose a significant hazard on marine life too [8]. Irrespective of the toxic effects of Silver NPs, researchers use them in devising sensors with increased precision and working [9]. Similarly, zinc oxide NPs cause cell membrane damage and increase oxidative stress [3]. Zinc oxide NPs are equally toxic; both in bulk and nano formulations [10]. ZnO NPs are considered toxic followed by CuO NPs and TiO₂ NPs as per reports [10,11]. With the increase in the concentration of ZnO NPs, the survival capacity of *Daphnia magna* has been reported to decrease [1]. However, ZnO NPs are extensively used in textile industry and U.V. shielding [12].

Despite the advanced applications in chemotherapy and MRI [13,14], Iron Oxide NPs show prominent accumulation in the vital organs of the human body [3]. Titanium oxide NPs used in electrode of desensitized solar cells [15] cause DNA damage and lung inflammation in animals [3]. Al₂O₃, SiO₂ and ZnO nanoparticles have bactericidal effects [11]. Renal toxicity has been observed with NPs of Cadmium sulphide in rats [16]. Polystyrene NPs get accumulated in the yolk sac as early as 24hrs and then migrate to vital organs resulting in reduced heart rate and general functioning [17]. Even though carbon based multi-walled nanotubes are extensively used in various technologies, they cause carcinogenic effect in animals [3]. Silica NPs used in biosensors show mitochondrial damage leading to oxidative stress [3]. Negative impacts of Nanoparticles have been observed on the Environment as well. Toxic effects of NPs have been observed on microalgae [1,18]. NPs have interfered with the removal of COD, nitrogen and phosphorus by CuO, ZnO and TiO₂, and thereby with the efficiency in remediation [18]. The higher concentrations of TiO₂ cause decrease in the density of algae [19]. Graphene oxide NPs cause lethality, free radical formation, reduction on feeding rates and accumulation on alimentary gut of *Ceriodaphnia dubia* [20]. The kinetics and extent of TiO₂ NP adsorption on algae depends highly on pH [10]. The toxicity of TiO₂ has been reported in *Artemia* and Algal cells [2]. The impairment in the physiological intestinal functioning of Zebra fish has been reported on exposure to TiO₂ NPs and biphenol A [21]. Aluminium oxide NPs have been reported to exhibit negative influence on root length, biomass and leaf count of the seedlings in *Nicotiana tabacum* [22]. Toxicity of nanoparticles has been reported in *Raphanus sativus*, *Brassica napus*, *Lolium multiflorum*, *Lactuca sativa*, *Zea mays* and *Cucumis sativus* [23]. On exposure to zinc oxide NPs, rye grass showed decrease in biomass, increased vacuolated epidermis and cortical cells of roots [24]. There has been a decreased survival rates with the increased exposure to copper NPs in *Phaseolus radiates* and *Triticum aestivum* [23]. Silver NPs pose a significant hazard on marine life [8]. Ag NPs are proved to be more toxic as

compared to soluble silver in case of bacteria [25]. Titanium oxide NPs have been reported to elicit greater toxicity in bacteria *Bacillus subtilis*, *Escherichia coli* and *Pseudomonas fluorescens* [11].

Conclusion

In conclusion, there is no technology without some degree of adverse effects. Hence, a methodical scheme has to be developed to check the potential implications of nanomaterials on humans and ecosystems. So far, the past reports are scattered and lack uniformity in the experimental setup and rational enquiry. Guidelines for carrying out research on toxicity assessment of nanomaterials on various organisms have to be scrupulously followed in the assessment of nano-toxicity. The negative connotation attached with nanomaterials may need to be relooked and proper awareness has to be created among laymen and researchers. Follow up mechanisms based on empirical toxicological evidence may need to be taken up to further the development of technologies based on nanomaterials.

References

1. Lee WM, An YJ, Yoon H, Kweon HS (2008) Toxicity and bioavailability of copper nanoparticles to the terrestrial plants mung bean (*Phaseolus radiatus*) and wheat (*Triticum aestivum*): plant agar test for water-insoluble nanoparticles. *Environ Toxicol Chem* 27(9): 1915-1921.
2. Bhuvaneshwari M, Thiagarajan V, Nemade P, Chandrasekaran N, Mukherjee A (2018) Toxicity and trophic transfer of P25 TiO₂ NPs from *Dunaliella salina* to *Artemia salina*: Effect of dietary and waterborne exposure. *Environ Res* 160: 39-46.
3. Bahadar H, Maqbool F, Niaz K, Abdollahi M (2016) Toxicity of nanoparticles and an overview of current experimental models. *Iran Biomed J* 20(1): 1-11.
4. Mukherjee A (2011) Antimicrobial activity of aluminium oxide nanoparticles for potential clinical applications. *Science against microbial pathogens: communicating current research and technological advances* 1: 245-251.
5. Vajargah MF, Yalsuyi AM, Hedayati A, Faggio C (2018) Histopathological lesions and toxicity in common carp (*Cyprinus carpio* L. 1758) induced by copper nanoparticles. *Microsc Res Tech* 81(7): 724-729.
6. Ren G, Hu D, Cheng EW, Vargas-Reus MA, Reip P (2009) Characterisation of copper oxide nanoparticles for antimicrobial applications. *Int J Antimicrob Agents* 33(6): 587-590.
7. Sharma VK, Siskova KM, Zboril R, Torresdey GJL (2014) Organic-coated silver nanoparticles in biological and environmental conditions: fate, stability and toxicity. *Adv Colloid Interface Sci* 204: 15-34.
8. Ellis LA, Baalousha M, Jones EV, Lead JR (2018) Seasonal variability of natural water chemistry affects the fate and behaviour of silver nanoparticles. *Chemosphere* 191: 616-625.
9. Luo X, Morrin A, Killard AJ, Smyth MR (2006) Application of nanoparticles in electrochemical sensors and biosensors. *Electroanalysis* 18(4): 319-326.
10. Aruoja V, Dubourguier HC, Kasemets K, Kahru A (2009) Toxicity of nanoparticles of CuO, ZnO and TiO₂ to microalgae *Pseudokirchneriella subcapitata*. *Sci Total Environ* 407(4): 1461-1468.
11. Jiang W, Mashayekhi H, Xing B (2009) Bacterial toxicity comparison between nano- and micro-scaled oxide particles. *Environ Pollut* 157(5): 1619-1625.

12. Becheri A, Dürr M, Nostro PL, Baglioni P (2008) Synthesis and characterization of zinc oxide nanoparticles: application to textiles as UV-absorbers. *Journal of Nanoparticle Research* 10(4): 679-689.
13. Mahmoudi M, Sant S, Wang B, Laurent S, Sen T (2011) Superparamagnetic iron oxide nanoparticles (SPIONs): development, surface modification and applications in chemotherapy. *Adv Drug Deliv Rev* 63(1-2): 24-46.
14. Qiao R, Yang C, Gao M (2009) Superparamagnetic iron oxide nanoparticles: from preparations to in vivo MRI applications. *Journal of Materials Chemistry* 19(35): 6274-6293.
15. Jung HS, Lee JK, Nastasi M, Lee SW, Kim JY, et al. (2005) Preparation of nanoporous MgO-coated TiO₂ nanoparticles and their application to the electrode of dye-sensitized solar cells. *Langmuir* 21(23): 10332-10335.
16. Rana K, Verma Y, Rani V, Rana SVS (2018) Renal toxicity of nanoparticles of cadmium sulphide in rat. *Chemosphere* 193: 142-150.
17. Pitt JA, Kozal JS, Jayasundara N, Massarsky A, Trevisan R, et al. (2018) Uptake, tissue distribution, and toxicity of polystyrene nanoparticles in developing zebrafish (*Danio rerio*). *Aquat Toxicol* 194: 185-194.
18. Zhang X, Zhou Y, Xu T, Zheng K, Zhang R, et al. (2018) Toxic effects of CuO, ZnO and TiO₂ nanoparticles in environmental concentration on the nitrogen removal, microbial activity and community of Anammox process. *Chemical Engineering Journal* 332: 42-48.
19. Wright MV, Matson CW, Baker LF, Castellon BT, Watkins PS (2018) Titanium dioxide nanoparticle exposure reduces algal biomass and alters algal assemblage composition in wastewater effluent-dominated stream mesocosms. *Sci Total Environ* 626: 357-365.
20. Souza JP, Venturini FP, Santos F, Zucolotto V (2018) Chronic toxicity in *Ceriodaphnia dubia* induced by graphene oxide. *Chemosphere* 190: 218-224.
21. Chen L, Guo Y, Hu C, Lam PKS, Lam JCW, et al. (2018) Dysbiosis of gut microbiota by chronic coexposure to titanium dioxide nanoparticles and bisphenol A: Implications for host health in zebrafish. *Environ Pollut* 234: 307-317.
22. Burklew CE, Ashlock J, Winfrey WB, Zhang B (2012) Effects of aluminum oxide nanoparticles on the growth, development, and microRNA expression of tobacco (*Nicotiana tabacum*). *PloS one* 7(5): e34783.
23. Monica RC, Cremonini R (2009) Nanoparticles and higher plants. *Caryologia* 62(2): 161-165.
24. Lin D, Xing B (2008) Root uptake and phytotoxicity of ZnO nanoparticles. *Environ Sci Technol* 42(15): 5580-5585.
25. Buffet PE, Zalouk-Vergnoux A, Châtel A, Berthet B, Métais I, et al. (2014) A marine mesocosm study on the environmental fate of silver nanoparticles and toxicity effects on two endobenthic species: the ragworm *Hediste diversicolor* and the bivalve mollusc *Scrobicularia plana*. *Science of the Total Environment* 470-471: 1151-1159.



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