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NANOPARTICLES TOXICITY IN FISHES

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AUTHOR'S CHAPTER

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Review Article

ABSTRACT

Nanoparticles have a size between 1 to 100 nm. Nanoparticles have applications in the production of agrifood, biomedical products, fertilizers, herbicides, pesticides, sensors, food processing, food packaging, nutraceuticals, diagnosis, drug delivery and treatment of diseases. Nanoparticles easily enter the environment unimpeded, entering soil, water and air through various anthropogenic activities. In water, fishes quickly ingest or inhale these nanoparticles. Due to their small size, nanoparticles easily enter the body and affect various tissues, and they also easily cross the blood-brain barrier. This results in different toxic effects on the fishes, an essential part of our ecosystem. Studies and research on fishes have revealed that various nanoparticles damage the gills, liver, intestine, brain, and enzyme system of fishes. They also lead to decreased heart rate, curvatures of the axis, delayed or early hatching, osmoregulatory failure, and genotoxic effects in fishes. Cerium oxide nanoparticles induced fish mortality in Rainbow trout at an initial concentration of 10 µg/L in tap and green waters. Studies on cell lines of various fish species such as rainbow trout, fathead minnow, zebrafish, goldfish, and haddock have proved that Silica nanoparticles are toxic to their epithelial tissues of skin and gills. These findings agree with similar human and mouse cell studies reported to date. If the nanoparticles accumulate in the fish tissue and the same fishes are consumed by the organisms from other trophic levels, the nanoparticles accumulate, leading to biomagnification. The release of nanoparticles in the environment must be checked and reduced. And further detailed research needs to be carried out on the effects of nanoparticles in fishes, humans, and other animals.

Keywords: Nanoparticles; fishes; silver nanoparticles; gold nanoparticles.

1. INTRODUCTION

Nanotechnology is a new area in science, and it is making a lot of advancements concerning the development of functional, engineered nanoparticles. Today, various nanoparticles from metals have been developed and exploited widely for many medical applications [1].

Nanoparticles are between 1 to 100 nm and are developed for use against diseases such as rheumatic diseases, malaria, asthma and HIV/AIDS. Gold

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nanoparticles are favored over silver nanoparticles as they are more stable, inert and biocompatible. The gold nanoparticles are used in diagnosis, drug delivery and treatment of diseases as they can quickly enter the cell and bind strongly to the amine and thiol groups. The gold nanoparticles have shown very few side effects in the patients [2].

Fishes are a vital chordate organism in the hydrosphere. They are found in all the water bodies such as ponds, lakes, rivers, seas, and oceans worldwide. As per estimates, there are about 32,000 fish species worldwide. The fishes are available in various sizes, from a cyprinid fish, the world's smallest fish, only 0.3 inches long, while the Whale Shark is one of the world's largest at over 30 feet long. The fish and fisheries provide food to the billions and livelihoods for millions of people worldwide. Fishes contribute immensely to their ecosystem by providing the essential nutrients that support the whole ecosystem. Worldwide, the fish population is decreasing due to many reasons, such as overfishing and climate change, and a critical reason is an aquatic pollution. Aquatic pollution happens in many forms, and there are different sources, such as the chemicals from the production plants, plastics from waste facilities, and fertilizers from agriculture. Now new observation is through the nanoparticles introduced into the aquatic system. The end result is the same: it severely harms or kills the fish [3].

Scientific proofs suggest that certain nanometals can bring a range of sublethal effects in fishes, including respiratory toxicity, disturbance in trace elements in tissue, inhibition of sodium-potassium – ATPase and oxidative stress. Organ damage due to nanometals has been found in various organs, including the gills, liver, intestine, and brain of fishes. Effects on early stages of fishes have been detected with reports of nanometals crossing the chorion, basically the Silver nanoparticles. Nano forms of some metals example, Copper nanoparticles and Zinc oxide nanoparticles, can be more toxic to the fish embryo and juveniles than the equivalent metal salts [4].

It was observed that there was an increase in stress molecules HSP 70 levels with an increase in the concentration of silver nanoparticles in young salmons. The Sodium – Potassium ATPase inhibition was observed, and it increased with an increase in exposure to silver nanoparticles, resulting in the osmoregulatory failure in Salmon. A concentration of silver nanoparticles at 100 μg/L has led to necrosis of gill lamellae and mortality of 73 % of fishes. In juvenile zebrafishes, the LC-50 was recorded at a concentration of 1.78 mg/L for dissolved Copper and 0.71 mg/L for Copper nanoparticles showing that the metallic nanoparticles are more lethal than the soluble forms [5].

Studies on embryos of Zebrafish have revealed that exposure to positively charged gold nanoparticles has caused malformation in the development of the eye and pigmentation and resulted in behavioral changes and damage to the nervous system. Titanium dioxide nanoparticles induce early hatching in zebrafish embryos. This was due to the obturated chorion pore canals entirely caused by the Titanium dioxide nanoparticles. In the embryos of Zebrafish, mortality and malformations such as the reduction in thickness of the intestine were seen upon exposure to nickel nanoparticles. Similarly, the Platinum nanoparticles exposure has resulted in decreased heart rate, curvatures of the axis and delayed hatching in Zebrafish embryos [5].

2. EFFECT OF NANOPARTICLES

The effect of cadmium sulphide nanoparticles has been studied in the gills of a freshwater fish Channa punctatus. It was noted that the exposure of Channa punctatus to cadmium sulphide nanoparticles caused injury to gill epithelium, loss of mucous cells and appearance of a higher number of vacuolated cells [6].

Silver nanoparticles have been reported to affect accumulation, DNA, development, and reproducibility. In the study on freshwater fish, Cyprinus carpio's effects on survival, embryonic growth, and pigmentation at high concentration exposure of silver nanoparticles have been seen [7].

Silicon dioxide nanoparticles are widely used in medicine, engineering and industries. Oreochromis mossambicus was exposed to a sublethal concentration (12 mg/L) of Silicon dioxide nanoparticles. After the exposure reduction in the activities of antioxidant enzymes, superoxide dismutase, catalase, glutathione reductase and glutathione peroxidase with a concomitant increase in the production of hydrogen peroxide and lipid peroxidation was observed. Liver tissue also showed induction of oxidative stress, which was evident by the significant decrease in the activities of antioxidant enzymes and the generation of hydrogen peroxide and lipid peroxidation [8].

Exposure of Titanium dioxide nanoparticles to Oncorhynchus mykiss, rainbow trout, has caused respiratory problems and other sublethal effects in the fish. Nanoparticles have a significant impact on Oryzias latipes medaka fish and their embryos. Nanoparticles were detected in the brain, testis, liver, and blood of medaka. Micropterus salmoides, Largemouth bass, when exposed to C60 fullerenes, show significant lipid peroxidation in brains. Total glutathione levels were also marginally depleted in the gills of this fish [9].

Iron oxide nanoparticles induce genotoxic effects in common carps by increasing the frequency of micronucleus and other abnormalities of the red blood cell core during a concentration-dependent process. So, if the Iron oxide nanoparticles are released into the environment, it will probably bring adverse effects on aquatic ecosystems [10]. Cerium oxide nanoparticles induced fish mortality at an initial concentration of 10 µg/L in both tap and green waters but not in brown waters, which have different and high organic matter sources, lower pH and conductivity values [11] Studies on cell lines of various fish species such as rainbow trout, fathead minnow, zebrafish, goldfish, and haddock have proved that Silica nanoparticles are toxic to their epithelial tissues of skin and gills. These findings agree with similar human and mouse cell studies reported to date [12].

3. DISCUSSION AND CONCLUSION

Nanoparticles have a size between 1 to 100 nm. Nanoparticles have applications in the production of agrifood, biomedical products, fertilizers, herbicides, pesticides, sensors, food processing, food packaging, nutraceuticals, diagnosis, drug delivery and treatment of diseases. Nanoparticles easily enter the environment unimpeded, entering soil, water and air through various anthropogenic activities. In water, fish quickly ingest or inhale these nanoparticles. Due to their small size, they enter the body and affect different tissue, and they also easily cross the blood-brain barrier. This results in other toxic effects on the fish, an essential part of our ecosystem. Studies and research on fishes have revealed that various nanoparticles damage the gills, liver, intestine, brain and even enzyme system of fishes. Platinum nanoparticle exposure has resulted in decreased heart rate, curvatures of the axis and delayed hatching in Zebrafish embryos. Titanium dioxide nanoparticles cause early hatching in Zebrafish embryos.

Silver nanoparticles resulted in osmoregulatory failure in Salmon fish. Cerium oxide nanoparticles induced fish mortality in Rainbow trout at an initial concentration of 10 µg/L in tap and green waters. So Cerium oxide release in any water body must be avoided [11]. Iron oxide nanoparticles induce genotoxic effects in common carps. So, if the Iron oxide nanoparticles are released into the environment, it will probably bring adverse impacts on aquatic ecosystems [10] Studies on cell lines of various fish species such as rainbow trout, fathead minnow, zebrafish, goldfish, and haddock have proved that Silica nanoparticles are toxic to their epithelial tissues of skin and gills. These findings agree with similar human and mouse cell studies reported to date [12].

Suppose the nanoparticles accumulate in the fish tissue, and the organisms consume the same fish from another trophic level. In that case, the nanoparticles accumulate, leading to biomagnification. The release of nanoparticles in the environment must be checked and reduced. And further detailed research needs to be carried out on the effects of nanoparticles in fishes [13]. The nanotoxicity studies that have been carried out in the fishes suggest that such studies must also be carried out in humans and other animals in the future to find out the adverse effects of various nanoparticles on them.

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