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Applications of nanoparticles in aquaculture

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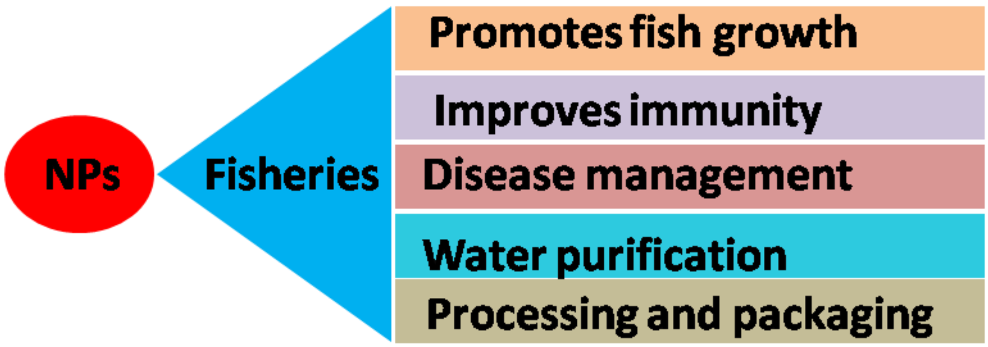
Introduction

Nanoparticles (NPs) are small particles made of single or multiple materials having at least one dimension in nanoscale ranging from 1 to 100 nm. The outstanding features of NPs, such as larger surface area and high particle number per mass unit as compared to their bulk material, superior mechanical performance, possibility of surface functionalization makes them perfect candidate for wide applications. The main factors that make the NPs significantly different from the larger size material are the surface effects and quantum effects. These effects provide them many enhanced features in terms of mechanical, thermal, magnetic, electronic, optical, and catalytic properties. NPs can be of different shapes such as spherical, conical, cylindrical, tubular, and spiral. They are generally classified into three groups, organic, carbon-based, and inorganic NPs based on their composition. Organic NPs are made of proteins, carbohydrates, lipids, polymers, or any other organic compounds. Carbon-based NPs are made exclusively from carbon atoms while the inorganic NPs (for example metal NPs) are prepared differently from the other two classes.

Synthesis of nanoparticles

The processes for synthesis of NPs are categorized into bottom-up (arranging atom by atom) or top-down (converting large materials to nanoscale) method. The most commonly used bottom-up methods are sol-gel, spinning, chemical vapour deposition (CVD), pyrolysis and biosynthesis. Among these, sol-gel is the most preferred method due to its simplicity and suitability to synthesize most of the NPs. For large scale production of NPs in industries, pyrolysis method is mainly followed. While the other methods use conventional chemicals, biosynthesis, a environmental friendly approach is a method for the synthesis of nontoxic and biodegradable NPs using bacteria, plant extracts, fungi, etc. The top-down method involves the reduction of a bulk material to particles of nanoscale size. Some of the most widely used top-down processes are thermal decomposition, mechanical milling, nanolithography, laser ablation, and sputtering.



Schematic diagram showing effects and uses of nanoparticles in fisheries sector

Applications in aquaculture

Aquaculture is considered as a fast-growing industry playing an important role to meet the demands of protein by the increasing population. Global consumption of food fish has increased and side by side the production has also escalated. However, there are concerns about the sustainability of aquaculture due to many challenges like environmental pollution, prevalence of diseases causing unwanted impact on productivity and production. So, various technical innovations or strategies need to be applied to increase the productivity, for successful breeding, for management of water quality and diseases in fish. Among these, nanotechnology has number of potential applications such as in production of effective fish feed, in aquariums and management of water qualities. Some of the applications of NPs in aquaculture are listed below.

1. Feed supplement: Fish feed incorporated with nano-selenium and NPs of iron can enhance weight gain and their antioxidant status. Fish fed with nano-selenium has more selenium content in the muscle. Also, addition of selenium, zinc and manganese NPs in feed of early stage improved stress resistance and mineralization of bone. Manganese NPs promoted growth and antioxidant system in freshwater prawn. Copper NPs improved the digestive enzyme activities, antioxidant system and non-specific immune response in freshwater prawn and red sea bream. *Azolla microphylla* based

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gold NPs increases hepatoprotective activity and antioxidant effects against chemical induced toxicity in common carp. Aloe vera NPs supplemented feed promote the growth of Siberian sturgeon.

2. Disease control: Nano-delivery system is an alternative strategy for delivery of vaccines in fish which enhance the efficacy and is also safer. For example, alginate particles are used for oral delivery of vaccines to aquatic animals. Chitosan, a biopolymer found in the exoskeleton of crustaceans and insects are used for preparation of formulations for delivering different kinds of vaccines in fish. Another biodegradable polymer, Poly (D,L-lactic-co-glycolic acid) is used for encapsulation and delivery of different compounds in fish. This compound when used for encapsulating DNA vaccine showed improved immunological parameters in Japanese flounder. Ginger NPs can protect common carp fingerlings from motile *Aeromonas* septicaemia. Neem based silver NPs can improve immunomodulatory and antibacterial activity in mrigal (*Cirrhinus mrigala*).

3. Water quality management: Nano-device has the ability to reduce the rate of water exchange and increase the quality of water. Nanoscale iron powder can also be used for the cleaning of less toxic, simpler carbon compounds from water. Silver, copper, zinc and chitosan nanoparticles in different forms are used for removal of microbial contaminants such as *Escherichia coli*, *Enterococcus* faecalis, *Cryptosporidium parvum*, *Staphylococcus aureus.* Other nanoparticle systems of titanium dioxide, silicon dioxide, nanocrystaline cellulose, graphene oxide, iron–aluminium oxide are used to remove contaminants like aureomycine hydrochloride, fluoride, lead, mercury etc.

4. Fish harvest and processing: Fishing lures nano-coated with a polyimide film increases the probability of catching fish two to three times. NPs can be used in processing and packaging to extend the shelf life and also to preserve the freshness and quality. For example, silver NPs integrated nano-ice reduced the microbial load and also inhibit the growth of *Acinetobacter* on flathead grey mullet. Chitosan NPs are effective antibacterial agent that can form an edible coating material for sea foods to reduce microbial load and extend the shelf life.

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