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A Minireview on Nanotechnology as an Innovative Tool for Sustainable Aquaculture

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Aquaculture has a vital role in the global food production as a poverty alleviator during the last few decades. Despite the tremendous benefits provided to the mankind aquaculture production system still faces many challenges like, disease outbreak, environmental calamities, water pollution and so on. To overcome these circumstances, it is mandatory to accept the most recent techniques like nanotechnology which may help to boost the aquaculture production at an incredible level. Nanotechnology is a new tool of biotechnology with implausible potential in vast areas of aquaculture like nutrition, detection of pathogens, water purification to name but a few. Its application in aquaculture may help to improve the productivity at a fast pace. This review article presents the current advancements of nanotechnology and its applications in several areas of aquaculture.

Keywords

Aquaculture, Nanotechnology, nutrition, water purification

Introduction

Aquaculture plays a crucial role in food security as a source of essential protein requirement for the ever-increasing population. However, apart from focusing only on traditional methods, aqua culturists nowadays practice innovative methods like nanotechnology to improve the fish culture system in an economic and sustainable manner. Novel advancements like nanotechnology not only improve the efficacy of the aquaculture production system, but it paves the way to find out more and more technological innovations in the field. Applications of nanotechnology in aquaculture is manifold like treatment of water, disease control, feed management, sterilization of ponds and tanks, disease control and so on. Nanotechnology involves the use of tiny nanoparticles with a size range between 1 to 100 nanometres in wide areas such as chemistry, physics, biology and engineering (Fajardo *et al.* 2022). The nanoparticles comprise of numerous dimensions of structural elements such as nanoclusters, quantum dots, nanospheres, nanotubes, graphene layers and dendrimers and so on (Shah and Mraz 2019). Some other types of nanoparticles included silver-based nanoparticles, Cu based nanoparticles, metal oxides nanoparticles which exhibit fewer toxicity than their biological materials (Munawar *et al.* 2021). The unique properties of nanoparticles are attributed to their small size, surface area, physical and chemical properties (Can *et al.* 2011). This article presents a review of nanotechnology and its applications on different areas in aquaculture.

Nanotechnology as a disease control tool in aquaculture

Nanotechnology is an effective technique used nowadays to reduce the detrimental effects of pathogens in the culture organisms. Some studies explained the harmful impact of antibiotics used in aquaculture rather than its advantages as a disease control agent (Nasr- Eldahan *et al.*, 2021 and Seethalakshmi *et al.*, 2021). Ineffectiveness of antibiotics like resistance and biological carrying in water and adverse effects of probiotics in host cells like increase in histamine levels and bacterial toxicity may lead to organ failure made them replaced by the use of vaccination. Nanoparticle incorporated vaccines improve the immune system of the fishes with least or no side effects and inhibits the spread of infectious diseases due to the similarity in size of nanoparticles and pathogens. Further, replacement of oil emulsion by nanoparticle carriers like chitosan and poly-lactide-co-glycolide acid (PLGA) as adjuvant may give more immunity to aquatic organisms with least side effects (Rather *et al*., 2011). Several nanoparticles are extensively used as a drug carrier agent due to its exclusive characteristics such as least side effects, method of transferring, maintaining safety and way of delivery. For instance, Poly D, L-lactide-co-glycolic acid (PLGA), and polymeric chitosan nanoparticles are used as vectors in the delivery of drugs in cultivable aquatic organisms. Apart from this, some other nanomaterials like gold nanoparticles are extensively used in the quick diagnosis of diseases in finfishes and shellfishes (Wahab *et al.*, 2022). Nanotechnology incorporated biosensors such as sensitized carbon nanotubes are also successfully used in aquaculture for the detection of microbes, parasites and heavy metal toxins (Haldar and Nath, 2020).

Nanotechnology in treatment of water

Adequate decontaminated water is the primary requirement of an aqua farm and unfortunately the existing water treatment systems are not carried out in a sustainable way and require huge infrastructure facilities and procedures to overcome these limitations. Applications of nanotechnology using nanoparticles seems very effective in removing toxins and pollutants from wastewater (Amin *et al.*, 2014). Evidences shows that nanomaterials such as nutraceuticals in water can improve fish growth and

metabolism. In addition, silver nanoparticle in water filtration system has been very effective for the eradication of fungal diseases in some fishes like rainbow trout (Nasr- Eldahan *et al.*, 2021). Munawar *et al.* (2021) also explicated the multiple roles of silver- based nanoparticle in diagnosing diseases and removing heavy metal contaminants from water.

One of the major problems seen in aquaculture is the pollution of water by means of different types of contaminants such as food waste, chemical waste, pathogenic microorganism etc. Some studies showed the possibility of titanium dioxide as a water purifying agent owing to their photocatalytic activity to kill wide varieties of microorganisms (Fajardo *et al.*, 2022). Furthermore, some experts point out that the effectiveness nanoparticles for the elimination of microorganisms, heavy metals, organic and inorganic compounds due to its high absorption, microfiltration and reaction capabilities (Bhattacharya *et al.*, 1998 and Amin *et al.*, 2014). Moreover, some experimental evidences confirmed that nano photocatalysts are chemically stable, inexpensive, and easily available and so in huge demand. In addition, due to its layered structure, high optical absorption coefficient and fine band edges it is very effective in removing pollutants from water (Ahmed *et al.*, 2022). Some other studies also disclosed effectiveness of nanotechnology in the treatment of effluents for maintaining sustainable aquaculture practices (Ogunfowora *et al.*, 2021). They stated about the efficacy of nano-clays and nanotubes in mitigating the quantity of pollutants from waste water by a process known as adsorption. However, due to the toxicity of nano – clays they recommended to use less toxic nanomaterial like gold nanorods doped poly composites in the treatment of aquaculture effluents.

Nanotechnology in aquaculture nutrition

In the nutritional point of view, nanoparticles can create positive impact on improving the nutritional qualities of aquaculture feed and feed ingredients. Shah and Mraz (2019) explained with evidence that dietary supplements like nutraceuticals can better incorporated into the diet with the help of nanotechnology and thereby improving their solubility in the gut. In this view point, growth rate of common carp is found to be upsurged by the addition of 1 mg of nano-Selenium (Se) per kg of fish feed. It has been detected that iron and selenium nano particle supplemented feed could improve fast growth rate in carp and surgeon fishes (Bhattacharya *et al.*, 2015). According to Sahraei *et al.* (2020) a notable improvement in the growth performance occurred in common carp fed with iron- and Zinc nanoparticles incorporated feed. Zinc oxide derived nanoparticles have the potential to overcome zinc deficiency in fishes. Dramatic growth increments exhibited in fingerlings of *Labeo rohita* fed with different concentrations of ZnONP-supplemented diet in an experiment done by Thangapandiyan and Monika. (2019. Similarly, an upsurge in muscle biochemical concentration, haematological parameters and production of digestive enzymes were also observed in the same study. Likewise, biochemical parameters such as carbohydrate, protein and lipid in muscle, gill and liver of Koi Carp *Cyprinus carpio* got increased by the dietary supplementation of zinc oxide nanoparticles (Soundhariya and Rajan, 2021).

Kumaran *et al*. (2020) elucidated the role of chitosan-based nanoparticle as an antimicrobial agent in pharmaceutical industries. Excellent biological and physicochemical properties such as biodegradability, perishability, adhesiveness and nontoxic nature made chitosan an appropriate candidate for developing drug delivery systems. Chitosan compound is extracted from easily available sources such as the exoskeletons of the crustaceans, crabs, and shrimps and used in aqua feed formulation. Seerengaraj *et al.* (2021) opined that dietary chitosan nanomaterial has beneficial impact on improving the growth performance in some

fishes. In addition, the study mentioned about the beneficial impact of antioxidant activity of chitosan nanoparticles specifically when orally administered.

Applications of nanotechnology occupies tremendously in the seafood sector also by improving the texture, flavour, detecting pathogens and nutrient absorption. In other words, it is a type of value addition technology used to enhance nutritional value of any sea food products which helps to earn foreign exchange. To cite an example, nanoparticle hydrophobic beta- carotene is extensively used for the preservation of proteins, vitamins, minerals and other nutrients in seafood (Ogunkalu, 2019). There are other manifold applications of this technology in the processing sector like, enhancing bioavailability, protection from microbial attack, carrier of nutrients, and as an additive (Can *et al.*, 2011).

Conclusion

This study recommends the use of nanotechnology owing to its effectiveness to mitigate the glitches in the field of aquaculture with the evidence of approved results. Moreover, nanotechnology based affordable technologies provided numerous solutions to control diseases, purification of water and removing pathogens in culture systems particularly in a sustainable manner. Correspondingly, in the nutritional perspective, lots of experiments with nanotechnology have been carried out until now due to the needfulness of nutrient rich aquaculture production for the betterment of society.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

Conflict of interest

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