Application of nanotechnology in diagnosis, prevention, and treatment of the fish diseases

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Abstract

The occurrence of the disease is one of the main threats to the intensive aquaculture system. With the development of the aquaculture industry, it is expected that the fish will encounter various infectious and non-infectious diseases. In addition to treatment costs, the use of antibiotics in the control of infectious diseases can also cause resistance in bacteria. Therefore, today, the use of additives such as vitamin and mineral supplements, probiotics, prebiotics, and various nanoparticles to improve the growth performance and health of fish, increase the performance of the fish immune system, and resistance to diseases has expanded. The aim of this study was the investigation of the use of anotechnology in aquaculture and effect of it on fish species health, the use of them in nanocarrieres, nanovaccine, nanosensores, etc. According to the increasing trend of studies in the field of nanotechnology, we can hope to provide other new methods in the field of health management of fish farms and prevent damages caused by the occurrence of diseases in the aquaculture industry.

Keywords: Nanoparticle, Fish, Disease, Nanovaccine, Nanosensors, Drug delivery

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Application of nanotechnology in aquaculture

With a size between 1 and 100 nm on at least one dimension (Baig *et al.*, 2021), nanoparticles present unique physicochemical properties that differ from their bulk materials such as a greater surface area to volume ratio, resulting in a larger reactivity. Relative size of nanoparticles compared to the size of different aquatic organisms is shown in Figure 1. The use of nanotechnology in various sciences, including aquaculture, is expanding. Nanotechnology has been growing explosively worldwide and become a ubiquitous tool for solving various aquaculture problems (Figure 2), including fish nutrition, water quality management, and disease treatment (Khan *et al.*, 2020).

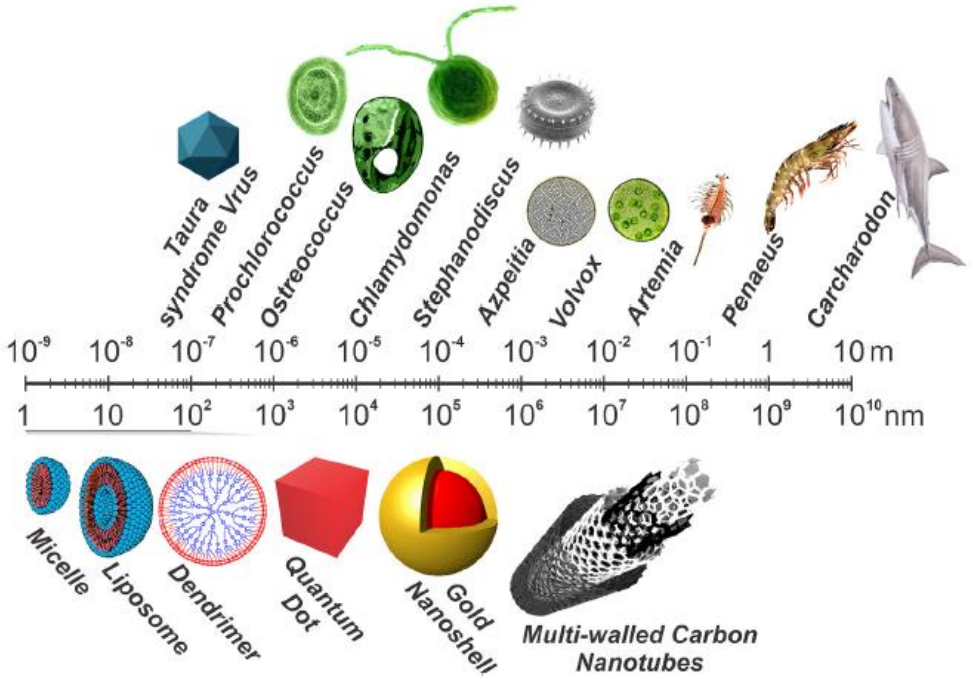

Fig. 1. Relative size of nanoparticles compared to the size of different aquatic organisms (Fajardo *et al.*, 2022)

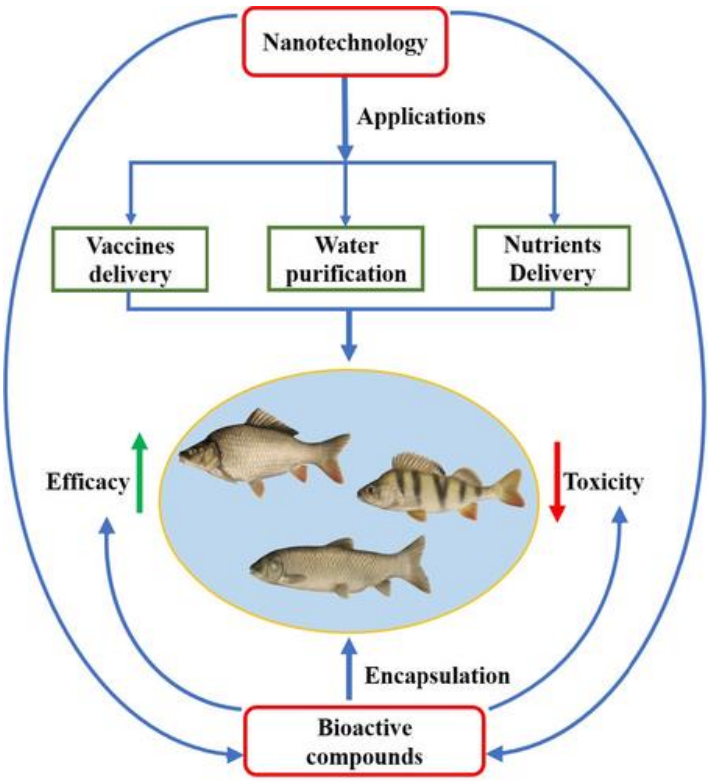

Figure 2: schematic representation of nanotechnology applications in aquaculture (Shah and Mraz, 2020).

Fish disease in aquaculture

The occurrence of diseases is one of the main threats to the intensive aquaculture system (Toranzo *et al.*, 2005). With the development of the aquaculture industry, it is expected that the fish will encounter various infectious and non-infectious diseases. Diseases can reduce reproductive performance and have a negative impact on feed conversion efficiency leading to reduced growth and overall performance of cultured fish (Tavares-Dias and Martins, 2017). In addition to treatment costs, the use of antibiotics in the control of infectious diseases can also cause resistance in bacteria, so, new antibacterial agents such as nanoparticles should be used.

Disease prevention is based on three methods including:

1. preventing pathogens from entering the farms
2. destruction of pathogenic agents using disinfectant compounds and also the use of physical methods
3. Strengthening the immune system of farmed fish by using natural plant stimulants and synthetic immune system such as probiotics, prebiotics, and synbiotics and vaccines.

Today, the use of additives such as vitamin and mineral supplements, probiotics, prebiotics, and various nanoparticles to improve the growth performance and health of fish, increase the performance of the fish immune system, and resistance to diseases has expanded.

Nanotechnology and fish disease management

Nanotechnology can play a role in the diagnosis, prevention, and treatment of diseases through new methods. Nanoparticles can act in fish disease control. The application of nanotechnology in the field of diagnostic tools like nanosensors is expanding; for example, gold nanoparticles are used in antibody-based immunodiagnosis protocol (Thiruppathiraja *et al.,* 2011). In addition to diagnosing diseases, nanotechnology is also widely used as nanomedicine, which is a developing industry and is effective in maintaining the health of fish. In this regard, the inherent properties of various forms of nanoparticles are used to improve fish health. Silver, zinc oxide, titanium dioxide, copper oxide, and graphene nanoparticles are currently used to reduce the pathogenic load in the aquaculture system (Siddiqi *et al.,* 2018). Mechanisms of action of silver nanoparticles for antimicrobial effect is shown in Figure 3.

Different nanocarriers such as chitosan, liposomes, polymeric nanoparticles of poly (lactic-co-glycolic) acid (PLGA) are used for drug delivery (Sarkar *et al.,* 2022). On the other hand, nanoparticles are used as nanocarriers. The Schematic representation of the nanocarriers is shown in Figure 4.

Vaccines are used as one of the important tools to prevent the occurrence of diseases in aquaculture, but vaccines have limitations, most of the vaccines used are stored and stored in liquid form at low temperatures and are usually administered intravenously due to their short shelf life. "Nanovaccine" is a future mass vaccination method in aquaculture due to the reduction of these limitations. For example, in Asian sea bass (*Lates clacrifer*) oral delivery of DNA vaccine using chitosan nanoparticles protect it from *Vibrio* (*Listonella*) *anguillarum* (Rajesh Kumar *et al.,* 2008). Recently an ultrasound device was designed for mass vaccination of fish.

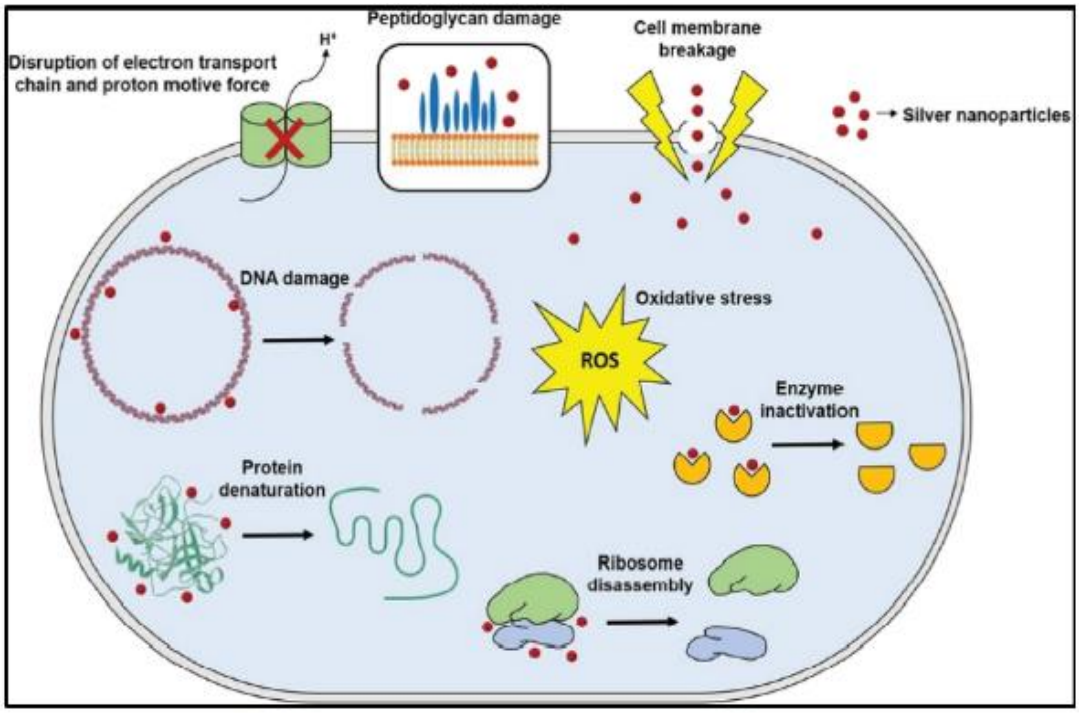

Fig. 3 Mechanisms of action of silver nanoparticles for antimicrobial effect (Roy *et al.*, 2019).

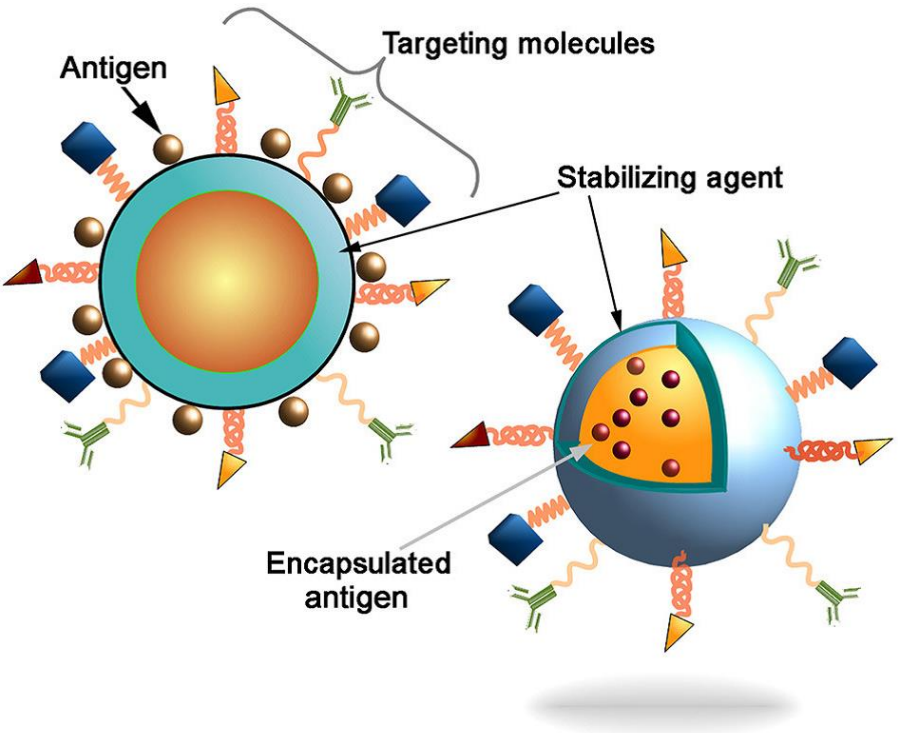

Figure 4: Schematic representation of the nanocarriers (Pati *et al.*, 2018).

Plant extracts are also used in nano form as medicine in the treatment of fish diseases and are more environmentally friendly than chemically synthesized nanoparticles.

Phytotherapy and its nanoformulation as disease management in the aquaculture sector are presented in Fig 5. There are some studies on plant extract based nanoparticles use in aquaculture (Korni and Khalil, 2017; Sharif Rohani *et al.*, 2017; Awad *et al.*, 2020; Baldissera *et al.*, 2020; Kurian and Elumalai, 2021; Paulpandian *et al.*, 2022; Nirmalkar *et al.*, 2022).

The use of nano-delivery of drugs is expanding with new features such as sustained release, regulation and control of size, shape, dispersion, and surface charge of target materials, specific location, multi-pathway delivery processes, and regulated degradation capability of the nanocarrier. Different parts of plants such as flowers, fruits, stems, leaves and roots containing phytochemicals have been used in various studies on plant-mediated synthesis of metal-based nanoparticles (Husen, 2017; Adeyemi *et al.*, 2019).

As a conclusion, according to the increasing trend of studies in the field of nanotechnology, we can hope to provide other new methods in the field of health management of fish farms and prevent damages caused by the occurrence of diseases in the aquaculture industry.

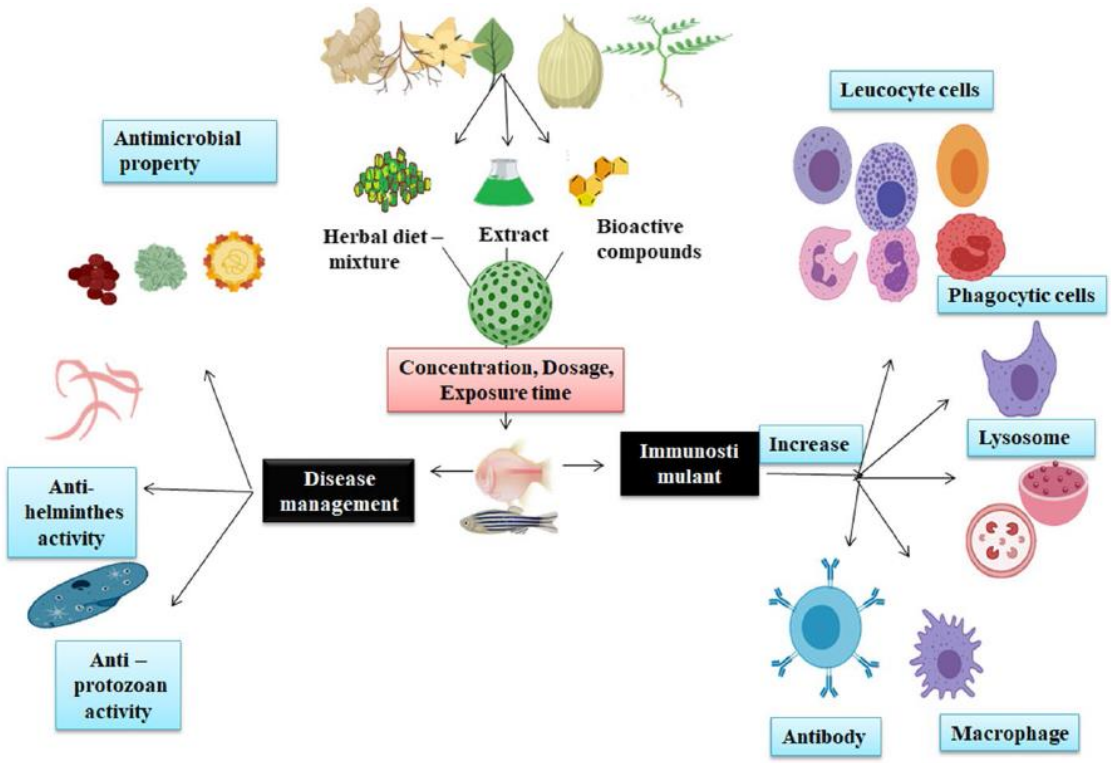

Figure 5: Phytotherapy and its nano formulation as disease management in the aquaculture sector (Jeyavani *et al.*, 2022).

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