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Pharmaceutical Applications of Fishery Byproducts – An Overview

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Abstract

The aquaculture is a rapidly growing sector globally. The purpose of this sector is to address global food insecurity and poverty, contribute to livelihood and coastal community resilience, and reduce pressure on wild capture fisheries, thereby protecting the natural habitat (Yaparatne et al., 2024). Aquaculture faces several challenges that limit its sustainable growth and global expansion. These include increasing demand for production, weak biosecurity measures to control waterborne diseases, inefficient use of water resources, and the harmful environmental impact of wastewater. Nanotechnology offers promising solutions to these issues by improving production efficiency, enhancing disease control, and enabling the reuse of water. This highlights a key research area where nanotechnology can help address major problems in aquaculture. Nanobubbles (NBs) are tiny gas bubbles in water, each smaller than 1 micron in diameter. They are a part of nanotechnology and are gaining attention in aquaculture because they can help improve fish growth, keep animals healthier, and maintain cleaner water. NBs are formed by mixing gas (like oxygen or ozone) into water under high pressure and then releasing it. Unlike regular bubbles, NBs are so small that they stay suspended in water for a long time without rising to the surface and bursting. In aquaculture, nanobubbles can increase oxygen levels in water, help remove harmful substances, and even reduce the spread of diseases. Many studies suggest that NBs could be a game-changer for making aquaculture safer and more sustainable. However, since this technology is still new, more research is needed to understand how effective, safe, and affordable it really is.

NBs for improving aquaculture production

A study primarily aimed at promoting the growth of sweetfish and rainbowtrout, revealed that there is a > 4-fold increase in oxygen concentration after running the NB aerator for 30 min (Ebina *et al.,* 2013). In the RAS system, where NB technology was applied found

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that there was a significantly higher average final weight, specific growth rate, and productivity of the grouper fish, i.e, *Epinephalus sp* (Hanif *et al.,* 2021). The Nile tilapia *(Oreochromis niloticus)* farming using NB technology for aeration increased the erythrocytes and leucocytes in the blood of tilapia (Gunanti *et al.,* 2019). Moreover, in the farming of whiteleg shrimp *(Litopenaeus vannamei)* where NB was used, there was increased total harvest, higher productivity and survival rate, significantly higher weight and length of the shrimp (Rahmawati *et al.,* 2021). The higher DO values for good growth of fish are imperative and this can be achieved with the aid of NB promoting significantly higher productivity, higher final weight, and higher specific growth rate.

Effects of NBs in shrimp farming

Air-enriched nanobubbles (NBs) have been shown to improve the dissolved oxygen levels in water and increase oxygen consumption in shrimp. When pure oxygen is used to generate NBs, the benefits are even greater. These bubbles not only provide the oxygen needed for better growth of aquaculture animals but also support a healthier gut environment in shrimp by promoting beneficial probiotics. A study found that in whiteleg shrimp farming, there was an increase in the beneficial bacteria *(Rhodobacter, Oscillospira, and Faecalibacterium)* in the shrimp intestine after using NB technology (Xu et al., 2022)

One of the major issues in shrimp farming is disease outbreaks caused by poor water quality. NB treatment helps improve water conditions, which leads to a significant reduction in disease incidence. As a result, there is less need for antibiotics in shrimp farming, making the practice more sustainable and environmentally friendly.

NB for aquaculture wastewater treatment

With the advent of rapid development of aquaculture, its wastewater is a major problem. The impact of this aquaculture wastewater is the altered growth and reduced resistance to infection in species reared in aquaculture systems. The NBs technology has some unique properties, such as mass transfer for gas supply, its adsorption, aggregation, and flocculation, which generate ROS and disinfect water (Magda leno et al., 2023; Yaparatne et al., 2022). These properties of NBs technology could be foundational in future wastewater treatment. Moreover, NB assisted wastewater treatment works on some important properties of NBs, such as high surface area, higher stability, enhanced gas-liquid mass transfer efficiency, and the ability to generate free radicals. Hence, because of these useful properties of NBs, the removal of pollutants can be enhanced due to increased adsorption and flotation. For the treatment of the aquaculture wastewater, NBs could be applied at different stages,

which function as modulators of physicochemical and biological strategies.

NB for degradation of oxytetracycline

A hybrid NB consisting of air and ozone NBs oxidizes oxytetracycline, an antibiotic, from aquaculture effluent (Farid *et al.,* 2022). Ozone Nb is more efficient compared to air NBs in removing oxytetracycline (20% higher oxytetracycline removal than air NB). However, studies are scarce regarding the application of NBs in removing antibiotics. Taking this useful property of NBs into consideration, NBs have a promising future in the aquaculture ponds in removing antibiotics.

NB for the inactivation of harmful microorganisms

Microbial infection is one of the major problems in the aquaculture sector, which affects the aquaculture production. More sustainable solutions are needed for this issue in order to minimize the negative effects of microbial infections and to increase aquaculture production. One of the major reasons for these microbial infections is the limited DO in the aquaculture system. Moreover, with the increase in infectious bacteria, the beneficial bacteria decrease, which affects the productivity of the cultivation system. To tackle this issue, NBs could be a game-changing technology. NBs hamper the growth of the drug-resistant bacteria and enhance the proliferation of beneficial bacteria. Hence, along with these applications, the use of NB technology also aids in reducing the usage of antibiotics in the aquaculture. The ability of NBs to minimize the use of antibiotics can be approached from two perspectives: 1) better control of pathogenic bacteria and viruses in the rearing tanks, and 2) improved immune system of the animals.

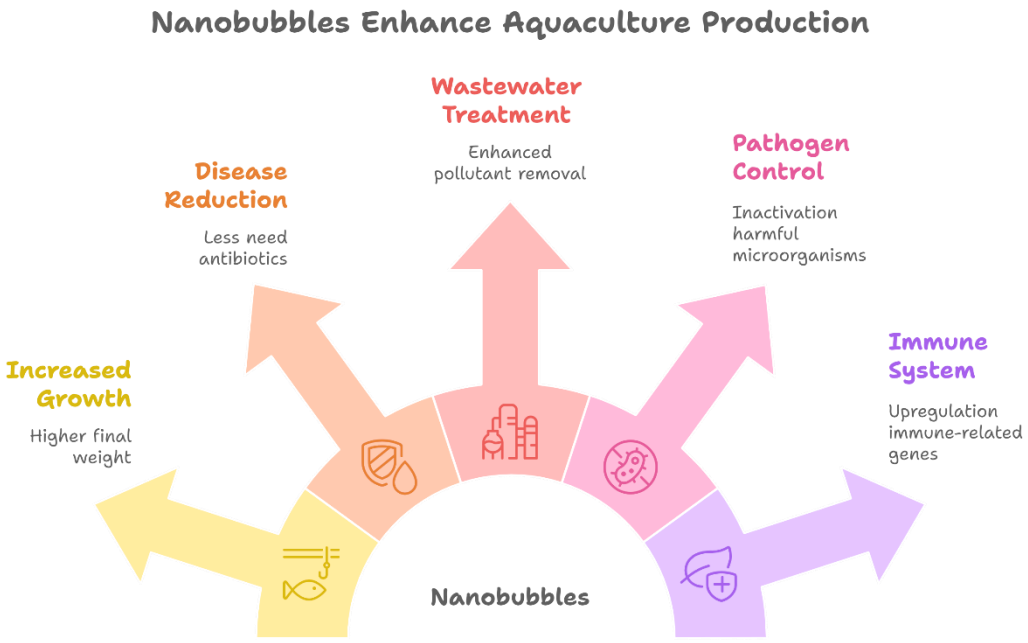
Effect of NB on the control of pathogenic microorganisms

One of the common pathogenic microorganisms in the aquaculture ponds is *Vibrio parahaemolyticus*. This microorganism is the cause of vibriosis in the majority of the fish, shrimps, prawns, and shellfish. The NB technology is used to control the bacterium. The studies also suggest that the NB sterilizes 99.9% of the bacteria within 1 minute. *Aeromonas hydropila* is another bacterium that is widely studied and has been attempted to control by NB technology. This bacterium potentially affects the aquatic environment and is even responsible for millions of losses in the aquaculture. A recent study successfully demonstrated the inactivation of both pathogenic bacteria *A. hydrophila* and *V. parahaemolyticus* in RAS-aquaponic water by using oxygen NB combined with a high-energy ultrasonic treatment (Rafeeq *et al.,* 2020). This NB technology is also effective in controlling other infectious bacteria, such as *Streptococcus agalactiae* and *Aeromonas veronii*. Hence, the NB technology has the potential applications in

the control of infectious pathogenic microorganisms. Thus, this technology should be optimized, and the safe applications of the technology in aquaculture should be studied.

Effect of NBs on improving the immune system of farming animals

An ozone NB is a very, very small bubble of ozone gas inside water. After exposure of the ozone NB into the fish rearing systems, the results showed an up-regulation of the immune-related genes, such as cytokines and lysozymes. Ozone NBs trigger the non-specific immune response in fish to prevent bacterial infection diseases in the farmed fish. The ozone NBs help to elevate the DO levels in the aquaculture ponds, and they improve fish survival by stimulating the fish's immune response. Both disinfection and immune modulation studies focus on the elimination of viral infections in fish using NBs. NBs technology also helps to reduce fish mortality against spring viremia of carp virus (SVCV) in the zebrafish, a model organism.



Conclusion

Nanobubble (NB) technology offers a transformative, eco-friendly solution for sustainable aquaculture by enhancing dissolved oxygen levels, improving animal immunity, and promoting beneficial microbial communities. NBs significantly boost growth rates and survival in fish and shrimp farming. They also reduce dependence on antibiotics through pathogen inactivation and immune modulation. Moreover, NBs play a vital role in wastewater treatment and the degradation of harmful substances like oxytetracycline. While promising,

further research is essential to optimize their application and assess long-term impacts across diverse aquaculture systems

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