Received: 04 Nov, 2024 | Revised: 25 April, 2024 | Accepted: 05 May, 2024

MANUSCRIPT ID: CoAS_V1IS12_01

POPULAR ARTICLE

Chronicle of Aquatic Science

Nanotechnology Advancements: A Catalyst for Transformative Growth in Aquaculture

Vivek Kumar[1] | Durgesh Kumar Verma*[2] | Narendra Kumar Maurya[3] | Ishwar Chandra[1]

[1]Faculty of Fisheries Science, Kerala University of Fisheries and Ocean Studies, Kochi, Kerala (682 506), India.

[2]ICAR- Central Inland Fisheries Research Institute, Prayagraj, Uttar Pradesh (211 002), India.

[3]College of Fisheries, Mangalore, Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar Karnataka (575002), India.

Correspondence

Durgesh Kumar Verma, ICAR- Central Inland Fisheries Research Institute, Prayagraj, Uttar Pradesh (211 002), India.

Email: durgeshkumarverma4@gmail.com

Publisher's Note

The opinions presented in this article are the exclusive views of the authors and do not necessarily reflect the views of their affiliated organizations, the publisher, editors, or reviewers. The publisher does not guarantee or endorse any product evaluated in this article or any claim made by its manufacturer.

Conflict of Interest

The authors assert that the manuscript was developed without any commercial or financial associations that could be interpreted as a potential conflict of interest.

Authors Contribution

All listed authors have contributed significantly, directly, and intellectually to the work and have endorsed it for publication.

Abstract

Aquaculture is only one of the many sectors that may be transformed by nanotechnology and has emerged as a burgeoning area of study. It can provide new approaches to fish breeding, aquatic health, fish biotechnology, and aquaculture, among other fields. Nanotechnology tools include smart medication delivery, nanomaterials, nanosensors, DNA nanovaccines, and gene delivery. Nanotechnology applications within the fish processing industry could enhance flavor intensity, elevate color vibrancy, and bolster barrier properties for enhanced safety. Additionally, they might facilitate germ detection within packaging materials. Advancements in nanotechnology promise to tackle worldwide anxieties surrounding aquaculture, such as food safety, human well-being, illness aversion, and environmental conservation. Enhancing barrier properties through nanotechnology applied in processing of fish can be employed to detect bacteria, intensify flavors, enhance the brilliance of the color, enhance packaging, and ensure stability. Examining their applicability in various fisheries sector domains will be a commendable undertaking.

KEYWORDS

Nanotechnology, Gene delivery, Fish growth, Water treatment

INTRODUCTION

As per the United States' National Nanotechnology Initiative (NNI), nanotechnology refers to "understanding and control of matter at dimensions of approximately 1 to 100 nm, where unique phenomena enable novel applications" (Rather et al., 2011). Nanotechnology involves the use of nanometer-sized particles or structures. It has enormous potential for use in various fields, including physics, chemistry, and biology. When dealing with nanomaterials, there are several factors to consider, including the kind of material, its composition, dimensions, distribution, accumulation, concentration, surface, charge, covering, and framework. The use of in vivo systems to evaluate nanoparticle toxicity, biodistribution, blood-brain barrier (BBB) delivery, cellular absorption, and other relevant research may be minimized by carefully evaluating the experimental circumstances. Therefore, an effective approach for disease identification and control is essential to maximize production and guarantee the high quality of fish products. To tackle many illnesses found in aquaculture systems, Numerous approaches have been devised, including antibiotics, immunostimulants, chemicals, and vaccinations. As per studies focusing on the utilization of nanoparticles for safeguarding against ailments in fisheries, a range of disease-causing pathogens are significantly resistant to nanoparticles like Ag-Nps (Silver nanoparticales), Au-Nps (Gold nanoparticales), ZnO-NPs (Zinc oxide nanoparticales) and TiO_2-NPs (Titanium dioxide nanoparticales). are capable of combating (Singh and Dutta, 2020).

ECO-FRIENDLY SYNTHESIS OF NANOPARTICLES

This approach uses scientific plant sculptures. Green dimensional technology, which is safe for the environment, non-toxic, easy to use, and economical, is crucial to material throughput. Numerous studies on the creation of gold and silver nanoparticles utilizing various plant resources have been published. As a reducing agent with strong antibacterial activity, it exerts a therapeutic effect. The creation of these gold particles was demonstrated when two vitamins of Tamarindus indica fruit extract were introduced into two components of 1-minute tetra chloroauric acid glass. A strong peak at 540 nm in the visible spectrum was confirmed (Susitharan and Sindhu, 2021).

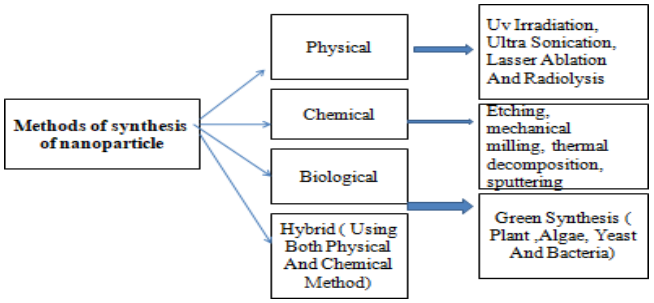

Fig 1. Approaches for generating metallic nanoparticles. (Haldar and Nath, 2020)

CHARACTERIZATION OF NANOPARTICLE

Characterization is the process of evaluating several properties once a nanoparticle has been created. Many types of in-vitro nanotechnology research are conducted using cell cultures. In order to

investigate how nanoparticles are absorbed and transported via the blood-brain barrier, cell Particularly in the early screening stage, culture models are vital resources for researching medication transport to the brain without inflicting unnecessary suffering on animals. Compared to animal experiments, the culture of cell technique has the benefit of expedited hazardous prospective analysis, absorption mechanisms for nanoparticles, and other associated molecular mechanisms required for drug administration. In vitro methods are used for live cell imaging investigations. Using microscopes and other excellent content screening tools, this technique creates photographs of live cells (Haldal and Nath, 2020).

USEFUL PROSPECTS OF NANOTECHNOLOGY IN AQUACULTURE

WATER TREATMENT

Currently, there are systems that use electronics to extract medicines from water. In aquaculture, nanomaterials such as carbon or alumina, along with additives like zeolite and iron-containing compounds, can be employed to promote the growth of aerobic and anaerobic biofilm. This biofilm aids in the removal of pollutants such as ammonia, nitrites, and nitrates. Similar to how trichloroethane, carbon tetrachloride, bi-azphenyl, and dioxin chemicals may be cleaned into less hazardous carbon compounds using iron-based ethical powder, remove aquaculture-related preparations is indicated there. 'Nano Check' is a water cleaning solution offered by Nevada-based Altair Technologies for guest pools and fish ponds. It employs a group of 40 lanthanum-based experts who educate the community on community development while absorbing chemicals from water. Large-scale testing is now being performed on Best Check (Haldal and Nath, 2020). Today's technology is capable of removing medicines from the water. Aquaculture adjuncts can be used to store aerobic and anaerobic biofilms to remove amine, nitrite, and nitrate pollutants. These ingredients include carbon or aluminium as the active agents, zeolites, and iron-containing components. Similarly, iron-based ultrafine nanoscale powder can be a useful tool for removing pollutants like dioxins, trichloroethane, carbon tetrachloride, and polychlorinated biphenyls, converting them into less toxic, simpler carbon compounds and opening the door for nano-aquaculture. Therefore, the aquaculture route has been abandoned.

TIO_2- STONES FOR AQUARIUM

Thai Balaji has been successful in treating fish core water with fish oil for plastic pieces (TiO_2). In ceramic or stone fish tanks with a TiO_2 coating, moss and scum may be removed. To reduce water treatment expenses, this approach can be implemented in commercial fishponds and aquariums. (Susitharan and Sindhu, 2021).

NANO-BIO-BAG

Water can be maintained clean, pollution can be reduced, and it can be utilized for aquaculture. Internal water bacteria can be inhibited, germs can be eliminated, and water can often be changed. Cleanliness is also possible, It reduces contaminants and nitrites, controls sewage, and makes it easier to utilize water, especially for aquaculture. The best paint for green walls in fish ponds is Nanoscale-composite coverings, also known as nanoscale ionized silver coatings, are presently being introduced in South Korea and Japan.

FISH/SHELLFISH HEALTH MANAGEMENT & NANO-VACCINES

Nanotechnology can revolutionize the fisheries and aquaculture industries by providing new tools, such as quicker disease diagnosis and improved fish absorption of hormones, vaccinations, and nutrients. This may be feasible given the enormous potential of nanotechnology, which extends beyond electronic and materials research to include the human, animal, and agricultural sectors, as well as bio-pharmaceuticals for the creation of non-viral medications, cancer therapy, aquaculture, and the study of biomolecules. It can be used in biological sciences and medicine. Targeting medication delivery, clinical diagnostics and treatment, etc.; vectors for gene therapy; serving as a transporter for DNA, proteins, or cells (Singh and Dutta, 2020)

DNA NANO-VACCINES

These tattoo capsules with short-stranded DNA were positioned on the fish machine submerged in water. It is broken down by an ultrasound device, which releases DNA and prompts an immunological reaction in fish. Similar to medical concepts and site-specific aquaculture initiatives, management and disease control of these ticks are also important.

NANO-BARCODING AND TAGGING

The Lithuanian barcode is a surveillance tool made of metal strips with electronics incorporated into them, where a method of encoding barcode variation is offered. By implementing tech barcoding, the business industry and customers can check the sales status of their aqua products and keep track of the source or market. Additionally, Tennessee is marked with color-coded probes and sensors that, when used with coupled DNA, may be used to detect and track changes in temperature, valence, and other factors, leading to an improvement in the quality of Tennessee-barcoded psychologists' products. A chip with a radio circuit that contains a scale component and an integrated identifying code is known as a radio-frequency database (RBI database).This tag can be expanded upon, remotely scanned, and inserted into the product to instantly identify any object everywhere. These tags may be used to monitor anti-terrorism efforts as well as fishing, swimming, and food consumption. The Lithuanian barcode is a surveillance tool made of metal strips with electronics incorporated into them, where a method of encoding barcode variation is offered (Rather et. al., 2011).

ENVIRONMENTAL IMPACT OF NANOPARTICLES IN AQUACULTURE

Interest in assessing the risks associated with the introduction of technology to understand boating has arisen in the cast of new species in fisheries and aquaculture. Water quality in natural hydrological systems can be changed with the help of physical; Biological and chemical processes that help improve water quality. Example: Sewage-based aquaculture, Kolkata. Recently. Metal ions normally enter and circulate through endocytosis in the fish intestine. It has been suggested that cadmium ions enter boats anchored in fishing bays via calcium rocks. Little is known about the fate and various effects of Engineered Penetrators (ENPs) in the aquatic sector. Recent experiments have shown that, with the help of a special shape, gold and copper can be transferred from Daphnia magnato earthworms to Danio rerio (zebra fish) and can also participate in bio-enrichment (Susitharan and Sindhu, 2021).

THE FUTURE OF NANOTECHNOLOGY

Further research is required to create a capsule that releases nutrients when inadequacies are found in other sensor firms. However, a detailed investigation of mechanical engineering, scalability, and cost analysis is required for effective engineering in commercial aquaculture (Susitharan and Sindhu, 2021).

TOXICITY OF NANOPARTICLES

However, the scientific community has some reservations regarding the application of many principles, particularly in light of certain philosophers' ideas for research and the environment. As water resources are especially vulnerable to direct and significant pollution from religion, various scientific papers have suggested that the context and impact of the material on the aquatic environment should be evaluated. There is a possibility of harmful effects on the fish and its habitat because of the uncertainties surrounding the dosages and concentrations of NPs. There have been reports of SEC-NP buildup in Oryzias latipes, the original seawater of medaka (Li et al., 2008). Ag-NPs dramatically decreased brain enzyme activity when administered to Cyprinus carpio at a concentration of 200 g/L. Additionally, reports of three different types of detrimental effects on fish embryo development have been made public. When ZnO-NPs were added to zebrafish embryos, Zhu et al. (2008) observed alterations in their growth and hatching rates in both laboratory and field trials. Additionally, it has been demonstrated that Iron Institute NPs (10 dipL/L) have embryocidal effects on Danio rerio, resulting in elevated mortality, hatching mortality, and malformations. Oncorhynchus maquis also includes a range of Cu-NPs (Singh and Dutta, 2020).

NANOPARTICLES AS A DRUG DELIVERY

Chitosan and Poly D, L-lactide-co-glycolic acid (PLGI) catechins are effective drug delivery systems for vesicles. Biocompatibility, non-toxicity, and biodegradability further support its application in the fishing sector. Oncorhynchus maquis (rainbow trout) exhibits vitamin C persistence for 48 h along with aggravation of the immune system independent of medication delivery (Singh and Dutta, 2020). Chitosan thicans and Cyprinus carpio collaborate to produce luteinizing releasing hormone (LRH). Compared with the typical injection of LRH, there was an increase in the fertilization rate of approximately 87%. When Mycobacterium marinum was injected with rifampicin produced from PLGI thiocans into zebra fish embryos, pyramid effects and enhanced embryo survival were evaluated compared to rifampicin alone. The in vitro absorption of 6-coumarin (6-CoUM)-loaded solid lipid thickeners (SLN) was examined in two types of gilthead sea bream (Spira ceaurata L.) cell gouges: a well-established cell line (SAF-1 cells) and Sir-Gurude's Primary Cultures (HK) (Singh and Dutta, 2020). Additionally, they discovered that at a maximum SLN concentration of 10 g/ml, SAF-1 loci were able to internalize larger percentages of 6-COUM SLN for 4, 8, and 24 h (Singh and Dutta, 2020).

NANOPARTICLES FOR ENHANCEMENT OF FISH GROWTH

According to research from the Russian Academy of Sciences, juvenile carp and sturgeon had faster development rates (30% and 24%, respectively) when given iron supplementation (Susitharan and Sindhu, 2021). Numerous selenium sources, including selenomethionine and nano-SCO (spin-crossover), have been found in studies to be advantageous. Crucian carp (Carassius auratus gibelio) may respond better to the basal diet in terms of final weight increase, relative gain rate, laptop

condition, and maglethione peroxidase (GS-PX) concentration Susitharan and Sindhu 2021. Additionally, seleno-methionine seems to be more effective than selenomethionine in raising selenium levels in other muscle slices. The expansion and effectiveness of the businesses utilized in these three tiers of veterinary pharmaceutical fraud are also highly regarded (Rather et al., 2011).

POSITIVE AND NEGATIVE ASPECTS OF NANOTECHNOLOGY

This issue is based on several technological suggestions. An overview of the historical development of the influence of technology in terms of its advantages and disadvantages will be presented as the primary goal of this subject. The importance of dendrimers and other carbon hybrids is discussed, along with an update on the possibilities and consequences of bio-nanotechnology, non-viral clothes for gene delivery, and the advent of technology. There will be an impact of online technology on aquatic organisms and health care, the effects of orthomedicine on neurodegenerative builders, and the importance of techniques for initiating dioxin. For their group, academics, medical experts, NGOs, and engineers undoubtedly demystify this issue. Therefore, the consequences of biotechnology on aquatic and human life are particularly pertinent. It has a result. As discussed, technological advancements may have both beneficial and harmful effects.

CONCLUSION

The use of nanotechnology in aquaculture and fisheries has improved a number of processes, including the diagnosis and treatment of genetic disorders in fish, the detection and eradication of pathogens even at very low densities, the rapid detection of heavy metals in water and food, the improvement of fish capacity to absorb drugs and nutrients, which increases output, the filtration and remediation of contaminated water, improved breeding, the control of biofouling agents, and many other processes. Nanoparticles, nanofiltration, and food packaging are three of the most important nanotechnology applications in the aquaculture and seafood sectors. Although some materials developed through nanotechnology have improved the quality and accessibility of products, the aquatic environment may still be at risk.

REFERENCES

Ashraf, M., Aklakur, M., Sharma, R. and Ahmad Sh, K.M., (2011). Nanotechnology as a novel tool in fisheries and aquaculture development: A review. Iran J Energy Environ, 2(3), pp.258-61.

Genwa, M., Kumari, K. and Singh, P., (2019). Nanotechnology: Beneficial or harmful. Nanoscience & Nanotechnology-Asia, 9(1), pp.3-3.

Haldar, C. and Nath, S., (2020). Nanotechnology: A novel technique for aquaculture and fisheries development. Int J Fauna Biol Stud, 7(6), pp.23-27.

Li H, Zhang J, Wang T, Luo W, Zhou Q and Jiang G. 2008. Elemental selenium particles at nano-size (Nano-Se) are more toxic to Medaka (Oryzias latipes) as a consequence of hyper-accumulation of selenium: a comparison with sodium selenite. Aquatic Toxicology 89: 251-256.

Rather, M.A., Sharma, R., Aklakur, M., Ahmad, S., Kumar, N., Khan, M. and Ramya, V.L., (2011). Nanotechnology: a novel tool for aquaculture and fisheries development. A prospective mini-review. Fisheries and Aquaculture Journal, 16(1-5), p.3.

Singh, M.K. and Dutta, M.P., Scope of Nanotechnology in Aquaculture: An Overview.

Susitharan, V., Sindhu, C. and Susitharan, C.A., (2021). Nanotechnological approaches in aquaculture. Vigyan Varta, 2(9), pp.31-36.

Zhu X, Zhu L, Duan Z, Qi R, Li Y and Lang Y. 2008. Comparative toxicity of several metal oxide nanoparticle aqueous suspensions to Zebrafish (Danio rerio) early developmental stage. Journal of Environmental Science and health Part A 43: 278-284.

How to cite this article: Kumar V, Verma DK, Maurya NK and Chandra I. Nanotechnology Advancements: A Catalyst for Transformative Growth in Aquaculture. Chron Aquat Sci. 2024;1(12):1-7