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NANOTECHNOLOGY: A UNIQUE FUTURE TECHNOLOGY IN AQUACULTURE FOR THE FOOD SECURITY

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Abstract: Nanotechnology exhibits a tremendous potential in agriculture and its allied fields like, aquaculture and fisheries. It is the new tools for aquaculture, fish biotechnology, fish genetics, fish reproduction and aquatic health etc. Nanotechnology tools like nanomaterials, nanosensors, DNA nanovaccines, Gene delivery, Drug delivery, Fluorescent biological labels, Probing of DNA structure, Bio detection of pathogens, Separation and purification of biological molecules and cells, antioxidant activity, antimicrobial activity cell toxicity etc. have the potential role to solve many problems like animal health, production, reproduction, prevention and treatment of diseases. It may presume that in the recent years, nanotechnology research will reform the science and technology and will help to boost up the livestock production in future. Nanotechnology applications in the fish processing industry can also be utilized to detect fish bacteria in packaging, produce stronger flavors, colour quality, and safety by increasing the protection properties. This review article presents the recent developments of nanotechnology and its applications in aquaculture and fisheries.

Key words: Nanotechnology; Aquaculture; Nanomaterials; Nanosensors; Nanobiomedicines; DNA nanovaccines.

INTRODUCTION

It is well known that the global population is growing at a breathtaking pace. In 1950 the world had a total of 2.5 billion people, a figure that had burgeoned to 7 billion by 2012 and this number could exceed the 9 billion mark by mid-century. As populations increase, so too does the need for food. For many years aquaculture played a relatively minor role in global fish production, but its significance has increased radicalmentely over the past 20 years, spurred by the demand from Asia's fast-growing populations. Fish is wild and widespread, affordable and healthy source of valuable protein. There is no question, therefore, that the global demand for fish will be intensified in future [1].

The FAO World Conference on Fisheries Management and Development, held at Rome in 1984, adopted a strategy endorsed by 147 countries that begins with the statement- Fish is an important part of daily diets in many countries and provides nearly one quarter of the world's supply of animal protein and in many countries fisheries are important sources of employment, income and foreign exchange.

It is mandatory to propose that after independence of our country in the year 1947, the country faced some economic challenges. The most important challenges are the food security. Food availability and stability were considered good measures of food security till the seventies and the achievement of self-sufficiency was accorded high priority in the food policies of developing countries. Naturally, it is interesting to propose that the real meaning of food security is that all people have both physical and economic access to the essential food they need. Moreover, it can observe that day by day food prices increase while the food production seems to be drastically low [1-3]. It may assume that aquaculture will provide the fish supply to meet growing demand and thus aquaculture may consider as one of the important factors of food security in particular [4-5]. Food security through fishes are achieving in the recent decade at the global level. Naturally, the aquaculture, as a protein source, would have to increase in the coming year [6]. Though India was successful in achieving self-sufficiency by increasing its food production and also improved its capacity to cope with year-to-year fluctuations in food production; it could not solve the problem of chronic household food insecurity [7]. India has the potential to produce enough food to feed its entire population, though there have been many setbacks in the past decade including droughts and natural disasters. The success or failure of crops is directly related to climate and weather. India has become a part of the global economy and in this soil several engineers, scientists, and computer specialists' helps to improve the quality of food materials.

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Naturally, our scientist would like to give trace on food grain production, milk production, the livestock and fishery sectors. Still, the productions of all above contents are not sufficient. To overcome the situation, scientist would like to accept the most recent techniques like nanotechnology which may help to boost up the production of fishery sector. The question may rise that why we would like to trace on aquaculture? It is obvious that the two sectors, like agriculture and fishery are the only sectors where the Green Revolution of socioeconomic status resides. Naturally, aquaculture may be part of the solution to the increasing need for food diversity and arresting the decline process of nutrition. On a global scale, cultured fish production has doubled from 1990 to 1996, reaching 26 million ton, and output could reach 39 million ton by 2010 [8]. Indian aquaculture is no exception to such phenomenal growth in world food production. The present process of aquaculture production can create a serious damage to the environment, as because, of introduction of several toxic chemicals in agricultural fields. However, managed growth and sustainable production practices could help the industry in perfect way. We are interested to explore the potential development of Indian aquaculture.

Nanotechnology and Nanomaterials

To explore the aquaculture, in particular, it is necessary to introduce the most recent technique. The Nanotechnology is very new in research frontiers. Nanosciences and nanotechnologies are highly promising and rapidly progressing disciplines in research and industrial innovation. Nanotechnology shows many interdisciplinary activities in both of agriculture and aquaculture sectors (Figure 1). The term "nano" refers to the measurement of size; a nanometre (nm) is a millionth of a millimeter. By way of illustration, a nanometer is about 1/50,000th the width of a human hair, and a sheet of normal office paper is about 100,000 nm thick. A nanoparticle (NP) is usually considered to be a structure between 0.1 and 100 nm (1/1,000,000 mm). The potential benefits of nanotechnology have been recognized by many industrial sectors and their products based on nanotechnology or the nanoparticles containing products are already manufactured such as in the field of microelectronics, consumer products (e.g. personal care products, paints, automotive industry) and the pharmaceutical industry. Also with respect to food and agriculture, a number of propitious applications are emerging, such as smart packaging, nanosensors for pathogen detection or registration of storage conditions, nano-formulations of agrochemicals, nano-encapsulation / nanodelivery of food ingredients, etc [9-11].

Besides engineered or manufactured nanoparticles, nano-sized particles occur naturally in many foodstuffs. We put light to sight one example, food proteins are globular structures between 10-100 nm (e.g. casein micelles in dairy products range from 300-400 nm) and most polysaccharides and lipids are linear polymers of 2 nm in thickness. Fat globules can also be regarded as natural nanoparticles as well, ranging in size from 100 nm to 20 µm, whereas fat globule membranes have a thickness of 4–25 nm. The homogenization of fat globules can be considered as a sort of "nanotechnology process" decreasing the average diameter and increasing the number and surface area of the fat globules.

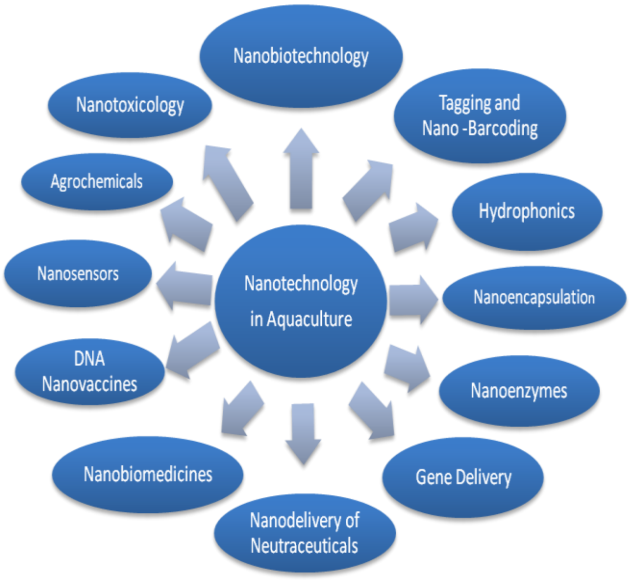

Figure 1: Multidisciplinary activities of Nanotechnology in Agriculture and Aquaculture.

Additionally, stabilized foams and emulsions are containing two dimensional nanostructures that one molecule thick at the air-water or oil-water interface and three dimensional nanostructures are formed when food biopolymers assemble into fibrous networks. Although nanotechnologies have the potential to bring significant benefits to both the industry and consumers [12] they may also introduce potential risks for human health and the environment. Due to the small size, surface reactivity and translocation possibility across biological membranes they exhibit a potential interaction of nanoparticles with the surrounding matrix and exhibits a crucial function across the cell membrane barrier, but always we should have to remember the risk assessment in the biological membrane functions of those particular nanoparticles. Nanosciences and nanotechnologies are highly promising and rapidly progressing disciplines in research and industrial innovation.

The potential benefits of nanotechnology have been recognized by many industrial sectors and their products based on nanotechnology or products containing nanoparticles (NPs) are already manufactured such as in the field of microelectronics, consumer products (e.g. personal care products, paints, automotive industry) and the pharmaceutical industry. Also with respect to food and agriculture, a number of promising applications are emerging, such as smart packaging, nanosensors for pathogen detection or registration of storage conditions, nanoformulations of agrochemicals, nano-encapsulation and nanodelivery of food ingredients, etc [13-14]. Nanosensors, nano-imaging and nanochips are usually using in different sectors for getting quick result in their respective sectors. Nano delivery systems are associated with nanocapsules, nanoballs, nanorobots, nanocochleates, nanomachines and nanodevices for proper execution the proper functions in the industry. Nutraceuticals and functional foods as food components that provide demonstrated physiological benefits or reduce the risk of chronic disease, above and beyond their basic nutritional functions. A functional food is very similar to a traditional food, while a aphrodisiac is isolated from a food and sold in dosage form, in both cases the active components remain intact in the food [15].

Moreover, the aquaculture industry can be revolutionized by using nanotechnology, as it helps to detect the rapid disease detection and enhancing the ability of fish to rapidly absorb drugs such as hormones, vaccines and nutrite feeding, disease control, and bio-fouling control processes are being re-engineered to get the maximum benefit from nanotechnology. The daily nutritional fish required food ingredient components i.e. proteins, carbohydrates, fats, minerals and vitamins are absorbed through nanotechnology. One recent idea is that nanoparticles will enhance aqua feeds by increasing the proportion of fish food nutrients that pass across the gut tissue and into the fish, rather than passing directly through the fish digestive system unused. Moreover, dietary minerals at the nanoscale level may pass into cells more readily than their larger counterparts and accelerates their process of assimilation into the fish gut. As an example, sturgeon and carp experts have found that the iron nanoparticles in the diet boost the growth of sturgeon and carp by 30 and 24 percent, respectively. Adding other mineral nutrients to the regular fish diet at the nanoscale level might also have a tremendous impact not only on growth but also on the overall health of the fish physiology. It has been propose that the use of nanomaterials in recycling process, the waste by-products from seafood processing plant scan enhance the feed for farm-raised fish. This would provide from one half to two-thirds of the amount of fishmeal in the fish culture area or in any fish farms .Now a days the existence of the antimicrobial activity is well known, exploited in dentistry to prevent caries and as preservative applications in food packaging industries [16].

Nanotechnology and Water Purification

Water treatment is important for various purposes. Purification of water involves removal of toxic ions, organic impurities, microbes, and their by-products, as well as oil spills. The removal of organic contaminants from water is a major industrial concern. The contaminated water from industries usually contains considerable amounts of organic hydrocarbons, such as benzene, toluene, methylbenzene, and xylene (BTEX), prohibiting directly release into water bodies. The dissolved organic compounds cause bacterial growth, odour generation, and biofouling and can change the water quality. Water treatment is a diverse field, the removal of oil spills, organic pollutants, and toxic chemicals from water required specific material properties, such as high absorption capacity; longer retention; and a wide range of catalytic activity, recoverability, and reusability of the material. It is very important to detect the contaminants which are usually present in low concentrations. Recently, it has been reported that the importance of Gold-PDMS foam for water treatment has the ability to remove the toluene, thiophenol, thioanisole, and Na_2S[17]. The wastewater treatment by Biotrickling filters is an important yardstick now days, introduced by ERICKSON group in the year 2003.

There are so many methods in recent times, have adopted following methods to purify the waste water.

a) Aerogels

- Hyrophobic silica Aerogels
- Aeroclay
- Maerogel (Rice Husk Derived Aerogel)

b) Nano Dispersants: One of the technologies used for oil spill response involves the use of chemical dispersants which contain surfactant molecules (surface-active agents) that migrate to the oil/water interface and reduce interfacial tension between oil and water. With the abettance of wave energy, tiny oil droplets break away from the oil slick. These small droplets get dispersed into the water column and remain in suspension and, thereby, become a good source of food for the naturally occurring bacteria. The dispersants catalyze the biodegradation process leading to the removal of spilled oil.

c) Hydrophobic Organoclays: Natural clays like bentonites contain metallic cations, which impart hydrophilic character to the clay. Therefore, they are not suitable sorbents for the removal of organic compounds. However, hydrophobicity can be induced in these clays by modifying them with quaternary amines (a type of surfactant containing nitrogen ion). The presence of these amines renders the clay hydrophobic in nature. These organophilic clays (or organoclays) are very efficient in selectively adsorbing the organic contaminants or oil from water

d) Magnetic Materials

- Magnetic Nanocomposites
- Hydrophobic Core-Shell Magnetic Fe_2O_3@C Nanoparticles
- Magnetic Polymer Nanocomposites
- Magnetic Carbon Composites
- Organo-clays with Magnetic Fe_3O_4 Nanoparticles
- Magnetic Liquid Foams; EcoMag® and CleanMag®

e) Nano membranes: Manchester Institute of technology, USA has developed absorbent, super hydrophobic nanowire membranes for the selective absorption of oil from an oil-water mixture. Using self-assembly method, they have constructed free-standing membranes comprising inorganic nanowires capable of absorbing oil up to 20 times their weight

By adopting the nano-wire mesh, MIT's SENSEable City Laboratory has recently created an autonomous oil-absorbing robot called Sea-swarm. This prototype robot uses a conveyor belt covered with the oil absorbing nano-wire mesh. When Sea-swarm moves along the surface of water, the conveyor belt along with the nano mesh rotates, and selectively absorbs the water to do the cleaning job. These autonomous vehicles use very little energy (as low as about 100 watts), run for weeks and have the capacity to clean up several gallons of oil per hour.

f) Carbon Nanostructures

- Exfoliated Graphite
- Carbon Nanotube Sponge
- Vertically Aligned CNTs (VACNTs) for Combating Oil Spills
- Graphene Worms and Nano Accordions Derived from thermally exfoliated graphite oxides TEGO
- RECAM® Technology is a novel reactive nanostructured carbon material.
- High Reactivity Carbon Mixture (HRCM) Sorbent.

g) Micro-and Nano-TiO_2 for Oil Spill Remediation: Oil spills generally result in contamination of seawater due to the dissolution of water-soluble crude oil fractions. This contaminated water, rich in dissolved hydrocarbons, is highly toxic in nature and can cause irreparable damage of the ecosystem. Photocatalytic decomposition of the oil-contaminated water using nanoscale or microscale TiO_2 particles can control the water quality. Photocatalysis degradation is proposed to involve the generation of a (e−/h+) pair leading to the formation of hydroxyl radicals, superoxide radical anions, and hydroperoxyl radicals, and these radicals are the oxidizing species in the photocatalytic oxidation processes. The efficiency of the dye degradation depends on the concentration of the oxygen molecules, which either scavenge the conduction band electrons. The electron in the conduction band can be picked up by the adsorbed dye molecules, leading to the formation of dye radical anions and the degradation of the dye [18].

h) DAG-PEG Lipids for Remediation of Oil Contamination:

Recently discovered that certain diacylglycerol-polyethyleneglycol (DAG-PEG) lipids such as PEG-12 GDO (glycerol dioleate) and PEG-12 GDM (glycerol dimyristate) can be used to remediate the oil spills. It has been observed that when DAG-PEG lipids are added to the surface of an oil spill in water, the lipids entrap both water and oil from the immediate surroundings and disperse the contents and vesicles into a suspension. Once the oil is entrapped into vesicles, it remains inside the bi-layers of the vesicle and in suspension indefinitely, since the formed vesicles are thermodynamically stable until disrupted by high energy mechanical shear, by enzyme activity [19-23]. Naturally, water can treat by introducing the proper methods and also with very recent device.

Nanotechnology in Aquaculture

Aquaculture continues to be the fastest growing animal food-producing sector and can help in maintaining the socioeconomic status. Aquaculture has the ability to contribute significantly to food and nutrition security in the society. It has been reported that about 20 percent per capita intake of animal protein. It is highly rich source of micronutrients, minerals, proteins and essential fatty acids [24].

Malnutrition is still the number one killer compared to other diseases and fish with its affordable protein and essential nutrients scores over other forms of animal protein. The protein requirements from fish is evident from the fact that while kg per capita fish consumption rose from 14.9 in 1995 to 17.1 in 2008, the percentage contribution of aquaculture increased from 29 to 46% for the same period. If the current growth can be sustained, it is estimated to meet more than 50 percent of the total fish requirements by 2015 [25]. It appears that the fish sector will continue to expand, particularly as new technologies are being introduced and institutional capacities are being strengthened [26]. Thus aquaculture's contribution will help in poverty reduction, food security, employment, trade and gender opportunities increased over the past decade [27,28].

Nanotechnology has a wide usage potential in aquaculture and seafood industries[29,30]. Less knowledge on the effect of nanoparticles on aquatic organisms. It has been observed that young carp and sturgeon exhibits a faster development due to effect of iron nanoparticle. It has also been observed that the nano selenium-supplemented diet could improve the fish weight, relative gain rate, antioxidant status of the fish, and increases the glutathione peroxidase activities and muscle selenium concentrations of crucian carp (*Carassius auratus gibelio*). Further, the growth and performance of the fish which were experimented through the above mentioned nanomaterials and observed that the nanolevel delivery of nutraceuticals can enhance the growth of fish. Direct use of silver nanoparticles in water to treat a fungal disease has been found toxic to young trout whereas a water filter coated with silver nanoparticles can prevent the fungal infections in rainbow trout fish in the fish culture. It can say here that the health of fish in aquaculture, nanotechnological applications on antibacterial surfaces in the aquaculture system, nanodelivery of veterinary products in fish food using porous nanostructures and nanosensors for detecting pathogens in the fish culture system. Thus nanomaterials have shown great potential in a wide range of the pond-ecosystem environmental. Nanoscale iron–manganese binary oxide was an effective sorbent for removal of arsenic (III) and arsenic (V) from both synthetic and actual field groundwater of fish culture.

Nano-bio-bag recycling unified filter water purification equipment shall be inoculated in the water a small amount of nano-nano-micro bacteria and placed water ecological base, with its carrier, which can effectively degrade fish, shrimp, shellfish, crabs, sea cucumbers and ammonia metabolites. Several experiments clearly denotes that nanoparticles can be processed sea water polyculture of freshwater fish, goldfish, without changing the water, no oxygen, no feeding cases, survival of 216 closed days. Moreover, nano-water stone: can block, the internal water bacteria inoculated microbes and can change the water for long periods, keep the water clean, to control pollution and for aquaculture, make the water clear. Nano helps in purify water, reduce ammonia, nitrite, used to control sewage and for aquaculture in particular. Nano silver ion antimicrobial coating nano-composite coatings, is the ideal fish pond green wall paint and these are now introducing in Japan and South Korea. Nanotechnology, biotechnology and electronics technology which borders three of the world are constantly cutting-edge technology integration. In the human eye cannot see the nano-world, people have realized more and more areas of their application. Often using some simple means of nanotechnology, can solve the traditional technology cannot solve the complex system problems, many of the world of nanotechnology oversimplifies complex issues. Nanotechnology and biotechnology used in aquaculture, pollution-free culture is green right direction, and the only way out. Applications in other fields like nanotechnology will completely enhance, improve, and replace traditional techniques of aquaculture.

Nanotechnology and biotechnology, aquaculture in China will surely make an important contribution to sustainable development in future. Recent work clearly denotes that Microfluidizer Processor®-based nanoemulsions significantly increase the bioavailability and efficacy of the nutraceutical alpha and delta tocopherol and it has tremendous effect in aquaculture[31]. Thus, nanotechnology, has the ability to improve the quality of fish feed for aquaculture species. This technology helps in antifouling in fishing and aquaculture nets, antibacterial substances for aquaculture tanks and new packaging materials for seafood products transports, new devices for detection of shelf life of sea products. Naturally, the above statement clearly denotes that food quality can be maintained by different processes of nanotechnology [32, 33]. Few experiments of nanoparticles have been successful in the aquaculture industry, like rapid growth of young carps (*C. auratus gibelio*)[34] with iron and selenium in diet.

Nano Tagging and Nano Barcoding

The entire chip can be about the size of a dust mite – closer to micro-scale than nanoscale, though incorporating nanoscale components. Developers of the technology envision a world where they can "identify any object anywhere automatically." Radio Frequency Identification (RFID) is a chip with a radio circuit incorporating a nanoscale component with an identification code embedded in it. These tags can hold more information, can be scanned from a distance and can be embedded in the product to identify any object, anywhere, automatically. RFID tag may be used from juvenile fish. It can be a tracking device as well as a device to monitor the metabolism, swimming pattern and possibly feeding behavior of the fish. Another possible benefit is to allow fish processing plants to identify the source of the fish by incorporating the "nano-barcoding" as part of their information management system. Whole fish exporters may also use this technology to track the delivery status of the tagged fish.

RFID nanotags having many advantages that such as consisting in its memory storage capacity, product identification number, price, product cost, characteristics, manufactured date, location, and inventory on hand. The traceability of fresh food, such as fish has become a challenging and important aspect in order to keep freshness and consumers safety. Although the application of this technology on finfish aquaculture is yet to be tested, however the above potential benefits could prompt industry participants to explore this opportunity further [35].

Furthermore, carbon nanotubes, which are increasingly used in a wider range nano fish culture. Carbon nanotube with certain oils can introduce on fish to control the different surface diseases of fish. Obviously this will be no problem in fish, but it is necessary to look after the toxicity of nanoparticles that must be assessed before its potential integration into aquaculture. The potential applications of nanotechnology in the aquaculture industry include use as a biosensor for microbial control. Researchers at NASA have developed a nanotechnological biosensor that is capable of detecting minute amounts of microbes, including bacteria, viruses and parasites. This is achieved using highly sensitized carbon nanotubes to detect pathogens in water and food sources. Another application involves the use of gold nanoparticles. Researchers at the University of Sydney have developed a system for parasitic targeting and elimination using gold nanoparticles. In this study gold nanoparticles were coated with antibodies, specific for the pathogen and can attach selectively to the infected regions which help in control the several pathogens of fishes. Aquaculture has become an economically important, production has decreased in recent years due to the spread of infectious diseases, mostly caused by bacterial infection. Fish-farming is use of Iron Nanoparticles to fasten the growth of fish. Studies have shown that young carp and sturgeon have shown a faster rate of growth i.e. 30% and 24% respectively, when they were fed on iron nanoparticles. The iron nanoparticles also boost up the health of fishes making them more productive. Now a days the, integrated multitrophic aquaculture which promotes economic and environmental sustainability and organic aquaculture are on the rise with the help of nanotechnology [36].

Nano- Vaccine in Fish

Ecosystem is the main gateway for several infectious diseases in fish. The natural biological cycle involves a stable association with one or more hosts, providing the pathogen with a medium for efficient replication and progressive transmission of the infection. As infection proceeds, the pathogen encounters minor variations in its natural environment, including individual variations in host genetics and the immunological response to infection [37].

Naturally, vaccination is an important role in fish farming and nano vaccines are never being used in the context of fish vaccine. Therefore, in the recent decade the use of nanoparticles for vaccination the fish is an important criterion. The application of nanoparticles in the vaccination of farmed fish is the unique processes. Nanoparticles have multifaceted advantages in drug administration as vaccine delivery and hence hold promises for improving protection of farmed fish against diseases caused by pathogens. However, there are concerns that the benefits associated with distribution of nanoparticles may also be accompanied with risks to the environment and health [38]. Naturally, polymeric nanoparticles have several advantages in vaccine delivery; they can provide sustained delivery of vaccines, they can solubilize drugs for intravascular delivery, and they can improve solubility of vaccine antigens against enzymatic degradation. poly–lactide-co-glycolide, encapsulated DNA encoding antigens are protected against enzymatic digestion and can therefore be released over extended periods of time. Within aquaculture one of the most important constraints for further growth is the prevalence of diseases. interesting possibility is the use of nanoparticles for delivery of vaccines Still the precautionary principle need to be supplemented by combining the ideal of best scientific practice for vaccination to the fish [39]. Therefore, natural resources (NR) research should be demanded in order to improve the quality of fish through natural resource materials.

Nanoparticles have multifaceted advantages in drug administration as vaccine delivery and hence hold promises for improving protection of farmed fish against diseases caused by pathogens. Now a day's global impact is that to control of fish pathogens for sustainable aquaculture production in worldwide. Fish health research has played a crucial role in the tremendous growth of salmon aquaculture, which followed from a shift from freshwater ponds to the use of sea pens in the 1970s. Farmed in open sea pens, salmon is generally vulnerable to diseases. Fish pathogens transmit well in water and high stocking densities and short distances between farms enable high transmission So far the salmon farming and fish health are concerned the epidemic bacterial diseases may prevent by an excessive use of antibiotics, which again was not environmentally sustainable. The motivation for attempting to utilise nanoparticles in salmon vaccines relates to the fact that oil-adjuvant vaccines hitherto have been ineffective against a range of intracellular pathogens (importantly viruses) and it has proved difficult to come up with strong alternative adjuvant systems. Moreover, oil-adjuvanted vaccines have been found to elicit unwanted side effects in the salmon such as adhesion of internal organs in the abdomen and (although less frequently) skeletal deformations and autoimmunity. Vaccine producers, then, are continuously trying to apply oil adjuvant with lesser side effects. The vaccines were to be mediated by nanoparticles.

Recently, fish vaccine project can develop with synthetic organic polymer referred to as PLGA (Poly lactic-co-glycolic acid). These particles protect antigens from premature degradation, i.e. before they can elicit an effective immune response. The PLGA particle will degrade in vivo, and therefore release the antigens over time. The rate of degradation of the particles can be designed by changing co-polymer composition and particle size, properties which the vaccine efficiency can be sensitive. Gold nano also play an important role to release vaccine in fish. The nano vaccine are peripheral one and one should have to give the time to get result thus this attained may considered as peripheral nano vaccine.

The vaccine can deliver through Chitosan nano that is able to wrap itself around vaccines and act as a carrier used in nanoencapsulation for treatment delivery in the fish physiology. Nanoencapsulated vaccines against the bacterium *Listonella anguillarum* can be introduced in Asian Carp[40-41]. Nanostructuring of a coating or paint through incorporation of metal oxide nanoparticles (CuO, ZnO, SiO2) can control biofouling (unwanted bacteria (as biofilm), algae (diatoms and seaweeds) and invertebrates (barnacles and mussels), as because, the coatings bind to metal nanoparticles, develop an efficient antifouling surface and improve the performance of antifouling control. Since nanotechnology may help aquaculture production by improving feeding formulation, disease control, biofouling control. Shrimp culture also can control by nanotechnology [42-43].

Ecofriendly synthesis of nanoparticles and its biological impacts on aquaculture

Nanotechnology is one of fastest emerging research fields. Green Synthesis of metallic nanoparticles is ecofriendly. Biosynthetic methods employing either biological microorganisms or plant extracts have emerged as a simple alternative to physical and chemical. The method involves the plant based synthesis of nanoparticles. Green synthesis techniques, is play a vital role in eco-friendly, nontoxic, simple, cost-effective, synthesis of nanomaterials. Environmental safety and safe solvents such as water, natural extracts etc., is used in biological approaches such as microorganisms and plants/plant extracts for synthesis of metal nanoparticles have been suggested as safe alternatives to chemical methods. Use of plant and plant materials for the synthesis of nanoparticles is relatively new and exciting research field. The biogenic metal oxide nanoparticles were synthesized using the leaves of *Parthenium hysterophorous* [44] and *Tabernae montana* [45] by green synthesis route. Now a days plant materials have became a prospective source for the synthesis of metallic nanoparticles. A number of researchers have reported on synthesis of silver and gold nanoparticles using different plant materials [46-47]. The Green synthesis of silver nanoparticles was consummated out using *Boerhaavia diffusa* [48] and *Ficus sycomorus* [49]. Plant extract as a reducing agent and effective antibacterial activity. The antifungal efficiency of zinc oxide nanoparticles was investigated against two pathogenic fungal species, *F. oxysporum* and *P. expansum* [50]. Antioxidant potential of nanoparticles was assessed through 2, 2–diphenyl-1-picrylhydrazyl (DPPH), hydroxyl, and superoxide anion free radicals with varying concentration, while it was found to decline in ZnO nanoparticles [51]. CuO Nanoparticles [52].

A number of researchers have worked on synthesis of silver and gold nanoparticles manipulated different plant materials [53-56]. Ascorbic acid or vitamin C is distributed widely in both plant and animal kingdoms. In vegetable cells, it bound to protein as ascorbigen [57]. Among animal organs, the liver, leukocytes and anterior pituitary lobe show the highest concentrations of ascorbic acid. Vitamin C also is present in many other biological systems and multivitamin preparations, which are commonly used to supplement inadequate dietary intake [58]. Antioxidants are micro constituents that can exploration reactive oxygen species (ROS) by terminating the oxidizing chain reaction [59]. ROS play a fundamental role in the pathogenesis of a variety of degenerative conditions including cardiovascular diseases and carcinogenesis DPPH assay are widely used to evaluate the radical scavenging ability of green synthesized nanoparticles [60]. ZnO is nontoxic; it can be used as photocatalytic degradation materials of environmental pollutants. Bulk and thin films of ZnO have demonstrated high sensitivity for many toxic gases [61-62].

Natural ecosystem and environmental impact of nanoparticles in aquaculture

Quality of water in natural aquatic ecosystem can change with the help of physical; biological and a chemical process which helps in improve the quality of the water. Fish pond water is the kidney of the aquaculture. In this context, if we would like to take one example, like East Kolkata Wetland, India, an International Importance of the Ramsar Convention and its water bodies are the important source for sustainable aquaculture [63-66].

A sewage fed East Kolkata Wetland, India, is very important part in city, in urban and also in rural area. The sewage should be clean for pollution free city. This processes are need to be utilize in a systematic way. Why the systematic way? As because, it is the source of huge nitrogenous products and can take the product of sewage by recycling process. Fish cultivation in Kolkata's sewage-fed fisheries is a unique feature. Naturally, we recently started our work to go through the ecology of the East Kolkata Wetland , specially the water body ecology, aquatic ecology, plant ecology, socio economical status of that regions , its geography etc. The purpose of this study to purify the sewage feed water body not only by natural phenomena but also by nano device, if possible. To ensure this, it is necessary to look after the entire matter of the water bodies of the wetland of East Kolkata for more aquaculture which can boost up the economy of the populations, who are living in adjoining areas of these regions. Moreover, the sewages are full of with agricultural discharges and other household residues. Industrial effluents contain are also there which are variety of toxic pollutants including suspended solids, organic compounds, inorganic compounds, pesticides and various toxic metal compounds etc. The chief sources of contaminants are the industrial waste discharge, mining, agriculture, household waste disposal and fuel combustion [66-67]. Aquaculture is totally based on aquatic quality, if the several toxic heavy metals like, cadmium, copper, mercury and zinc etc. are reported in the water quality, then it is highly inexpedient to culture the fish. These are not only toxic to human health but also can damage several tissues of several organs of the fish [68].

Recently it has been established that the several nanoparticles can deposited in the food web and can enter in the animal physiology is reported in Kumar and Singh, 2010. In general, they are not biodegraded and therefore, their bioaccumulation in fish, oyster, mussels, sediments and other components of aquatic ecosystems have been reported from all over the world. It appears that problem of heavy metals accumulation in aquatic organisms including fish needs continuous monitoring and surveillance owing to metal ions which are usually absorbed through passive diffusion or carrier mediated transport over the gills of fishes while metals associated with organic materials are ingested and absorbed by endocytosis through intestine of fish. It has been suggested that cadmium ions enter the chloride cells in the gills of fish through calcium channels. Once enter in the cells of physiological system the metal is made available for the interaction with cytoplasm components such as enzymes (causing toxic effects) and metallothioneine (probably being detoxified). Although metallothoneine is induced in the gills it does not appear to be as capable of sequestering the vast majority of accumulated Cd^{2+}, as it is in the liver. However, high calcium concentrations in water protect them from cadmium uptake by competing at uptake sites. It is very rare that only one toxic element, at a time, is released into the aquatic ecosystem. Most of the heavy metals interact with each other and also influenced by other ions (e.g. Ca^{2+}, Mg^{2+}, Na^{2+}, Mn^{2+}, Fe^{2+}, Pb^{2+}, S^{2+}, Se^{2+} and Ni^{2+}). Calcium has been shown to interact with Cd^{2+} to potentiate or minimize their toxicity. Elevated ingestion Cd^{2+} bioaccumulation of cadmium takes place at tropic level and found to be highest in algae. Organs directly following uptake through the gills and intestine, but there may also be redistribution of cadmium form other organs.

The recent developments involving carbon nano tubes (CNTs) in smart delivery systems of various biomolecules / genes/drugs enter into the cells, studies have been progressively being performed in an effort to find the uptake and transport mechanism of CNTs into the intact plant cells. Metallic nanoparticles are also absorbed in plants either through soil or through nature and can transmitted to secondary consumer in process of food chain of aquatic ecosystem [69]. The present knowledge on the applications, opportunities and risks of nanotechnology in the food chain ("from farm to table") is very essential. The production and application of engineered nanoparticles is expeditiously increasing, and development of acceptable models for screening nanoparticles for attainable toxic effects is essential to protect aquatic organisms and support the imperishable development of the nanotechnology industry. Relatively little is known regarding the fate and possible toxic effects of engineered nanoparticles (ENPs) in the aquatic domain. At this moment, the reports are coming that the nanoparticles particokinetics within cells in culture are influenced by a range of factors as well as pH, ionic strength and viscosity of the culture media together with particle size, shape and charge density. All of these factors influence the agglomeration and sedimentation rate of the particles within the media, which in turn determines the bioavailability of particles to the cells and resultant toxic effects. But still it is in observation stage. If we look in to this matter very properly and handle the fact in a particular way then in my opinion it will not be any problem in the application of nanoparticles in the aquaculture practices. This type of experiments are very mandatory because the people will know how the means of handling the nanoparticles in the aquaculture media without knock up of pollution effects in the food chain of aquatic media [70].

In every new application where some environmental impacts are there and that should be evaluate. Now it is clearly that nanoparticles are available from lower trophic levels to terrestrial food webs [71]. Moreover, recent experiments helps to denote that a particular size of nanoparticles like, gold, copper etc., can transfer from *Daphnia magna* to earthworms to *Danio rerio* (zebra fish) and also take part in bio magnifications. Moreover, the main problem in taking the engineered nanoparticles (ENPs) which has the ability to enter in the environment in significant quantities and some exposure experiment clearly denotes that the oxidative damage and DNA damage can perform in the different tissues of fish but no adverse health effects. It is obvious that the potential health risks associated with exposure to engineered ENPs are now a major international concern, yet almost nothing is known on fate and biological uptake of engineered nanoparticles in the aquatic environment. Furthermore, almost all studies in recent decade have been focused on the raw engineered nanoparticles, rather than the forms entering in the environment. Naturally, focus will be in future to evaluate the role of engineered nanoparticles have the ability to damage the soft tissues of gills and embryos of fishes or not. Sustainable development of fish culture where nanotechnology can take part for bacteria identification in water quality of fish culture and food quality monitoring using biosensors; intuitive, active, and smart food packaging systems; and nano encapsulation of bioactive food compounds are few examples of emerging applications of nanotechnology for the fish-food industry. Despite the success of nanotechnology in the food and bioprocessing industry hinge on the perspicacity of consumers and societal acceptance [72].

Nanotechnology has been attaining a great momentum and becoming a global important tool for the food and bioprocessing industry to meet the increasing world demand resulting from population growth and increasing financial income in developing countries. Nanotechnology might improve the processes of production of innovative and moderate and highly public demanded products with better characteristics and new functionalities in the food and bioprocessing industry.

Conclusion

Fish play an important role in sustaining food security in many developing countries. The importance of fish is coming more to the forefront, however, as the state of world fish stocks is revealed to be parlous, and as the tide of fish demand keeps rising. The challenges of meeting future world fish supply needs and improving food security are indeed daunting. Aquatic environment for aquaculture is an important part and that can be maintained by our recent technique – the nanotechnology. Within this nano vision, a revolution is inevitably occurring in science and technology, based on the recently developed ability to measure, manipulate and organize matter on the nanoscale 1 to 100 billionth of a meter. At the nanoscale, biology, chemistry, physics, engineering and materials science converge toward the same principles and tools. Article provides a general overview of the wide variety of nano-materials and technologies in fish culture that offer significant promising role for water recovery. It is quite evident from the foregoing discussion that nanomaterials have enormous potential to provide innovative solutions for proper or sustainable aquaculture. However, for their successful implementation in aquaculture, as commercially viable technologies, one needs to carry out a thorough study on the engineering aspects, environmental issues, scalability and cost analysis. As a result, progress in nanoscience will have very far-reaching impact, but still, the next generation fish production will be the prime one with the help of nanotechnology. The fisheries and aquaculture industry can be revolutionized by using nanotechnology with new tools, rapid disease detection and enhancing the ability of fish to rapidly absorb drugs such as hormones, vaccines and nutrients etc. for more fish production in sustainability. Green synthesis of nanoparticles is effective role in antimicrobial activity against both bacterial strains and fungal strains. The photodegradation of synthesized nanoparticles in its organic, carcinogenic dye of industrial effluents and it's a wide variety of organic pollutants introduced into the natural water resources or wastewater treatment systems. DPPH radicals. In addition, to this very simple, not expensive, stable and nontoxic, safety and eco-friendly without side effects of human beings.

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