ROLE OF THE ANTIBIOTIC RESISTANCE OF SILVER METAL AS A NANOPARTICLE IN AQUATIC PATHOGENS

M.V. Bhaskar Reddy[1] and C.V.N.Murthy[2]

Jawahar Bharati Degree College, Kavali, Nellore

Andhra Pradesh (AP), India.

ABSTRACT Nanotechnology in the recent years has been a highly promising field of research and hence has occupied center stage in the modern era of scientific research. Various types of nanoparticles like magnetic-nanoparticle, gold-nano particles and Silver nano particles have been increasingly used in medicine particularly in prevention and treatment of diseases in the recent years. The use of Silver nano particles is also on the rise. Although several reports point to the advantages of silver nano particles, there are studies on the other hand demonstrate that silver nanoparticles are toxic to human health. In order to address this toxicity issue, the need of the hour is to identify methods to prepare silver nano particles with no toxicity. Moving in this direction, studies are being focused to exploit various plant materials and products for the biosynthesis of harmless or nontoxic silver nano particles that is termed as green technology. This review focuses on the importance of silver, nano silver and the green synthesis of silver nanoparticles and their applications particularly in combating the aquatic pathogens.

Keywords: Magnetic nano particles, Silver nano particles, Green technology, aquatic pathogens

Introduction:

Aquaculture, most importantly fisheries in India is an important economic activity and a flourishing sector with varied resources and potentials. Fisheries together with agriculture represent a vital sector. However, the major problem faced by the aquaculture industry worldwide is diseases caused due to various biological and non-biological agents. Among the groups of microorganisms bacterial infections are considered the major cause of mortality in aquaculture leading to the loss of millions of dollars annually (Grisez et.al. 1995). Some of the bacterial pathogens include *Shigella flexneri*, *Escherichia coli*, *Klebsiella pneumonia*, *Proteus myxofaciens*, *Vibrio sp.*, *Bacillus cereus*, *Staphylococcus aureus*, *Styphylococcus epidermis*, *Streptococcus pyogens* and *Clostridium species.* The list provided here is just a mention of few of the several pathogens.

Use of antibiotics in aquaculture:

In aquaculture, many strategies have been used to control these bacterial diseases and more solutions are still being investigated (Schneider, Steslow et al. 1991; Sugita H 1992). A fast and common solution to control bacterial diseases is through the use of antibiotics. In aquaculture, particularly shrimp hatcheries antibiotics have been applied to the shrimp feed and water in large quantities primarily to treat and prevent diseases in farmed shrimps. Orfloxacin, oxytetracycline, enrofloxacin, ciprofloxacin, chloramphenicol, erythromycin, furaxolidone. nifurpirinol, oxolinic acid, ormetoprim, rifampicin, trimethoprim and various sulfonamides are commonly used antibiotics in aquaculture (Gräslund 2001).

Multiple antibiotic resistance:

However, use of antibiotics has its downfalls-as the overuse and misuse of antibiotics can cause bacteria to become resistant. Of particular concern is the indiscriminate use of antibiotics leading to the development of Multiple Antibiotic Resistant (MAR) pathogenic bacteria in shrimps and humans (Zanetti S 2001). It has also been demonstrated that bacteria can transfer their resistance genes to human pathogens, thus endangering human health. In addition to the resistance problem, residual antibiotics can also have adverse effects on the organism's welfare and on the environment (Clatworthy, Pierson et al. 2007; Das, Ward et al. 2008). Hence, there is an immediate requirement for the development of novel methods to control and prevent infectious diseases in aquaculture also combating the drug resistant bacteria. One major alternative method being explored in recent times is the application of nanotechnology as an antimicrobial drug in aquaculture.

Nanotechnology:

The field of nanotechnology is one of the upcoming areas of research in the modern field of material science and is rapidly expanding into various areas, such as health, food, feed, environmental aspects and agricultural practices (Roszek et al. 2005). Nanoscale materials are structures ranging from 1 to 100 nm, as defined in the chemistry context, which have contributed to the development of nanoscience and nanotechnology at an exponential rate in recent years. Nanomaterials by virtue of their physico-chemical properties have emerged as promising antimicrobial agents. These nanoparticles can adopt various mechanisms like inhibition of the synthesis of functional biomolecules or impeding normal cellular activities to kill pathogens. Various metals that are being used to prepare nanoparticles include Gold, Silver, Zinc, Copper, Aluminium and Iron.

Among the above metals, silver is gaining increased importance in the recent times as it provides superior material properties and functional versatility apart from being cheaper. Silver is naturally occurring precious material most often as a mineral ore in association with other elements and has the highest electrical and thermal conductivity of all metals and has the lowest contact resistance (Nordberg and Gerhardsson.1988). Reports indicate that metallic silver appear to exhibit minimal health hazards while few reports suggest soluble silver get readily absorbed and may cause potential adverse effects (Drake and Hazelwood. 2005).

Silver nanoparticles:

Silver has been largely used as a disinfectant in food and water. Further, Silver, Since ancient times, has been implicated in Ayurvedic medicine for microbial inhibition owing to its antimicrobial property and minimal toxic effects (Jung et al. 2008). Over the years, Application of Nano-silver has been shown to be an effective agent against a broad spectrum of Gram negative and Gram-positive bacteria (Burrell et al. 1999), including antibiotic-resistant strains (Wright et al. 2002; Percival et al. 2007). Further these particles have been reported to provide effective treatment against fungal as well as the viral diseases (Kim et al. 2007; Sun et al. 2005). The current statistics demonstrate that the various nano particles being used today kill more than 650 pathogens.

Green technology:

The green synthesis is a concept that is introduced to define the method used in synthesis, which is favoured over solvent medium. This is because green synthesis is environmentally friendly and contains a reducing agent that is benign to the environment. Besides, it also utilizes a non-toxic stabilizer in forming silver nanoparticles (AgNPs). Preparation of nanoparticles by green synthesis using the natural products obtained from the plants and their by-products is of considerable interest since plant material seems to be the best candidate for large scale bio-synthesis of nano particles. Nanoparticles produced by plants are more stable, and the rate of synthesis is faster than that in the case of other organisms.

Several plants have been successfully used for efficient and rapid extracellular synthesis of silver nanoparticles. Different plant products like leaf extracts of Geranium (*Pelargonium graveolens*) (Shanker et al., 2003), Lemongrass (*Cymbopogonflexuosus*) (Shankar et al., 2005), *Cinnamommum camphora* (Huang et.al.,2007), Neem (*Azadirachtaindica*) (Shanker et.al., 2004), Aloe vera (Chandran et.al.,2006), Tamarind (*Tamarindus indica*) (Amkamwar et.al.,2005a) and fruit extract of *Emblica officinalis* (Amkamwar et.al.,2005b) have been successfully prepared and characterized. Yet there are several more to be added in this list.

Silver nanoparticles combating aquatic pathogens:

Aeromonas hydrophila is a heterotrophic, Gram negative bacterium which is primary or secondary cause of ulcers, fin rot, tail rot, and hemorrhagic septicaemia in fish. The treatments for this infection are only restricted to some antibiotics. The antimicrobial efficacy of AgNPs using *Cedrus deodar* leaf extract elicited antimicrobial activity against this major fish pathogen. *Aeromonas hydrophila* generates hope for its possible application as a disinfectant or antimicrobial agent for better fish health management. Antibacterial and antifungal activities of the native and chemically modified extracts from neem seeds, seed-hulls and antibacterial activity of synthesized AgNPs showed effective inhibitory activity against water borne pathogens like *Escherichia coli* and *Vibrio cholera* (Wafaa et al. 2007). The therapeutic effects of the AgNPs prepared from the wild tea leaf extracts were tested against *Vibrio* species which is an opportunistic aquatic pathogen that attacks the shrimp cultures.

Other applications of nanoparticles in aquaculture:

Apart from possessing enhanced therapeutic activity, the AgNPs could be used in the development of aquatic nano-bio sensors for detecting fish and other aquatic pathogens, disease diagnosis, smart and effective drug delivery, for improving the fish growth, food packaging, to maintain the quality of water through filtration and remediation, waste water treatment, management of aquatic environment.

Conclusions:

Overall, various types of biosynthesized AgNPs have multiple applications in the fisheries and aquaculture. The developments in this area of research provide us new tools and techniques for aquaculture, fish genetics and for the improvement of aquatic health. The antimicrobial properties of various nanosilver based herbal formulations could be exploited to reduce the accumulation of bacteria and to reduce their effects in the aquaculture system. This technology provides us a promising alternative approach for controlling diseases caused by various aquatic pathogens. Thus the biosynthesized AgNPs may in future be included among the potential biological disease controlling agent in aquatic pathogens. Although several reports have demonstrated the beneficial effects with respect to controlling various pathogens one has to understand the impact and toxicity level of AgNPs on soil microbial community and plants. Hence there is an immediate requirement from the scientific community for a complete and comprehensive understanding of the toxicity of the particle if any, their interactions within the ecosystem and ultimately the fate of the biosynthesized AgNPs so that this powerful technology could be adapted for the welfare of the human and animal welfare as well in the environmental conservation.

References

1. Ankamwar B, Chaudhary M and Sastry M. 2005a. Gold nanotriangles biologically synthesized using tamarind leaf extract and potential application in vapor sensing. *Synth React Inorg Metal-Org Nano-Metal Chem* 35:19–26.
2. Ankamwar B, Damle C, Ahmad A and Sastry M. 2005b. Biosynthesis of gold and silver nanoparticles using *Emblica officinalis* fruit extract, their phase transfer and transmetallation in an organic solution. *J nanosci Nanotechnol* 5:1665–1671.
3. Burrell RE, Heggers JP, Davis GJ, Wright JB. 1999. Efficacy of silver-coated dressings as bacterial barriers in a rodent burn sepsis model. *Wounds* 11: 64-71.
4. Chandran SP, Chaudhary M, Pasricha R, Ahmad A and Sastry M. 2006. Synthesis of gold nanotriangles and silver nanoparticles using *Aloe vera* plant extract. *Biotechnol Prog* 22:577–583.
5. Clatworthy AE, Pierson E, Hung DT. 2007. Targeting virulence: a new paradigm for antimicrobial therapy. *Nat Chem Biol* 3: 541–548.
6. Das S, Ward LR, Burke C. 2008. Prospects of using marine actinobacteria as probiotics in aquaculture. *Appl Microbiol Biotechnol.* Dec, 81 (3): 419-29.
7. Drake PL, Hazelwood KJ. 2005. Exposure-related health effects of silver and silver compounds: A review. *Ann Occup Hyg* 49:575-585.
8. Graslund, S. And B. E. Bengtsson. 2001. Chemicals and biological products used in South-east Asian shrimp farming, and their potential impact on the environment a review. *Sci.Total Environ.* 280: 93-131.
9. Grisez, L. and F. Ollevier, 1995. *Vibrio* (Listonella) *anguillarum* infection in marine fish larviculture. In: P. Lavens, E. Jaspers and I. Roelande, Eds, *91- Fish and Crustacean Larviculture Symposium, European Aquaculture Society, Gent, Special Publication,* 24: 497.
10. Huang J, LiQ, Sun D, Lu Y, Su Y, Yang X, *et al.* 2007. Biosynthesis of silver and gold nanoparticles by novel sundried *Cinnamomum camphora* leaf. *Nanotechnology* 18:105104–105114.
11. Jung WK, Koo HC, Kim KW, Shin S, Kim SH, Park YH. 2008. Antibacterial activity and mechanism of action of the silver ion in *Staphylococcus aureus* and *Escherichia coli. Appl Environ Microbiol* 74:2171–2178.
12. Kim JS, Kuk E, Yu KN, Kim JH, Park SJ, Lee HJ, Kim SH, Park YK, Park YH, Hwang CY, Kim YK, Lee YS, Jeong DH, Cho MH. 2007. Antimicrobial effects of

silver nanoparticles. *Nanomedicine* 3:95-101.

13. Nordberg G, Gerhardsson L. 1988. Silver. In: Seiler HG, Sigel H, Sigel A, editors. Handbook on toxicity of inorganic compounds. *New York: Marcel Dekker*. p 619-624.
14. Pal, S., Yu Kyung, T. and Song, J.M. 2007. Does the Antibacterial activity of silver nanoparticles depend on the Shape of the nanoparticle? A study of the gram-negative bacterium *Escherichia coli*. *Appl Environ Microbiol* 73, 1712–1720.
15. Percival SL, Bowler PG, Dolman J. 2007. Antimicrobial activity of silver-containing dressings on wound microorganisms using an *in vitro* biofilm model. *Int Wound J* 4:186-191.
16. Roszek B, de Jong WH, Geertsma RE. 2005. Nanotechnology in medical applications: State-of-the-art in materials and devices. *RIVM report 265001001*.
17. Schneider KR, Steslow FS & Sierra FS. 1991. Ozone depuration of *Vibrio vulnificus* from the southern quahog clam, *Mercenaria campechiensis*. *J Invest Pathol* 57: 184–190.
18. Shankar SS, Ahmad A, Pasrichaa R and Sastry M.2003. Bioreduction of chloroaurate ions by geranium leaves and its endophytic fungus yields gold nanoparticles of different shapes. *J Mater Chem* 13:1822–1826.
19. Shankar SS, Rai A, Ahmad A and Sastry M. 2005. Controlling the optical properties of lemongrass extract synthesized gold nanotriangles and potential application in infrared-absorbing optical coatings. *Chem Mater* 17:566–572.
20. Shankar SS, Rai A, Ahmad A and Sastry M. 2004. Rapid synthesis of Au, Ag, and bimetallic Au core–Ag shell nanoparticles using neem (*Azadirachta indica*) leaf broth. *J Colloid Interf Sci* 275:496–502.