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Bio nanoparticles role in Insect Pest Management

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Abstract

Increase in the population and growing industries have resulted in contamination of natural reservoir. It leads to several problems like global warming, green-house effect nowadays nanoparticles are used for the various fields due its unique properties and inevitable application. There are various methods used for synthesis of nanoparticles, like physical, chemical and biological method. For its inimitable function, it was used for the water purification, drug delivery; anti-microbial, anti-cancer, antioxidant and it also used for the Pest management, etc. Nanoparticles have unique size dependent properties according to their reactivity and strong adsorption. Ag nanoparticles at low concentration used for the insect control. These are the spherical metal particles have larvicidal activities and used against larvae of parasite. In other side, this nanoparticle leads to bio magnification and bioaccumulation. In this way, they pose a great health risk to non-target organisms as they are carcinogens in nature. So, these nanoparticles played various roles in different fields but they should be utilizing in wise manner.

Keywords: Insect Pest Management, vector, Nano pesticide, Plant extract, Eco friendly.

Introduction

Mosquitoes are little flies belong to phylum Arthropoda and order Diptera. Their body consists of long proboscis i.e. labium and stylets. The whole body has covered with setae as well as scales [1]. They consist of piercing and sucking mouthparts. Their life cycle shows four different stages. These are egg, larva, pupa, and adult. The lifespan of females differs with males. In other words, adult male lives for 10 days, in other hand, adult female lives for 42-56 days. They are ectoparasites of humans and pet animals. They are meant for transferring pathogens of human diseases in Central America, Africa, Asia and Mexico. Mosquito species are commonly found in the different zones of the world [2]. They, generally, spread human diseases like malaria, dengue, filariasis, yellow fever and chikungunya which results in the millions of death. Malaria is mainly transmitted by *Anopheline* species in India. Every year, about two to three

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million cases of malaria were observed. The other genera, *Aedes aegypti*, dengue vector of that caused by arbovirus, widely found in tropical as well as sub-tropical zones [3].

In Maharashtra, 209 villages were infected by dengue fever. About 80,000 people were infected in Karnataka and Andhra pradesh since 2005. *Culex quinquefasciatus*, vector of Wuchereria species, causing filariasis. So, mosquito control is one of the approaches for human health. Mosquito - borne diseases are controlled by interrupting the disease - transmission via prevention from biting as well as killing of these vectors. Their control, mainly, observed by the use of insecticides, made up of chemicals, but they created a lot of problems like damage of non-target organisms and imbalance in environment. During the past, several types of chemicals like organophosphates i.e. temephos and growth regulators like diflubenzuron and methoprene were used to reduce the population of mosquito [4]. The continued use of these insecticides helped to reduce the larvae but also make problem of insect resistance i.e. firstly, they kill the insect but after a long use, they were unable to kill them. Finding safer and efficient techniques, researchers paid their attention to natural compounds [5]. Various extracts as well as essential oils from plants were used as source for controlling mosquitoes [6-7].

Plant mediated nanoparticles

The plant extracts were utilized to synthesize nanoparticles. Nanoparticles are smaller in size. They play an important role in imaging, diagnostics, tissue engineering [8]. This method proved more beneficial over physical as well as chemical methods because it is environment-friendly and cost-effective [9]. The green synthesis of nanoparticles occurred by various natural products. Generally, Silver nanoparticles are proved to be most important because of their high potential against bacteria, fungi, plasmodium and maximum larvicidal property. They are also non-toxic to non-target organisms [10].

Green synthesized nanoparticles against Mosquito vector

The larvicidal activity of *Polianthus tuberosa* was reported against mosquitoes. Its flowers blooms at night and are waxy whitish in colour. In order to prepare extract as well as silver nanoparticles, its bud were used along with silver nitrate solution. The silver ions were reduced by the treatment of $AgNO_3$ solution with extract of *P.tuberosa.* They were highly effective against *Culex vishnui* and *Cx. quinquefasciatus.* The mortality rate was assessed at 20 ppm with different concentration of LC_{50} and $LC_{90.}$ They also identified that these nanoparticles

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have no effects on other organisms i.e. *Toxorhynchites* larvae (predator of mosquito), *Diplonychus annulatum* (predatory water bug). They calculated the mortality rate by using Abott‘s formula. The greater mortality was shown by fourth instar larva. But the mechanism of larvicidal activity is yet unknown [11].

Alqahtani *et al*. [12] investigated the effects of silver nanoparticles of the leaf extract of *Rubus ellipticus* against different stages i.e. egg, larvae and adults of mosquitoes. All the three genera of mosquitoes were tested. The leaf extract mainly attacked on oviposition, larvae and adults. They also studied its effects on three aquatic species these three species are non- target organisms that have little harmful effects. The synthesis of silver nanoparticles was detected by the fast color change from yellow to brown. Different techniques were utilized to detect the shape, size, composition of these particles. They showed 100% death rate. The different concentrations of this extract and AgNPs were highly responsible for delaying the activity of oviposition in females of these species. This can be done by the help of strong smell of higher concentration of extract and synthesized silver nanoparticles. The adult showed continued movement without any rest and in abnormal manner that leads to the death of the adult [12].

Elumalai *et al*. [13] collected fresh leaves of *Achyranthes aspera* for the preparation of leaf extract and synthesized nanoparticles by using $AgNO_3$ solution. These nanoparticles were bind with S-containing proteins or P- containing DNA that leads to the loss of cellular function and ultimately cell death. They were penetrated through the membrane of larva. The leaf extract has high larvicidal activity against *Aedes* and *Culex*. Saponins extracted from the extract were used as killing compound. The mortality rate of these vectors depends upon the dose of leaf extract that used. They concluded that these AgNPs were more effective at its low concentration.

Dinesh *et al*. [14] investigated the mosquito killing properties of *Aloe Vera*. They prepared the leaf extract that is further utilized for the formation of silver nanoparticles. They tested them against 4th instar larvae and pupa of *An. stephensi.* They stressed on the toxicity of leaf extract as well as AgNPs in both lab and field conditions. They showed that extract was toxic at low dosages but AgNPs were more toxic against *An. stephensi* under lab conditions. In case of field, synthesized AgNPs were capable for the reduction of larva i.e. 74.5, 86.6 and 97.7% after 24, 48 and 72h. LC50 of extract was 48.79 ppm for 1^{st} instar, 59.09 ppm for 2^{nd} instar and 70.88 ppm for 3^{rd} instar and 152.55 ppm for pupae. The synthesis was occurred after

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120 min. Maximun absorption observed at 410 nm. They also established their maximum toxicity against bacteria *B. subtilis, K. pneumonia* and *S. typhii.* The concentration tested by them was 150mg/L which was much suitable against *B. subtilis.* They concluded that these AgNPs as an excellent mosquitocidal tool and quite efficient against the vector *An. Stephensi.*

Plant	**Particles Size (nm)**	**UV-vis range**	**Larval Instar**	**Concentration (ppm)**		**References**
				LC50	**LC90**	
Ambrosia arborescens	14	414	3rd	0.28	0.43	Bianca et al., [15]
Polianthus tuberosa	50	450	3rd	9.65	27.18	Rawani 2017 [11]
Aloe vera	35-55	410	2nd 3rd	59.09 70.88	333.52 298.55	Dinesh et al., [14]
Feronia elephantum	20-60	420	3rd	14.19	24.30	Veerakumar et al., [3]
Sida acuta	20-60	420	3rd	26.13	47.52	Veerakumar et al., [16]
Murraya koenigii	20-35	410	2nd 3rd	374.95 461.01	891.16 1021.90	Suganya et al., [17]
Solanum nigrum	56.6	450	3rd	1.26	14.39	Rawani et al., [18]
Pergularia daemia	123.5	520	2nd 3rd	5.12 5.66	11.13 12.40	Patil et al., [19]
Plumeria rubra	105	456	2nd	1.49	14.00	Patil et al., [20]

Table 1: List of Plant AgNPs against mosquito larvae

Balakrishnan *et al*. [21] tested the leaf extract of *Avicennia* marina against mosquitoes. *A. marina* is a mangrove plant used for the synthesis of nanoparticles. This can be identified by the colour change of extract which occurs by the presence of both Callous and leaf extract with $AgNO_3$. From this extract many functional groups of different chemical classes were collected. Terpenoids proved that they have maximum larvicidal ability against these vectors. This methodology also proved the efficacy of *A.marina* extract i.e. they kill mosquitos at large scale.

Synthesis, Characterization and larvicidal activity

The larvicidal efficacy of synthesized AgNPs was studied by using plant of family *Rutaceae*. They prepared leaf extract using *Feronia elephantum* and investigated

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against the 3rd larval stage of vectors.They used different concentrations of aqueous crude extract and AgNPs for 24 h exposure to larvae. The activity against mosquitoes differs according to different concentrations. They proved that the crude extract were less toxic than aqueous extract. They took the late third instar larvae for testing purposes. Different techniques that are UV-spectroscopy, FTIR and XRD were used to study the detailed information of these nanoparticles. With the help of FTIR different banding patterns were studied. These particles showed 88% mortality of 4th instar larvae. The maximum repellent action was showed by crude extract against three mosquito vectors but varies in time limit [3].

Veerakumar *et al*. [16] performed the research on leaf extract of *Sida acuta* for controlling the population of three vectors. They did their work under controlled conditions in laboratory. They used different concentrations of extract and assessed mortality of vectors. They got death rate at $P < 0.05$ level of significance. AgNPs were also formed by leaves of *Catharanthus roseus.* This effect was studied by [22]. Veerakumar et al., [16] explained the non-toxicity as well as reducing nature of synthesized nanoparticles. They were more toxic than crude extract and showed high mosquito killing property.

Rawani *et al*. [18] proposed their work on mosquito control using the plant *Solanum nigrum*. They utilized fresh as well as dry leaves and also green berries against larvae of mosquitoes. They also studied its effect against human and fish pathogenic bacteria. They also found some effects against non-target organisms but no abnormality was found.. They formed chloroform methanol and crude extract against *Culex quinquefasciatus.*

The extract was formed within minutes and confirmed by the change in colour from colorless to reddish brown. The synthesized AgNPs were light brown in color. The metal nanoparticle undergoes surface plasmon vibrations which was responsible for color change [23]. Nanoparticles were polyhedral in shape. The 100% mortality was obtained in case of 2nd and 3rd instar larvae of *An. stephensi* by using 10 ppm concentrationof fresh leaf extract and at the same concentration of berries, larvae showed only 96.65 % mortality. The actual mechanism of killing is yet unknown. It can be assumed that AgNPs entered in midgut membrane that leads to the inactivation of enzymes which are responsible for forming peroxide that cause cell death [24].

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Chandran *et al*. [25] studied mechanism of formation of silver nanoparticles using *Aloe vera* plant. This plant has large number of medicinal properties and act as antioxidative as well as antipyretic. They explained the reaction between extract and aqueous silver ions which produces nanoparticles. They, initially, were triangular in shape but by increasing the amount, their shape becomes spherical. These nanoparticles were pale yellow within 24h. They also synthesized gold nanoparticles by using aqueous *Chloroaurate* ions. These were also triangular shaped and capable of maintaining the size. Formation of gold nanoparticles was occurred by slower rate of reaction.

Conclusion

The purpose of this review is to view the trends in the field of mosquito control. From the study, it is concluded that the plant synthesized nanoparticles were highly effective as well as eco-friendly towards mosquito control. It is very easy to prepare the green nanoparticles and then used under control set up against mosquitoes. In future, bio nano based pesticides will be developed and existing in market.

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