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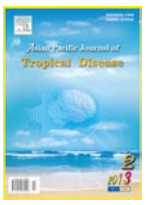

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Nano particles of herbal origin: A recent eco-friend trend in mosquito control

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To the editor,

Vector control is an essential requirement in control of epidemic diseases such as malaria, filariasis, dengue that are transmitted by different species of mosquitoes. Emergence of insecticide resistance and harmful effect on non-target organisms and environment necessitated an urgent search for development of new and improved mosquito control methods that are economical and effective as well as safe for non-target organisms and the environment. Insecticides of synthesized natural products, such as silver, gold or silicon nano-particles of herbal origin become a priority in this search.

The word "nano" is derived from a Greek word meaning "dwarf". In technical terms, the word "nano" means 10^{-9}, or one billionth of a meter. Targeted nanoparticles exhibit many novel characteristic features, such as extra ordinary strength, more chemical reactivity, magnetic properties and or high electrical conductivity. "Nano-technology" deals with application of such particles in biological, physical, chemical, environmental, agricultural, industrial or pharmaceutical science.

At present, a number of physical, chemical, biological, and hybrid methods are available to synthesize different types of silver, gold, silicon, zinc and platinum nanoparticles. Although physical and chemical methods are more popular and widely used for synthesis of nanoparticles, the related environmental toxicity and non biodegradable nature of the products limited their applications. So, the "green" route for nanoparticle synthesis from herbal origin is of great interest due to eco-friendliness, economic prospects, feasibility and wide range of applications[1].

Nano technology has a wide application in vector control in the form of nanocapsules for herbicide delivery and vector and pest management and nanosensors for pest detection[2]. Synthesized silver or gold nanoparticles also help to produce new insecticides and insect repellants. Applications of nano technology have been extended in the field of mosquito control by the synthesis of silver/gold nano particles from environmentally acceptable plant extract and eco-friendly reducing and capping agents. The characterization and the structure determination of these nano particles also become possible through the application of modern scientific instruments such as UV-VIS spectroscopy, Fourier Transform Infrared Spectroscopy, X-ray Diffraction, Scanning and Transmission Electron Microscopy, which also advocates for its wider application. Green synthesis of nanoparticles are also used in the molecular

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level where gene silencing triggered by dsRNA or small interfering RNA, siRNA have been also practiced in mosquito control operations.

The use of "green" processes for the synthesis of nanoparticles is a new and rapidly developing branch of nanotechnology. However, knowledge of the bioactivity of nanoparticles against mosquitoes and malaria parasites is limited. Rajakumar *et al*. reported the use of silver nano particles synthesized from leaf extract of *Eclipta prostrata*, to control 4th instar larvae of *Culex quinquefasciatus* (*Cx. quinquefasciatus*) and *Anopheles subpictus* (*An. subpictus*)[3]. The synthesized particles' size was 35-60 nm. The highest mortality was calculated at 24 h in synthesized silver nano particles against *Cx. quinquefasciatus* (LC_{50}=4.56 mg/L; LC_{90}=13.14 mg/L) than *An. subpictus* (LC_{50}=5.14 mg/L; LC_{90}=25.68 mg/L). Sareen *et al.* had reported the larvicidal efficacy of silver nano particles synthesized from aqueous leaf extract of *Hibiscus rosasinensis* against the larvae of *Aedes albopictus*[4]. After 12 hours of exposure, 50% mortality was observed and after 16 hours of treatment, 90% mortality was calculated in 1.0 mg/L. 100% mortality was recorded in 5.0 mg/L of silver nano particles after 3 hours of exposure. Santhoshkumar *et al.* studied synthesis of Silver nano particles using *Nelumbo nucifera* leaf extract and its larvicidal activity was judged against *Cx. quinquefasciatus* and *An. subpictus*[5]. The maximum efficiency was observed against the larvae of *An. subpictus* (LC_{50}=0.69 mg/L; LC_{90}=2.15 mg/L) compared to *Cx. quinquefasciatus* (LC_{50}=1.10 mg/L; LC_{90}=3.59 mg/L). Jayaseelan *et al.* observed the larvicidal potentiality of synthesized silver nano particles using leaf aqueous extract of *Tinospora cordifolia* Miers against *An. subpictus* and *Cx. quinquefasciatus*[6]. The maximum efficacy was found against the larvae of *An. subpictus* (LC_{50}=6.43 mg/L). Haldar *et al*. synthesized highly stable nanoparticles of metallic silver with average dimension of 26.6 nm by a simple, cost-effective, reproducible and previously unexploited biogenic source viz. dried green fruits of *Drypetes roxburghii* (Wall) and reported its mosquito larvicidal activity against *Anopheles stephensi* and *Cx. quinquefasciatus*[7]. The larvicidal potential of silver nanoparticles synthesized using fungus *Cochliobolus lunatus* against two species of mosquitoes *Aedes aegypti* and *Anopheles stephensi* Liston have been reported by Salunkhe *et al*[8].

These results reveal that the green, biological synthesis of silver/gold nano particles have the potential to be utilized as a good, rapid, eco-friendly approach for the control of mosquito population. It is totally a new pathway but can be effectively utilized for the efficient killing of mosquitoes.

Conflict of interest statement

We declare that we have no conflict of interest.

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