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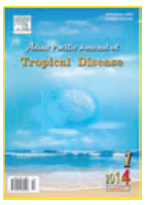

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Green synthesis of silver nanoparticles and its application for mosquito control

Naba Kumar Mondal[1*], Arnab Chowdhury[1], Uttiya Dey[1], Priyanka Mukhopadhya[2], Soumendranath Chatterjee[2], Kousik Das[1], Jayanta Kumar Datta[1]

[1]*Department of Environmental Science, The University of Burdwan, Burdwan-713104, India*

[2]*Parasitology and Microbiology Laboratory, Department of Zoology, The University of Burdwan, Burdwan-713104, India*

PEER REVIEW

Peer reviewer

Prof. Bikash Mondal, Department of Chemistry, Bejoy Narayan Mahavidyalaya, Hooghly, India.
Tel: +919474778062
E-mail: bmondal.bnm@gmail.com

Comments

This particular research highlighted the insight of bioactive agent in the formation of nanoparticles and their possible role towards the control of mosquitoes. It has a great application in community health improvement.
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ABSTRACT

Objective: To synthesize and characterize silver nanoparticles from aqueous root extract of *Parthenium hysterophorus* (*P. hysterophorus*) and also to evaluate the potentiality of synthesized silver nanoparticles as larvacidal agent against *Culex quinquefasciatus* (*Cx. quinquefasciatus*).
Methods: The silver nano particles were generated using root extract of *P. hysterophorus*. The characterization of synthesized nanoparticles was done by visual color change, UV-Vis spectrum, scanning electron micrograph, fluorescent microscope and Fourier transform infrared spectroscopy.
Results: It was found that aqueous silver ions can be reduced by aqueous root extract of *P. hysterophorus* to generate extremely stable silver nanoparticles in aqueous medium. Larvae were exposed to varying concentrations of plant extracts, aqueous silver nitrate solution and synthesized silver nanoparticles for 0, 24 and 48 h separately. Aqueous root extract showed moderate larvicidal effects; however, the maximum efficacy (60.18%) was observed with the synthesized silver nanoparticles against the larvae of *Cx. quinquefasciatus*.
Conclusions: These results suggest that the green synthesis of silver nanoparticles have the potential to be used as an ideal eco-friendly approach for the control of the *Cx. quinquefasciatus*. This is the first report on the mosquito larvicidal activity of the nano particle synthesized by *P. hysterophorus*.

KEYWORDS

Silver nanoparticles, Larvicidal potential, *Culex quinquefasciatus*, Biological control

1. Introduction

Mosquito have the ability of carrying and transmitting human and animal diseases across the countries causing hundreds of millions of clinical cases and millions of death annually[1,2]. Among several species of mosquitoes *Culex quinquefasciatus* (Diptera: Culicidae) (*Cx. quinquefasciatus*) is main periodic vector of filarial parasite *Wuchereria bancrofti*, accredited for human lymphatic filariasis transmission[3]. *Cx. quinquefasciatus* is a cosmopolitan mosquito with worldwide distribution, especially in the tropical and subtropical areas and is associated with human dwellings. The adult females lay eggs preferentially in relatively large, permanent aquatic habitats with high concentrations of decomposing organic matter, such as sewage effluents and septic tanks.

Several insecticides namely, DDT, dieldrin, organophosphrous, fenithothion and propoxur were widely used in India to mitigate this dangerous problem[4]. Persistent application of the synthetic chemical products mostly available in local markets causes undesirable consequences including production of resistant strains of

*Corresponding author: Naba Kumar Mondal, Department of Environmental Science, The University of Burdwan, Burdwan-713104, India.
Tel: +919434545694
Fax: 0342-2634200
E-mail: nkmenvbu@gmail.com

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mosquitoes, ecological imbalance and elimination of non-target organism in the environment[5].

Therefore, a demand stems out for the synthesis of bio-origin mosquito repellent[6,7]. In this juncture the field of nanotechnology is one of the most active areas of research in modern material sciences[8]. Nanoparticles are particles with a size of 100 nm which has a vast application in pharmaceutical, industrial and biotechnological fields[9]. Silver nanoparticles (Ag NPs) are emerging as one of the fastest growing materials due to their unique physical, chemical and biological properties; small size and high specific surface area. Ag NPs are reported to possess anti-viral, anti-bacterial and anti-fungal properties[10-12]. Presently Jayaseelan *et al*.[13] investigated the larvaecidal activity of Ag NPs against *Heteroscodra maculate*, which was synthesized by using aqueous leaf extract of *Musa paradisiaca*. The efficacies of synthesized Ag NPs using aqueous leaf extract of *Mimosa pudica* against the larvae of *Rhipicephalus microplus*[14]. Suman *et al*.[9] synthesized silver nanoparticle from aqueous aerial extract of *Ammannia baccifera* that can effectively inhibit larval activity of the larvae *Anopheles subpictus* (LC_{50}=257.61 ppm) and the larvae *Cx. quinquefasciatus* (LC_{50}=257.61 ppm) and synthesized Ag NPs showed significant toxic effects against the larvae of *A. subpictus* with an LC_{50}=29.54 ppm and against the larvae of *Cx. quinquefasciatus* at LC_{50}=22.32 ppm.

The use of environmentally benign materials such as silver nanoparticles offer numerous benefits of eco-friendliness and compatibility for larvicidal application. Keeping in mind the above fact the present aim of this study was to investigate the bioactive components present in the root extract of *Parthenium hysterophorus* (*P. hysterophorus*) plant which help the biosynthesis of silver nanoparticles and to analyze the larvicidal effects of the extract as well as silver nanoparticles on one mosquito species *Cx. quinquefasciatus*.

2. Materials and methods

2.1. Preparation of plant extract

A total of 0.84 g NaCl (Merck, USA) was dissolved in 100 mL of distilled water to prepare the saline water. The parthenium roots were collected from the road side of G. T. Road, Burdwan (23.2383° N, 87.8608° E) and washed with the saline water. The roots were then soaked in tissue paper for drying. A total of 4 g of dried root were cut into small pieces and smashed with 100 mL sterilized distilled water. Then it was boiled in the water bath for three minutes and the solution was collected through Whatmann No. 42 filter paper and kept into the refrigerator.

2.2. Preparation of $AgNO_3$ solution

Initially 0.17 g $AgNO_3$ (Merck, USA) was dissolved in 100 mL double distilled water for stock solution of $AgNO_3$.

2.3. Preparation of nanoparticle

The root extract of *Parthenium* and the $AgNO_3$ solution were mixed in the ratio of 1:3, 1:5, 1:7, and 1:9 and kept at room temperature for 72 h for the development of reddish brown color. The best color was formed from the 1:9 ratio of solution.

2.4. Observation of color change at different time interval

The root extract, having no color, became white after 8 h of mixing with $AgNO_3$ solution and became deep white after 18 h. A light red color appeared after 24 h of incubation and finally the solution became deep reddish brown after 72 h. After 8 d the solution became colorless because the particles were precipitated.

2.5. Characterization of nanoparticles

The solution in each beaker were dried and sent for scanning electron micrograph (SEM). The SEM characterization was carried out using a scanning electron microscope (HITACHI, S-530). Infrared photograph was recorded by Fourier transform infrared spectroscopy (FTIR) (BRUKER, Tensor 27), absorbance was measured by UV-Vis spectrophotometer (Perkin Elmer, Lamda 35) and fluorescent spectrophotometer (SD 1000).

2.6. Collection of mosquito larvae and maintenance of mosquito culture

Cx. quinquefasciatus larvae were collected from stagnant and slow moving water bodies of the submerged rice field from different areas of Burdwan district, West Bengal following the method of Service and Laird[15,16]. During each survey, a habitat was first examined for the presence of mosquito larvae visually, and then captured by using a standard dipper (11.5 cm diameter and 350 mL capacity), pipettes and white plastic pans[15,17]. Larvae were brought to the laboratory and morphological features were recorded through stereoscopic binocular and light microscopic