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ORIGINAL ARTICLE

Mosquito larvicidal potential of potash alum against malaria vector *Anopheles stephensi* (Liston)

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Abstract Mosquito larviciding may prove to be an effective tool for incorporating into integrated vector management strategies for reducing malaria transmission. Here, we report the potential of potash alum, a traditionally known salt in Indian Ayurveda and Chinese medicine system, in malaria vector control by evaluating its aqueous suspension as larvicide and growth disruptor of *Anopheles stephensi*, under laboratory conditions. Immature stages of the mosquito were tested using WHO guidelines. 50 and 90% lethal concentrations among various larvae ranged between 2.1 to 48.74 ppm and 15.78 to 93.11 ppm, respectively. The results indicated that larvicidal effects of potash alum were comparable to various biological and chemical insecticides. The study provides considerable scope in exploiting local indigenous resources for the control of nuisance mosquito vectors.

Keywords *Anopheles stephensi* · Potash alum · Mortality · LC_{50} · Malaria

Introduction

Mosquito-borne diseases form a major group of communicable diseases such as malaria, filariasis, dengue, Japanese encephalitis etc. in India as well as other developing countries. Every year about 300 million people are estimated to be affected by malaria, a major killer disease, which further threatens 2,400 million (about 40%) of the world's population (Sharma 1999). Malaria is responsible for 250 million cases of fever and approximately 1 million deaths annually (WHO 2007) and India contributes about 70% of malaria in the South East Asian Region of WHO (Dash et al. 2008). *Anopheles stephensi* is the main urban mosquito vector of malaria in the Indian subcontinent.

The incidence of mosquito-borne diseases is increasing due to uncontrolled urbanization creating mosquitogenic conditions for the vector mosquito populations. Therefore, mosquito control forms an essential component for the control of mosquito borne diseases. Several strategies have been adopted to control these diseases but vector control as an in-built component of the nation-wide disease control strategy has been the main plank so far wherein synthetic insecticides have been effectively used during past several decades to control varied dipteran pests. However, the use of chemical insecticides has been greatly impeded due to development of physiological resistance in the vectors, environmental pollution resulting in bio-amplification of food chain contamination and harmful effects on beneficial non-target animals (Rao et al. 1995).

As a consequence of the emergence of resistant insect populations, more number of bio control agents were screened for their efficacy, mammalian safety and environmental impact. Many organisms have been investigated as potential agents for vector mosquito control including fishes, bacteria, fungi etc. (Vyas et al. 2007; Chandra et al. 2008; Fillinger et al. 2003). A number of vector control products based on bacterial strains have been designed to control mosquito larvae (Poopathi and Tyagi 2002; Singh and Prakash 2008). These products have achieved moderate commercial success in developed countries but high cost restricts their use in developing countries. Moreover, concerns have also been put forward about their long term usage due to resistance. Furthermore, efforts have been made to

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improve their efficacy by employing genetic recombinations (Park et al. 2005; Wirth et al. 2004, 2007).

Therefore, the need of alternate, more potent, cost effective and environment-friendly control agents became urgent. Potassium alum has long been used as a disinfecting agent at the household level (Oo et al. 1993; Crump et al. 2004). The present paper highlights the use of potash alum, a traditionally known salt in Indian and Chinese medicine system, as a potent larvicide against *A. stephensi* and an excellent candidate for use in vector control programmes.

Materials and methods

Anopheles stephensi colonies

Mosquito larvae were collected from various localities of Agra (27°10′N, 78°05′E), India and all instars were maintained in the laboratory at a temperature of 25 ± 2°C, relative humidity of 70 ± 5%, and photoperiod of 14:10 (light:dark). Larvae were reared in dechlorinated water and fed upon 5% glucose.

Laboratory bioassays

Bioassays were performed according to standard method recommended by the World Health Organization (WHO 1996). Batches of 20 larvae of each instar (I, II, III, and IV) were transferred to beaker containing 200 ml of deionized water. Potash alum ($AlK(SO_4)_2 \cdot 12H_2O$, powdered) was procured from a local dealer and a fresh stock solution was prepared (1,000 ppm), from which appropriate volume of stock was added to the beakers containing 100–200 ml of deionized water to obtain the desired target dosage starting with the lowest concentration. Both control and test concentrations were run parallel to each other under similar environmental conditions. The experiment was repeated thrice with six test concentrations in each replicate. Larval mortality was recorded following 24 h of exposure.

Statistical analysis

Probit analysis was used to determine the median lethal concentration (LC_{50}) and 90% (LC_{90}) lethal concentration for all instars larvae (Finney 1971). The mortality was corrected by Abbott's formula (Abbott 1925) and relation between probit of kill and log concentration was established by probit equation.

Results

Larvicidal potential of potash alum was investigated to control mosquito larvae, i.e. *A. stephensi* under laboratory conditions. The LC_{50} and LC_{90} value of alum were tested against various instars of mosquito larvae following 24 h of exposure. No mortality was observed in the control groups over the course of experiment. The size of larvae of various instars strongly influenced the pattern of mortality. Relation between probit of kill and log concentration for each instar larvae has been depicted through Probit regression line in Figs. 1 and 2.

Potash alum was also found to be effective against all instar larvae. The LC_{50} and LC_{90} among various larvae ranged between 2.1 to 48.74 ppm and 15.78 to 93.11 ppm, respectively.

The differences are summarized in Fig. 3 in which larval mortalities (LC_{50} and LC_{90}) are shown for various instars following 24 h exposure in deionized water. It is evident from this figure that I instar is most susceptible or least resistant to the alum, whereas IV instar is least susceptible or most resistant to the alum. Morphological changes were observed in various instar larvae following treatment with different concentrations of alum. Maximum damage was observed in I instar.

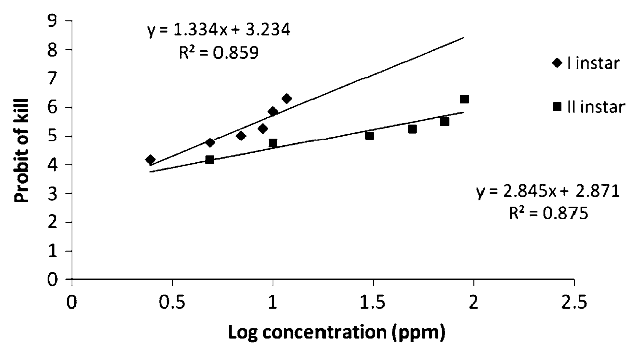

Fig. 1 Probit regression line depicting relationship between probit of kill and log concentration of potash alum following 24 h of exposure for first and second instars of *Anopheles stephensi*

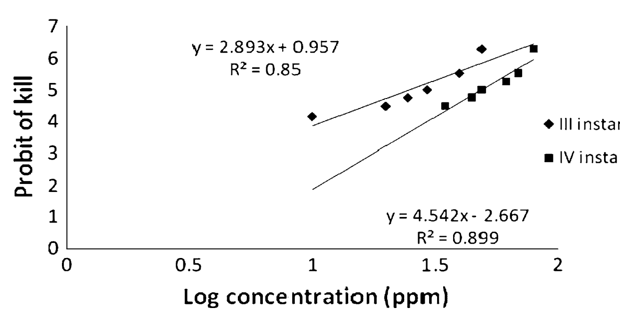

Fig. 2 Probit regression line depicting relationship between probit of kill and log concentration of potash alum following 24 h of exposure for third and fourth instars of *Anopheles stephensi*

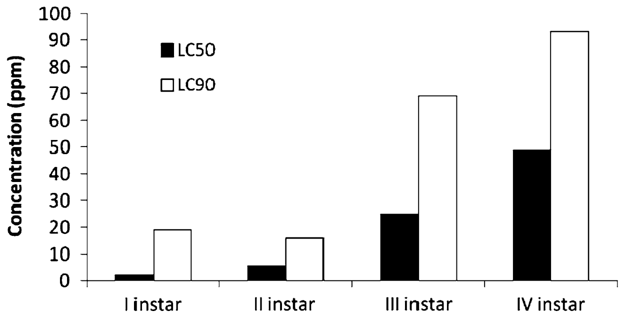

Fig. 3 LC_{50}, and LC_{90} of Alum against various instar larvae of *Anopheles stephensi* following 24 h of exposure

Discussion

Mosquitoes are responsible for the biological transmission of several dreaded diseases including malaria. Vector control is still one of the most effective means of disease suppression however, it is facing a threat due to the emergence of resistance in vector mosquitoes to conventional synthetic insecticides, warranting either countermeasures or development of newer insecticides (Omer et al. 1980). Plants being a natural source of compounds, are known to contain larvicidal properties may serve as suitable alternatives to synthetic insecticides as they are relatively safe and biodegradable. Though several plants from different families have been reported for mosquitocidal activity (Jeyabalan and Murugan 1999; Green et al. 1991; Latha et al. 1999; Chowdhury et al. 2008; Vinayagam et al. 2008), only a very few botanicals have moved from the laboratory to field use, like *Azadirachta indica* based insecticides, which might be due to the light and heat instability of phytochemicals compared to synthetic insecticides (Mulla and Su 1999; Okumo et al. 2007).

Environmentally safe chemicals could serve as an additional tool in an integrated vector management programme and can be recommended in larviciding mosquito breeding sites (Chandra 1995; Mukhopadhyay et al. 2010). In the present study potash alum, a known antiseptic and flocculating agent was evaluated for its larvicidal properties. The results already demonstrated that potash alum could serve as candidate for managing various mosquito habitats in the field. This is a first report on the mosquito larvicidal activity of potash alum.

Potash alum is well known as chelator, which coagulates salts in water and posed adverse effect on the tegument of larvae and acted as contact poison, which was apparently visible in treated larvae. The results showed that the major malaria vector in India, i.e. *A. stephensi*, is highly susceptible to potash alum under laboratory conditions and these LC values found in laboratory experiments are similar to those found in earlier studies (Batabyal et al. 2007; Nathan et al. 2008; Senthilkumar et al. 2009). However, there are a number of studies reporting LC_{50} values remarkably higher than our study (Sosan et al. 2001; Dwivedi and Karwasara 2003). This larvicidal efficacy is comparable to fenthion, a commercially available organophosporus larvicide (Amalraj and Das 1996) and Malathion (Azmi et al. 1998). Recently, fenthion has been developed as biodegradable aluminium carboxymethyl cellulose matrices for mosquito larvicides.

The present findings have important implications in the practical control of mosquito larvae at the breeding sites which offers a potentially simple, readily available, inexpensive and environmentally safe larvicidal agent. Eventhough further studies are needed to observe its toxic effects on non target organisms, their mode of action and field trials to recommend potash alum for development of eco-friendly chemicals for control of these nuisance vectors.

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Conflict of interest There exist no conflict of interest.

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