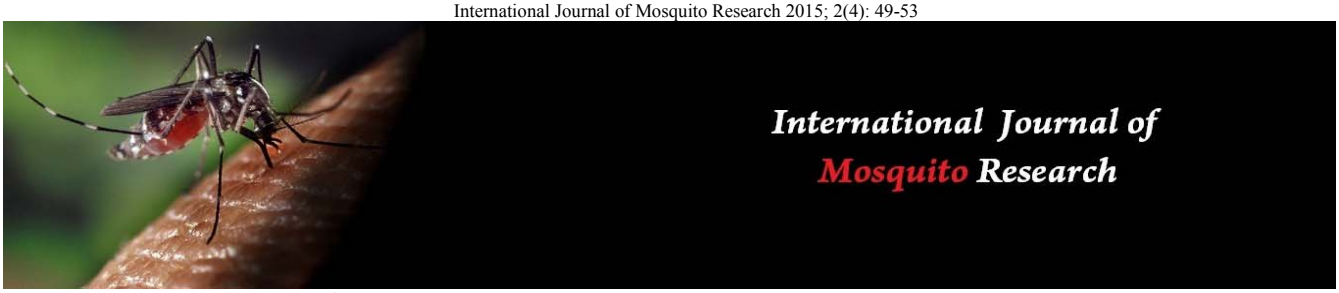


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# Mosquito protective textiles - A review

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**Abstract**
The review outlines the use of different textile materials for protection against the mosquito menace. Textile based mosquito protection is one the popular methods of protection against mosquito with the use in the form of nets, uniforms, garments etc. The current trends in the preparation and use of insecticide infused textile materials and the various limitations and challenges are discussed in detail. The use of natural products especially the essential oil incorporated textile materials and the effective method of microencapsulation for increasing the longevity of the protection is also discussed in this review. The engineering of fabric with or without insecticide for effective protection against mosquito is the need of the hour.

**Keywords:** Insecticide, textile, essential oil, microencapsulation, mosquito, mosquito nets, repellent

## 1. Introduction
Mosquito protective textiles are classified as insecticide infused nets, curtains, home textile materials, military uniforms etc and used as protective barrier against adult mosquito bite. Of all the methods of mosquito bite protection, textile based method assumes significance because textile materials are considered as third most important essential element of life apart from food and shelter for human living. Textiles protect human skin from harsh weather as well acts as a barrier for airborne harmful microorganisms. It also acts as a shelter by means of nets, tent cloth etc. Mosquito repellent textiles are one of the revolutionary methods in the advancement of the textile field, by providing the much-needed features of driving away mosquitoes, especially in the tropical areas. Other methods of protection commonly used are spraying of insecticides inside the premises popularly known as indoor residual spraying, smoking or fumigation, air shield, use of ultra-sonic rays etc.

Due to rapid urbanization, climate change and other factors, the ill effects of mosquito bite are increasing day by day. Mosquitoes are holometabolous insects and therefore grow through an egg, larva, pupa to adult stage. The larvae and pupae are aquatic, the adults are free flying. Larva goes through four larval instars in about 4 days before pupating. The pupa takes three days before the adult emerges. Adult females live several weeks. Males usually live less than a week. The mosquitoes breed and multiply with astonishing speed [1]. In India, the most prominent diseases spread by mosquitoes are malaria, dengue and chikungunya, as well as Japanese B encephalitis. It is to be noted that mosquitoes only transmit the pathogens acquired from the infected person while feeding. Mosquito-borne diseases or mosquito-borne illness are disease caused by viruses or parasites transmitted by mosquitoes. According to a literature, over 700 million people are affected by mosquito transmitted illness worldwide resulting about one million deaths [2]. According to UNICEF, Malaria kills over 1,200 children a day [3]. Malaria is caused by parasites of the Plasmodium family and transmitted by female Anopheles mosquitoes. Dengue & chikungunya disease are spread by Aedes mosquitoes. Normally this type of mosquito bites during day time. Japanese encephalitis virus and filarial parasite are transmitted by Culex mosquitoes.

As per the world Health Organization (WHO), current methods of preventing malaria due to mosquito bite are indoor residual spraying of pesticides, long-lasting insecticidal nets and insecticide-treated clothing or repellents when people are away from houses or otherwise not under nets at the times when and places where malaria vectors prefer to bite [4].

The use of the repellents such as lotions, coils and liquidators are limited in their efficacy due to various reasons. This has necessitated the development of mosquito repellent fabrics. A textile fabric with the mosquito protection is one of the revolutionary ways and the much needed feature of driving away the mosquitoes. It protects the humans from the bite of mosquitoes and thereby promising safety from the mosquito borne diseases.

This review outlines the various developments in the mosquito repellent textiles as well as challenges and opportunities in this area of research.

## 2. Insecticide treated Textile Materials

Mosquito protective textile materials are produced by incorporating synthetic or natural insecticidal or repellent substances. Insecticide treated Mosquito protective textiles can be broadly classified into two categories namely Mosquito nets, home textiles, carpets and garments with insecticidal or repellent properties

Mosquito nets and home textile products are generally treated with insecticidal agents. Synthetic insecticides like permethrins, organophosphates and carbamates etc can be incorporated to textile materials. According to United State Environmental protection Agency, the only insect repellent currently used for factory treatment of clothing is permethrin [5]. Permethrin is a pyrethroid based insecticide similar to pyrethrins, a natural insecticide extracted from chrysanthemum flowers.

The permethrin infused materials are used as military uniforms for the soldiers working in the dense forest area where they are prone to insect attack. The permethrin can be sprayed on the clothing in the well ventilated area and dried before use. It should not be sprayed directly to skin or garment while they are being worn. The permethrin treated textile materials need to be washed separately without mixing with untreated one.

The use of bed net for protection against mosquito bite is one of the popular method. The permethrin can be incorporated in the nets during different stages of manufacturing like fibre preparation itself, yarn stage or at the fabric stage. It is reported that permethrin can be incorporated to polyethylene monofilament fibres while melt spinning of polymer. The permethrin content is restricted to the amount of 20g/ kg of fibre. The net prepared from such insecticide treated fibre showed mosquito protection with the durability for 20washes [6]. The insecticide treated nets (ITN) acts as a both physical barrier for the mosquito bite as well as provide insecticidal efficacy.

The insecticidal agent can also be coated on the conventionally prepared nets also. Polyester based long lasting insecticidal nets (LLIN) have been prepared and available in different brand name in which insecticide like cypermethrin is bound on the surface of the fibre using a polymeric binder. Such coated fibres are being used to prepare the nets. It is reported that such nets offer good protection compared to cypermethrin directly treated nets.

Temporary mosquito protection can also be done by treating nylon or cotton nets used in the house by treating with permethrin. The treated net showed the efficacy for 2-6 months depending upon the usage, wash cycle etc [7]. It is also attempted to produce long-lasting insecticide and repellent-treated net (LLIRN) by combined application of permethrin and DEET. Such product exhibited good protection against mosquito bite [8].

### 2.1 Issues and challenges

WHO Pesticide Evaluation Scheme (WHOPES) has registered several ITN from their extensive testing of insecticidal activity. For WHOPES recommended nets, insecticidal effectiveness is currently not included in the estimation of ITN/LLIN survival, since these nets have already passed WHOPES phase III testing. The durability of nets for anti-mosquito bite efficacy is determined using two factors: net attrition (complete loss of nets) and physical integrity (holes and tears in nets still existing in households). The longevity or durability of ITNs is measured only by testing physical damage to the nets. Hence, in the textile point of view, lots of research is required to study the relationship between hole size and effectiveness of the net for mosquito entry [9].

The insecticide treated nets is generally made up of polyester, polypropylene and synthetic fibres. The synthetic fibres are poor absorber of moisture and thermoplastic in nature. They may create discomfort in terms reduced ventilation and moisture vapour transmission to the user during usage and they may be hazardous in case of fire. Allergic reaction to the users may not be overruled due to the physical properties of net. Hence, the development of natural fibre used nets is very important to improve the comfort for the users. However, binding pesticide on the natural fibre is a challenge compared to synthetic fibres. The hydrophilic nature of the natural fibre may prevent the strong binding of pesticides using polymeric binders.

In the case of insecticide treated textile materials like uniforms, there is no effective method currently available to study the effectiveness of the insecticidal action after putting into wear. Generally the testing of mosquito repellent textiles along with differently washed material are done by bio assay method, knock test etc, which is done in controlled condition. The efficacy of the fabric can vary depending upon the actual usage. The determination of insecticide concentration in the net is a complex process and required sophisticated testing set up. Hence, research in this aspect is required to find a simple method to know about the pesticide concentration in the textile materials [10].

The use of chemical based repellents to control insects and arthropods has raised several concerns as they are not environment friendly and are unsafe human beings, animals and aquatic species. Pyrethroid based synthetic insecticides are neurotoxic in nature. Apart from environment implications, it is reported that major concern in using these agents is the development of resistance in the insects. Hence, the development alternate chemical moiety based insecticide is very much necessary in order to address the problem. Many research studies are available in the literature about the pyrethroid resistance in the insects. Recently, pyrrole moiety based insecticide is proposed alternative to pyrethroid. This insecticide is not neurotoxic in nature but show contact and stomach toxicity against mosquito [11]. The literature survey indicated some novel mosquito repellent textiles without the use of insecticidal agent. In one such study, it is proposed that pyroelectric coatings on textile can prevent mosquito bite [12].

## 3. Mosquito Repellent Textiles

Several natural and synthetic substances are identified as possessing mosquito repellent efficacy. Mosquito repellents can be directly applied to the skin and generally considered as harmless without much contact toxicity. They emit peculiar odour not liked by the mosquitos to keep away them. The prominent synthetic substances used for mosquito repellency are DEET (N,N-Diethyl-meta-toluamide), Picaridin (2-(2-hydroxyethyl)-1-piperidinecarboxylic acid 1-methylpropyl ester), N,N-diethyl phenylacetamide (DEPA). Carbon dioxide and lactic acid present in the warm blooded living beings act as an attractive substance for mosquitoes. The mosquito repellent chemical has to be applied on the skin to mask the human odour which is attracting the mosquito. These chemicals are considered safe to use without any adverse side effects. The longevity of mosquito repellent efficacy is one of the area of concern. It is reported that the chemical based repellents are

effective for the initial period of 3-6 hrs after that the efficacy is reduced making the skin vulnerable to mosquito attack [13]. Attempts have been made to increase the longevity of DEET by encapsulation with chitosan microcapsules [14] and by inclusion of DEET and permethrin in cyclodextrins grafted to textile substrates [15]. Using microencapsulation technique the fragrance compounds are encapsulated and applied to the textile materials. The slow release of the aromatic compounds during wearing gives the necessary protection against the mosquito bite. The inclusion forming compounds like β-Cyclodextrin can be utilized to entrap the aromatic fragrance compounds. They can be fixed on the textile material by way of chemical bonding using cross-linking agents. Polycarboxylic acids such as 1, 2, 3, 4-butane tetra carboxylic acid, citric acid or polyacrylic acid can be used to fix the cyclodextrins on textile materials in the presence of disodium hydrogen phosphate or sodium dihydrogen hypophosphite. Adverse effects of mosquito repellents containing DEET on skin have been reported. DEET can irritate skin when applied directly in high concentration or for long periods of time. It can even cause severe skin reactions in certain individuals. In addition, synthetic chemicals used for control of vectors are causing irreversible damage to the ecosystem, as some of them are non-degradable in nature [16, 17, 18]. Hence people tend to prefer a natural alternative.

### 3.1 Natural Product based Mosquito Repellent Textiles

Extensive studies have been carried out to assess the mosquito repellent properties of large number of plant products. Extracts from roots, stem, leaves, flowers, fruits and seeds of diverse species of plants have been assessed for mosquito repellent properties. Several natural products like rosemary oil, clove oil, eucalyptus oil etc have been identified for giving mosquito repellence. Essential oils are complex mixtures of volatile organic compounds present in the plants. Monoterpenes, sesquiterpenes, and phenols are the main groups of compounds produced as secondary metabolites in the plant system [19]. Repellent properties of several essential oils appear to be associated with the presence of lower isoprenoids. Monoterpenes such as α-pinene, limonene, terpinolene, citronellol, citronellal, camphor and thymol are common constituents of a number of essential oils that show mosquito repellent activity [20-25]. A compilation of natural substances used as a mosquito repellent is given in the table 1.

**Table 1:** Natural substances and essential oil used as mosquito repellent

| S. No | Common Name | Botanical Name | Nature |
|---|---|---|---|
| 1 | Citronella grass Lemon grass [21] | *Cympobogon spp., Cymbopogon citratus* | Oil |
| 2 | Eucalyptus oil Lemon eucalyptus oil [25] | *Eucalyptus citriodora,* | Oil, leaf extract |
| 3 | Geranium [25] | *Pelargonium citrosum* | Oil |
| 4 | Peppermint [25] | *Mentha piperita* | Oil, leaf extract |
| 5 | Holy Basil [25] | *Ocimum spp* | Oil, leaf extract |
| 6 | Toothache Tree [8] | *Zanthoxylum limonella* | Oil |
| 7 | Kakronda [26] | *Blumea lacera* | Leaf extract |
| 8 | Neem [27] | *Azadirachta indica* | Oil in mixture with coconut oil |
| 9 | Thyme oil [22] | *Thymus vulgaris* | oil |
| 10 | Lavender [28] | *Lavandula angustifolia* | Oil |

Apart from repellence, essential oils like eucalyptus, Cryptomeria japonica, Nerium oleander L flower extract [29], Lawsonia inermis leaf extract [30], Chromolaena odorata L [31], Dalbergia sissoo demonstrated high larvicidal activity against mosquito larvae [32]. Azadiractin, the active ingredient of neem has long been recognised for its mosquito larvicidal capability [33].

### 3.2 Issues and challenges

One of the major limitations with the use of natural products for mosquito repellent finish is lack of durability of the finish. Most of the applied mosquito repellents can be removed during washing since they do not have any affinity to textiles or they are not fixed on the textiles. Microencapsulation is one of the method used to trap the active agents using wall materials like modified starch, gum acacia, sodium alginate etc and then applied on the textiles. Another method than can be used is forming inclusion compounds. The inclusion forming compounds like β-Cyclodextrin can be utilized to entrap the aromatic fragrance compounds. They can be fixed on the textile material by way of chemical bonding using cross-linking agents. Polycarboxylic acids such as 1,2,3,4-butane tetra carboxylic acid, citric acid or polyacrylic acid can be used to fix the cyclodextrins on textile materials in the presence of disodium hydrogen phosphate or sodium dihydrogen hypophosphite.

It is reported that thyme oil, cypress oil and grapefruit oils in combination of 2:1:1 has been microencapsulated using different wall material such as sodium alginate, *Acacia arabica* and *Moringa oleifera* gum and applied on bamboo/ tencel 50:50 blended using exhaustion method. The treated fabric with *Moringa oleifera* gum as wall material showed mosquito repellent efficacy durable up to 30 washes and also found that there was no allergic reaction to wearer [34].

Microencapsulated citronella oil using different wall materials like gum arabic, chitosan etc has been applied on the textile fabric which has presented a higher and longer lasting protection from insects compared to fabrics sprayed with an ethanol solution of the essential oil, assuring a repellent effect higher than 90% for three weeks [35].

The development of mosquito repellent fabrics using chrysanthemum oil nano emulsion has been studied in the literature. Nylon net fabrics treated with this nano emulsion 100% mosquito repellent efficiency and 90% mortality rate with durability upto 25 washes [36]. In another study, β-cyclodextrins were fixed to cotton fabrics via citric acid. Citriodiol®, a mosquito repellent derived from a natural source, was incorporated to β-cyclodextrin treated textiles to obtain long lasting and reloadable mosquito repellent fabrics [37].

The aqueous and methanolic extracts of lemon grass plant were microencapsulated and applied on polyester fabric. The aqueous extract microcapsules showed 92% repellency activities whereas methanolic microcapsules exhibited 80% repellency against mosquito [38]. Citronella oil is used for mosquito repellent finish on cotton fabrics in combination with lavender oil for fragrant finish to produce a mosquito repellent fragrant textile [39]. It is also reported that textile fabric treated with leaf

extract of *Vitex negundo* plant loaded with alginate nanoparticle [40], *Andrographis paniculata* plant extract[41], three herbal extracts of *Ricinus communis*, *Senna auriculata* and *Euphorbia herita* [42] showed mosquito repellent properties durable for 10-15 washes.

Naturally occurring botanical compounds contain a broad range of chemical active ingredients which can intervene in all biological processes of the mosquito, thus interrupt its life cycle and dispersal and reduce harms to human and animals. [43] The justification of essential oils as green pesticides lies in the fact that the constituents of all essential oils are moderately or mostly found non-toxic to mammals, birds and the aquatic ecosystem [44].

## 4. Conclusion

This review outlined various textile based protective methods against the mosquito bite. The main challenge is to device a suitable method for incorporating insecticide and repellent substance inside the fabric, ensuring effective release and durability. Research is also needed in the engineering of fabrics for making them as a physical barrier against the mosquito bite without using any insecticides.

## 5. References


1. Mosquito information sheet. http://insected.arizona.edu/skeeterinfo.html., 2015.
2. Hector Caraballo & Kevin King. Emergency Department Management of Mosquito-Borne Illness: Malaria, Dengue and West Nile Virus. Emerg Med Prac. 2014; 16(5):1.
3. Malaria fact sheet by UNICEF New York. http://www.unicef.org/media/media_81674.html, 2015.
4. Control of residual malaria parasite transmission Guidance note – September 2014 by WHO. http://www.who.int/malaria/publications/atoz/technical-note-control-of-residual-malaria-parasite-transmission-sep14.pdf. 16 September, 2015.
5. Repellent-Treated Clothing by EPA, United States Environmental Protection Agency. http://www2.epa.gov/insect-repellents/repellent-treated-clothing. 16 September, 2015.
6. Report on "permethrin-incorporated mosquito net" WHO/IS/NI/331/2002. http://www.who.int/whopes/quality/en/OlysetInterimSpecification.pdf.
7. Curtis CF, Schreck CE, Sharma VP. Mosquitos and other biting diptera in (Ed) Rozendaal JA, Vector Control Methods for use by individual and communities. WHO Geneva, 1997, 88-118.
8. Faulde MK, Nehring O. Synergistic insecticidal and repellent effects of combined pyrethroid and repellent-impregnated bed nets using a novel long-lasting polymer-coating multi-layer technique, Parasitol Res 2012; 111(2):755-765.
9. WHO Guidance Note for Estimating the Longevity of Long-Lasting Insecticidal Nets in Malaria Control. http://www.who.int/malaria/publications/atoz/who_guidance_longevity_llins.pdf?ua=1. 16 September, 2015.
10. Klun JA, Kramer M, Debboun M. A new in vitro bioassay system for discovery of novel human-use mosquito repellents, J Am Mosq Control Assoc. 2005; 21(1):64-70.
11. Oxborough RM. The activity of the pyrrole insecticide chlorfenapyr in mosquito bioassay: towards a more rational testing and screening of non-neurotoxic insecticides for malaria vector control. Malaria J. 2015; 14(1):124.
12. Novel Pyroelectric Coatings to Provide Insect Resistant Textiles. https://sbirsource.com/sbir/awards/148168-novel-pyroelectric-coatings-to-provide-insect-resistant-textiles. 16 September, 2015.
13. Raju KS, Raman VLM, Sridevi N. Study of safety of mosquito repellents, J Den Med Sci. 2015; 14(1):42-45.
14. Fei B, Xin JHN. N-diethyl-m-toluamide-containing microcapsules for bio-cloth finishing. Am J Trop Med Hyg. 2007; 77:52-57.
15. Romi R, Nostro PL, Bocci E, Ridi F, Baglioni P. Bioengineering of a cellulosic fabric for insecticide delivery via grafted cyclodextrin. Biotechnol Programme 2005; 21:1724-1730.
16. Das NG, Baruah I, Talukdar PK, Das SC. Evaluation of botanicals as repellents against mosquitoes, J Vector Borne Dis. 2003; 40(1-2):49-53.
17. Thavara U, Tawatsin A, Chompoosri J. Phytochemicals as repellents against mosquitoes in Thailand, in: International Conference on Biopesticide, Malaysia 2002, 233-242.
18. Peterson C, Coats J, Insect repellents – past, present and future, Pestic. Outlook, 2001; 12:154-158.
19. Isman MB. Pesticides based on plant essential oils, Pestic Outlook 1999; 10:68-72.
20. Jaenson TGT, Paalsson K, Borg-Karlson AK. Evaluation of extracts and oils of mosquito (Diptera: Culicidae) repellent plants from Sweden and Guinea-Bissau. J Med Entomol, 2006; 43:113-9.
21. Ibrahim J, Zaki ZM. Development of environment-friendly insect repellents from the leaf oils of selected Malaysian Plants. ASEA Rev Biodiv Environ Conserv (ARBEC), 1998; 6:1-7.
22. Park BS, Choi WS, Kim JH, Kim KH. Monoterpenes from thyme (Thymus vulgaris) as potential mosquito repellents. J Am Mosq Control Assoc. 2005; 21:80-3.
23. Omolo MO, Okinyo D, Ndiege IO, Lwande W, Hassanali A. Repellency of essential oils of some Kenyan plants against Anopheles gambiae. Phytochemistry, 2004; 65:2797-802.
24. Yang YC, Lee EH, Lee HS, Lee DK, Ahn YJ. Repellency of aromatic medicinal plant extracts and a steam distillate to Aedes aegypti. J Am Mosq Control Assoc. 2004; 20:146-9.
25. Junaid U, Rehman Abbas Ali, Ikhlas A. Khan Plant based products: Use and development as repellents against mosquitoes: A review Fitoterapia. 2014; 95:65-74.
26. Singh SP, Mittal PK. Mosquito repellent action of Blumea lacera (Asteraceae) against Anopheles stephensi and Culex quinquefasciatus. Int J Mosq Res. 2014; 1:10-13.
27. Mishra AK, Singh N, Sharma VP. Use of neem oil as a mosquito repellent in tribal villages of mandla district, Madhya Pradesh, Indian J Malariaol. 1995; 32(3):99-103.
28. Thomas GT, Jaenson Samira Garboui, Katinka Pålsson. Repellency of oils of lemon eucalyptus, geranium, and lavender and the mosquito repellent MyggA Natural to Ixodes ricinus (Acari: Ixodidae) in the Laboratory and Field, J Med Entomol. 2006; 43:731-736.
29. Raveen RK. Kamakshi T, Deepa M, Arivoli S, Samuel Tennyson. Larvicidal activity of Nerium oleander L. (Apocynaceae) flower extracts against Culex quinquefasciatus Say (Diptera: Culicidae), Int J Mosq Res. 2014; 1(1):8-42.
30. Dass K, Mariappan P. Larvicidal activity of Lawsonia inermis and Murraya exotica leaves extract on filarial vector, Culex quinquefasciatus, Int J Mosq Res.

2014; 1(2):25-27.
31. Sukhthankar JH, Hemanth Kumar, Godinho MHS, Ashwani Kumar. Larvicidal activity of methanolic leaf extracts of plant, Chromolaena odorata L. (Asteraceae) against vector mosquitoes, Int J Mosq Res. 2014; 1(3):33-38.
32. Cheng SS, Chang HT, Chang ST, Tsai KH, Chen WJ. Bioactivity of selected plant essential oils against the yellow fever mosquito Aedes aegypti larvae, Biores Technol. 2003; 89(1):99-102.
33. Das NG, Goswami D, Rabha B. Preliminary investigation of mosquito larvicidal efficacy of plant extracts, J Vect Borne Dis. 2007; 44:145-148.
34. Geethadevi R, Maheshwari V. Long lasting UV protection and mosquito repellent finish on bamboo/ tencel blended fabric with microencapsulated essential oils, Indian J Fibre Text Res. 2015; 40:175-179.
35. Miró Specos MM, García JJ, Tornesello J, Marino P. Microencapsulated citronella oil for mosquito repellent finishing of cotton textiles, Trans R Soc Trop Med Hyg, 2010; 104:653-658.
36. Bhatt L, Kale R. Development of mosquito repellent textiles using chrysanthemum oil nano emulsion, Int J Text Fash Tech. 2015; 5(3):15-22.
37. Specos MMM. Microencapsulated citronella oil for mosquito repellent finishing of cotton textiles, Trans R Soc Trop Med Hyg, 2010; 104:653-658.
38. Anitha R, Ramachandran T, Rajendran R, Mahalakshmi M. Microencapsulation of lemon grass oil for mosquito repellent finishes in polyester textiles, Elixir Bio Phys 2011; 40:5196-5200.
39. Marta FM, Sarah JM. Plant-based insect repellents: A review of their efficacy, development and testing, Malaria J. 2011; 10(1):S11.
40. Rajendran R, Radhai R, Rajalakshmi V. Development of mosquito repellent fabrics using Vitex negundo loaded nanoparticles. Malaya J Biosciences. 2014; 1:19-23.
41. Ramya K, Maheshwari V. Development of eco-friendly mosquito repellent fabric finished with Andrographis paniculata plant extracts, Int J Pharmacy Pharm Sci. 2014; 6(5):115-117.
42. Sumithra M, Vaasugi Raja. Mosquito repellency finished in blended denim fabrics. International J Pharm and Life Sci. 2012; 3:1614-1616.
43. Geetha RV, Roy A. Essential Oil Repellent – A short Review, Int. J. Drug Dev & Res. 2014; 6(2):20-27.
44. Kaul O, Walia S, Dhaliwal GS. Essential oils as green pesticides Potential and Constraints. Bio-pesticide Int. 2008; 4(1):63-84.