ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

A REVIEW ON MOSQUITO REPELLENT FINISH FOR TEXTILES USING HERBAL EXTRACTS

Lalit Jajpura , Manju Saini* , Abhilasha Rangi , Kalpana Chhichholia
Associate Professor, Department of Fashion Technology, BPSMV, Khanpur kalan, Sonepat, India
*Research Scholar, Department of Fashion Technology, BPSMV, Khanpur kalan, Sonepat, India
Research Scholar, Department of Fashion Technology, BPSMV, Khanpur kalan, Sonepat, India
Research Scholar, Department of Fashion Technology, BPSMV, Khanpur kalan, Sonepat, India

Keywords: Mosquito; Repellent; Herbal; Textile finish

ABSTRACT
Mosquito repellent textiles are one of the most growing ways to advance the textile field by providing the needed characteristics of protecting against mosquitoes, especially in the tropical areas. These types of textiles ensure the protection of human beings from the mosquitoes and the mosquito borne disease includes malaria, filariasis and dengue fever. This study focussed on the penetration of mosquito repellent finish in textile applications as well as nature based alternatives to commercial chemical mosquito repellents in the market. Suitable technologies and materials to achieve mosquito repellency are discussed and pointed out.

INTRODUCTION
Mosquitoes are one of the most harmful vectors which transmit parasites and pathogens impacting human life to a very great extent by spreading the deadly diseases like malaria, dengue, filariasis and chickunguniya [1-4]. Approximately 2700 species of mosquito are found all over the world; the three most significant of these are the Aedes, Anopheles, and Culex According to the World Health Organization (WHO), more than 1 million people dies every year due to mosquito bites and the majority are due to malaria.
In 1897-1898 while working in India, British Army Doctor Ronald Ross first discovered and demonstrated how malaria parasites get transmitted first between a patient and a mosquito, and then between hosts via mosquitoes. For this work Ronald Ross was honoured with the Nobel Prize in 1902. But it was Henry Shortt and Cyril Garnham who in 1948 discovered that malaria parasites develop to the final stage in the life cycle in the liver before entering the blood stream [5]. A brief history in the description of malaria and parasite is given in fig 1 below.

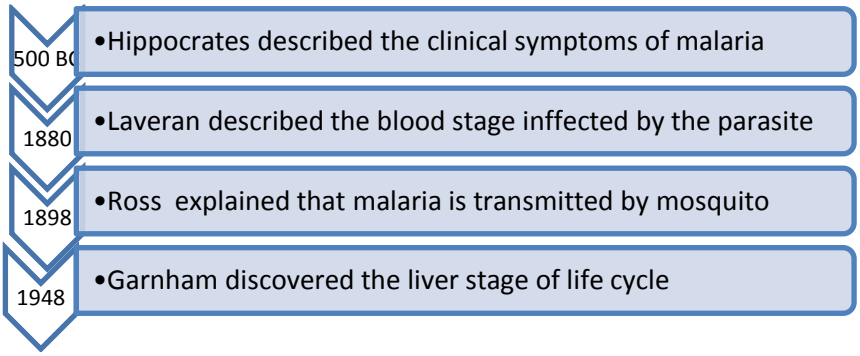


Fig 1: Historical highlights in the description of malaria and the parasite.

Mosquitoes are responsible for transmitting various diseases that are deadly to mankind so various kind of products such as lotions, coils and liquidators are available in market which are used as mosquito repellents. Due to various reasons like skin irritation, eczema problems, choking hazards from the burning fumes of coils etc. their use is limited. To overcome these limitations, need of a product with no such drawbacks is felt. This brings the development of mosquito repellent fabrics. A textile fabric with the characteristics of mosquito repellency is one of the revolutionary ways and much needed for driving the mosquitoes away [6].

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

NEED OF MOSQUITO REPELLENT TEXTILE

Increase in global warming leads to the expanded distribution of mosquitoes from tropical regions to northern latitudes and give birth to overwhelmed viral infections and is one of the factors that have resulted in the development of mosquito repellent finishes. To protect against mosquito-transmitted viral infections such as Malaria, dengue fever, chickengunia, the need for finishing textile products is felt [3, 4, 7].

MECHANISM OF MOSQUITO REPELLENTS

The action of mosquito repellent agents can be broadly divided into two types:

1. Olfactory mode
2. Tactile mode

Mosquitoes usually use the warm and humid convection rising from the human body as a mode for contacting humans by sensing an increase in atmospheric carbon-dioxide concentrations. In Olfactory mode which is also called as **transpiration repellency,** humidity-sensing holes of mosquitoes which helps the mosquitoes in locating the living organisms are blocked hence they cannot locate humans. While the tactile mode is based on the action of repellent substances on the mosquito's nervous system which causes them to enter in a confused state and resist their behaviour at sub-lethal/mortal/toxic doses, before knockdown due to their contact with fabric surface. The tactile mode action is also called as **direct-contact repellency** which drives the insects away from the surface before they can suck blood [1, 8].

CLASSIFICATION OF MOSQUITO REPELLENTS

Mosquito repellents can be classified on different basis and are shown in figure 2. They are classified as chemical or herbal repellents depending on their nature of origin. They can also be classified on the basis of their action. **Repellent Insecticides** are substances that are mainly used to repel insects and pests rather than killing them or their death. While **Contact Insecticides** are the substances that contain neuro-toxins for mosquito and insects to disturb their nerve system and to make them unconscious when they come in their contact [1,7]

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR
International Journal OF Engineering Sciences & Management Research

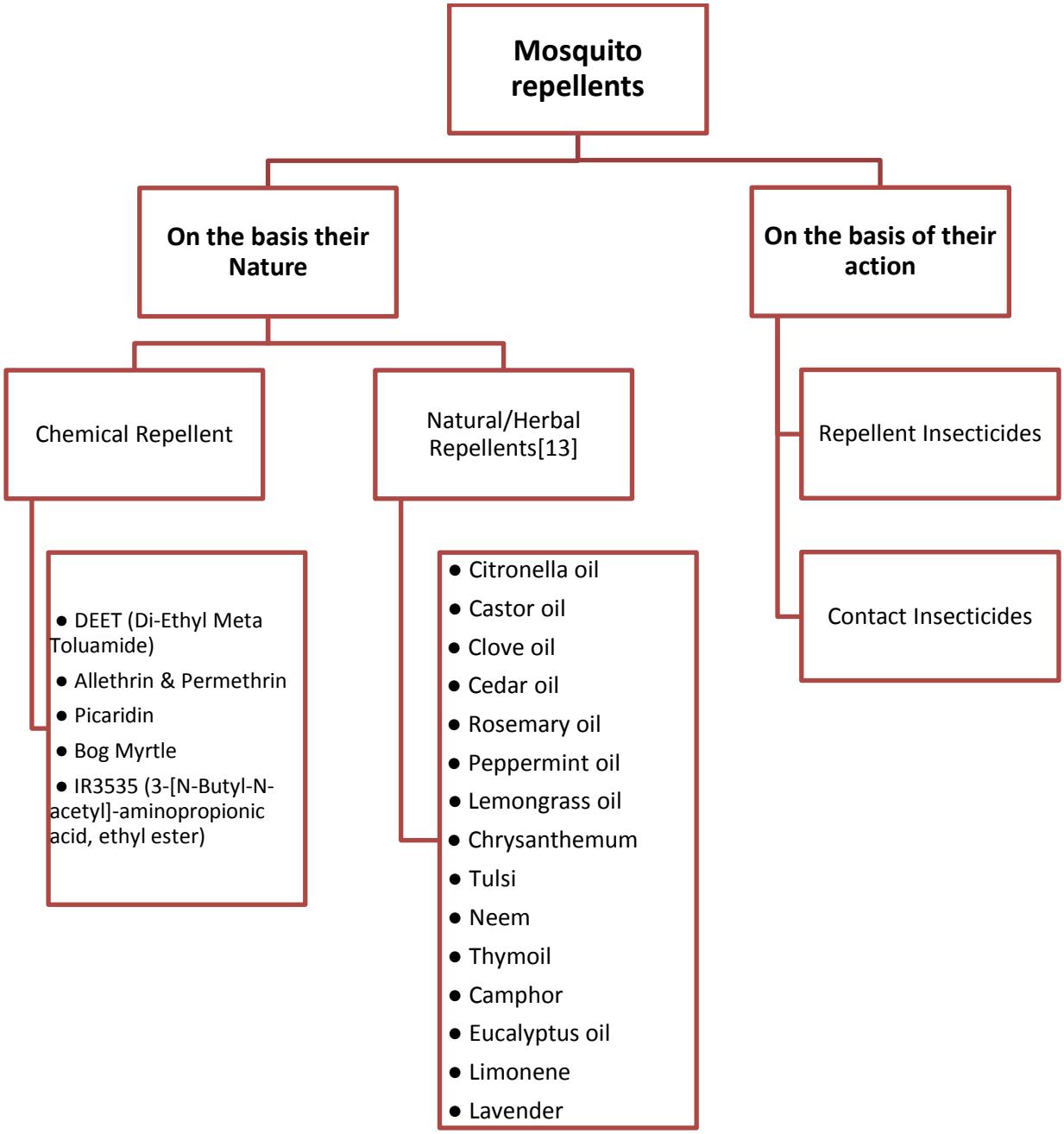


Fig 2 : Classification of Mosquito Repellents

NEED OF HERBAL MOSQUITO REPELLENTS

Regardless of the widespread use of the DEET containing product, Researchers like Tenenbein and records from poison control centre telephone data [9] have reported and found relatively few cases of toxicity of dermatitis, allergic reactions, and neurologic and cardiovascular toxicities like seizures after the use, ingestion and high-concentration usage on children and adults of DEET [10-12]. Some other adverse health effects like encephalopathy, tremor, slurred speech, behaviour changes, coma, and even death have also been reported. [13-15].

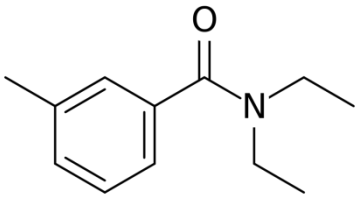
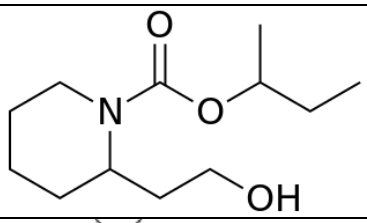
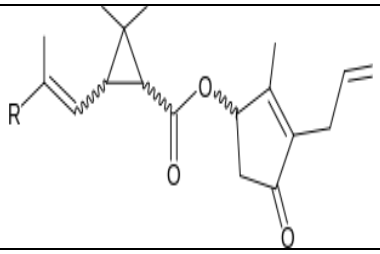
Some commercially used chemical mosquito repellents along with their chemicals structure and limitations are given in table 1. Because of their limitations and drawbacks, the formulation and demand of herbal products in market has reached to the peak of popularity**.** Herbal textile forms a tremendous place as one of the most

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR
International Journal OF Engineering Sciences & Management Research

important and useful need in an eco-friendly manner. Innovators and researchers are working together to add value to fabrics using natural herbs and other resources that are eco friendly [16].

Table 1: Extensively used Mosquito Repellents and their chemical structure

Sr. No.	Name of Chemical used as Mosquito Repellent	Chemical Structure	Limitation
1.	DEET		• Skin irritation • Toxic • Can dissolve synthetic fabrics as it is an effective solvent
2.	Picaridin		• Toxic to aquatic life • Eye irritation
3.	Allethrins		• Low toxicity towards humans and birds but high toxicity level towards aquatic life

MOSQUITO REPELLENT FINISH BY HERBAL METHOD

Herbal repellents are superior to Chemical repellents as they are eco friendly, non allergic, non toxic. To apply herbal repellent first herbal extracts are prepared then those extracts are applied on textiles.

1. EXTRACTION OF HERBAL EXTRACTS

Fresh herbs are sorted out and shadow dried, after drying the herbs are grounded to fine powder. For extraction appropriate amount of dry powder is mixed with solvents like methanol, ethanol, hexane etc. [4, 17-21] or in water [4] and kept either overnight or for few days or few hours in the closed container. [4, 17, 20] then the extract is filtered through filter paper. After filtering the herba1l extracts are condensed by evaporating the solvents [22, 23] and stored for later use.

2. APPLICATION OF HERBAL EXTRACTS

Various areas where mosquito repellent textiles are used are shown in figure 3. To make textiles mosquito repellent herbal extracts need to be applied on textile substrate for this following method can be used:

2.1 DIRECT APPLICATION METHOD:

In this method, the prepared extract is directly applied on the fabric using pad-dry-cure method. The fabric is padded in extract, squeezed, dried and cured [24- 26].

2.2 MICROENCAPSULATION METHOD

In this method the herbal extracts are enclosed in microcapsules. The fabric is then finished using exhaustion method. The fabric is kept immersed in the microcapsule solution, then removed, squeezed, dried and cured [6, 24, 27, 28].

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR
International Journal OF Engineering Sciences & Management Research

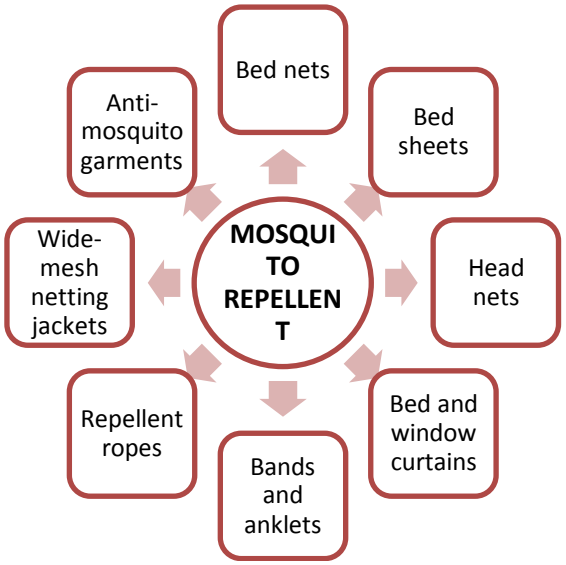


Fig 3. Application areas of mosquito repellent textile

EVALUATION METHODS

There are various testing methods for evaluation of mosquito-repellent textiles which are given below:

1. THE FIELD TEST:

It is the most meaningful evidence for the efficacy of treated textile. The field test is especially performed in locations where numerous of floodwater mosquitoes are present [1, 7]. In this method solution of 0.5ml of repellent is applied on forearms and forearms are exposed to mosquitoes. No. of mosquito bite is recorded.

Fig 4. Field Test

2. WHO CONE TEST:

In WHO cone test [29] a standard WHO plastic cone is attached to the treated test surface. Afterwards, 5 mosquitoes are transferred into the cone with an aspirator and exposed to the treated surface for 3 minutes. At the end of the exposition, test mosquitoes are removed from the cones, placed in small cages for further observation and kept in insecticide-free air. The number of immobilized, knocked-down test mosquitoes is documented one hour after the exposition, the mortality rate is determined using the following formula:

Mortality % = (No of Dead specimen/ Total No. of exposed specimen) X 100

The natural mortality rate is determined with an untreated textile. It is found that mosquito might spend more time resting on the cone than on the treated surface [1, 30].

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR
International Journal OF Engineering Sciences & Management Research

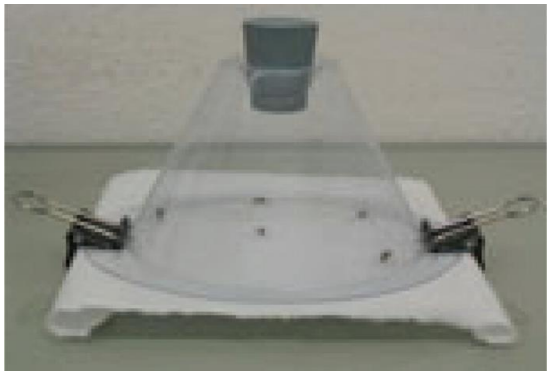


Fig 5. Cone used in cone test for mosquito repellents by WHO

3. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARD E951-83 [31]

This method is for non-commercial mosquito repellent formulation on the skin in this method mosquito-repellency activity is assessed using the test cage as shown in figure 6. The flexor regions of the forearms of volunteers are outlined with five circular 29mm diameter test areas. 0.025 ml of dilutions of the essential oils in ethanol and 0.025 ml of the diluent is applied to the marked areas of circles. Ethanol 95% was applied at the middle, which was the third circle as the control test. The test cages are positioned securely on the arms of each volunteer with Velcro tapes to ensure that only the test areas are exposed for mosquito bites. Fifteen female mosquitoes, between four and seven days old, are introduced into each cage and the numbers of bites are recorded at the end of 120 seconds.

Fig 6. Test Cage method for mosquito repellents by ASTM

ADVANTAGES OF HERBAL MOSQUITO REPELLENT FINISHING

Following are few advantages of herbal mosquito repellents finishes:

- Eco friendly, non allergic and non toxic
- Not absorbed by skin and active compounds are not removed on sweating
- Better affinity towards cotton and synthetic fibres.[1]

MOSQUITO REPELLENTS USING HERBAL EXTRACTS

In the past, focus of chemical mosquito repellent manufacturers was solely on the efficacy and response of mosquitoes but after the introduction of herbal mosquito repellent remarkable work has begun on entomological studies and toxicological actions of mosquito repellents. Various researchers have reported the use of herbal extracts as mosquito repellents. Sarita Kumar et al, (2011) examined and found remarkable repellent properties of essential oil extracted from the leaves of peppermint plant. They reported 100% protection till 150 min against the larval and adult stages of Aedes aegypti [32]. B.Tuetun et al, (2008) developed a natural alternative

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

to synthetic repellents for protection against mosquitoes using celery-based products for chemical composition, skin irritation, and mosquito repellency with achievement of goal to develop a natural alternative to synthetic repellents for protection against mosquitoes [33]. J. Banupriya et al, (2013) applied rosemary on cotton fabric and found 92% repellency using excite chamber method [17] while M. Anish Sharmila et al, (2015) finished cotton fabric using citronella and lavender oil and reported 93% repellency [34]. Sumithra et al, (2012), in their study developed mosquito repellent finish for denim fabric using three natural herbs extracts of Ricinus communis, Senna auriculata and Euphorbia herita which were applied directly by using pad dry cure method. The results showed good efficiency of 68% repellency in denim fabric and also highest repellency rate of 52% even after 30 industrial washes when compared to other fabrics [16]. M.M. Miró Specos et al, (2010) applied microcapsules containing citronella essential oil to cotton fabric. They found that fabric treated with microencapsulated citronella presented a higher and longer lasting protection than fabrics sprayed with an ethanol solution of the essential oil [27]. In another study by R. Anitha et al, (2011) comparison of microcapsules prepared with aqueous and methanolic extracts was done. Microcapsules of lemon grass aqueous extract showed 92% repelllency on polyester fabric whereas methanolic extracts exhibited only 80% mosquito repellency activity [4]. Ramya.K et al, (2014) investigated the plant extracts of Andrographis paniculata as mosquito repellent finish for fabric. They also compared the direct and microcapsualtion application method. Samples treated by the direct application method showed about 96% efficiency, while the microencapsulated sample showed 94% efficiency. Whereas the wash durability of the encapsulated samples showed better efficiency and high retention than by directly applied samples [24]. Instead of direct application or microcapsualtion A.Hebeish et al, (2008) used the properties of limonene against mosquitoes. Their study concluded that the treatment of cotton fabrics with limonene oil using polymer coating methods imparts toxic activity even after about 18 months [35]. The study by R. Ramasamy et al, (2014) is mainly carried out for the development of mosquito repellent fabrics using nanoparticle loaded with *V. negundo* leaf extract which were synthesized using ionic gellification method. The finished fabrics were analyzed using Mosquito Repellency Behavioural test which showed 76% mosquito repellent efficiency and retained their activity until 15 washes [6].

CONCLUSION

The relatively lower incidence of adverse reactions of herbal products and their reduced cost as compared to modern synthetic products can be attractive and eco-friendly alternative to synthetic agents for textile applications. The natural and herbal finishing agents which were applied on the fabric have very good mosquito repellent property. These are eco-friendly, bio-degradable, non-toxic and non-allergic to the skin and have a great potential as commercial repellent products.

REFERENCES

1. Dr Naresh M. Saraf, Dr Ashok G. Sabale and Dr Vaishali Rane, Durable Mosquito Repellents for Textiles /ART136.Pdf [To Bite or Not to Bite], Sarex: India, 2011, 23-25.
2. Susheela Palanisami, Ezhili Natarajan, Radha Rajamma, Development of eco-friendly herbal mosquito repellent, Journal of Innovative Biology, Vol.1, Issue.3, Sep.2014, 132-136.
3. S. Lakshmi Manokari1, N. Charanya Meenu, Evaluation of the Use of Insect Repellent Pouches Developed From Vetiveria Zizanioides, International Journal of Science and Research, Vol.3 , Issue.8, Aug.2014, 1366-70.
4. R. Anitha, T. Ramachandran, R. Rajendran, M. Mahalakshmi, Microencapsulation of lemon grass oil for mosquito repellent finishes in polyester textiles, Elixir International Journal Elixir Bio Phys., 40 , 2011, 5196-200.
5. Francis EG Cox, History of the discovery of the malaria parasites and their vectors, Parasit vectors, Vol.3, Issue.1, Feb. 2010.
6. Rajendran Ramasamy, Radhai Rajan, Rajalakshmi Velmurugan, Development of Mosquito repellent fabrics using Vitex negundo loaded nanoparticles, Malaya Journal of Biosciences, Vol.1, Issue.1, 2014, 19–23.
7. Kanwar Varinder pal singh, Elementary idea of textile dyeing, printing and finishing, Kalyani Publishers, 2004, pp.5, 29
8. Ek. Patel, A. Gupta , Rj. Oswal, A Review On: Mosquito Repellent Methods, International Journal Of Pharmaceutical, Chemical And Biological Sciences, Vol.2, Issue.3, 2012, 310-317
9. Bell, J.W., Human Exposures to N,N-diethyl-m-toluamide insect repellents reported to the American Association of Poison Control Centers 1993-1997, International Journal Of Toxicology, Vol.21, Issue.5, 2002, 341-352.

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

10. Maragret Brown, Adelaide A. Hebert, Insect Repellents: An Overview, Journal of the American Academy of Dermatology, Vol.36, Issue.2, Feb.1997, 243-249
11. Tenenbein M. , Severe toxic reactions and death following the ingestion of diethyltoluamine containing insect repellents, Journal of the American Medical Association, Vol.258, Issue.11, Sep.1987, 1509-11
12. Veltri JC, Osimitz TG, Bradford DC, Page BC, Retrospective analysis of calls to poison control centers resulting from exposure to the insect repellent N,N-diethyl-m-toluamide (DEET) from 1985-1989, Journal of Toxicology - Clinical Toxicology, 1994, Vol.32, Issue.1, 1-16
13. Petrucci N., Sardini S., Severe neurotoxic reaction associated with oral ingestion of low-dose diethyltoluamide-containing insect repellent in a child, Pediatric Emergency Care, Vol.16, Issue.5, 2000, 341-342
14. Zadikoff, C.M., Toxic encephalopathy associated with use of insect repellent, Journal of Pediatrics, Vol.95, Issue.1, 1979, 140-142
15. Oransky, S., Seizures Temporarily Associated with Use of DEET Insect Repellent-New York and Connecticut, Morbidity and Mortality Weekly Report , Vol.38, Issue.39, 1989, 678-680
16. Sumithra, Vasugi Raaja, Herbal coating of denim fabric to enhance the wickability, International Journal of Biomedical Research , Vol.05, Issue 02, 2014, 95-97
17. J. Banupriya, V. Maheshwari , Effects of Mosquito Repellent finishes by Herbal Method on Textiles, International Journal Of Pharmacy & Life Sciences, Vol.4, Issue.11, Nov. 2013, 3133-34
18. S. Swathi , G. Murugananthan , S. K. Ghosh , A. S. Pradeep, Larvicidal and repellent activities of Ethanolic Extract of *Pongamia Pinnata* Leaves against Mosquitoes, RGUHS Journal of Pharmaceutical Sciences, Vol. 1, Issue. 1, Apr-Jun 2011, 55-57
19. S. Swathi , G. Murugananthan , S. K. Ghosh , A. S. Pradeep, Larvicidal and repellent activities of Ethanolic Extract of datura stramonium Leaves against Mosquitoes, International Journal of Pharmacognosy and Phytochemical Research, Vol. 4, Issue. 1, 2012, 25-27
20. OI Aremu, MN Femi-Oyewo, KOK Popoola, Repellent Action of Neem Azadirachta indica) Seed Oil Cream against Anopheles Gambiae Mosquitoes, An International Multi-Disciplinary Journal, Ethiopia , Vol. 3, Issue. 3, April, 2009, 12-22
21. Rukpong Sanghong, Anuluck Junkum, ej Choochote, Udom Chaithong, Atchariya Jitpakdi, Doungrat Riyong, Benjawan Pitasawat, Repellency screening of herbal products against the dengue fever vector Aedes aegypti (Diptera: Culicidae), Chiang Mai Medical Journal, Vol.53, Issue. 2, 2014, 53-62
22. V. krishnaveni, Mosquito repellent finish on textiles, *http://articles.fibre2fashion.com*, Nov.2009
23. Sarkar RK, Purushottam DE, Chauhan PD, Bacteria-resist finish on cotton fabrics using natural herbal extracts, Indian Journal of Fibre and Textile Research, Vol.28, Issue.3, Sep. 2003, 322–331
24. Ramya.K & Maheshwari, Development Of Eco Friendly Mosquito Repellent Fabric Finished With Andrographis Paniculata Plant Extracts, International Journal of Pharmacy and Pharmaceutical Sciences, Vol.6, Issue. 5, 2014 , 115-117
25. M.Sumithra, N.Vasugi Raja, Mosquito repellency finishes in blended denim fabrics, International Journal Of Pharmacy & Life Sciences, Vol. 3, Issue. 4, April 2012, 1614-16
26. S. Basak, Kartick. K. Samanta, S. K. Chattopadhyay, R. Narkar, M. Bhowmick , S. Das, A. H. Saikh, Fire Retardant and Mosquito Repellent Jute Fabric Treated with Thio-urea, Journal of the Textile Association, Jan-Feb.2014, 273-281
27. M.M. Miró Specos, J.J. García, J. Tornesello, P. Marino,M. Della Vecchia, M.V. Defain Tesoriero, L.G. Hermida, Microencapsulated citronella oil for mosquito repellent finishing of cotton textiles, Transactions of the Royal Society of Tropical Medicine and Hygiene, Vol.104, Issue.10, 2010, 653–658
28. Tanveer Malik, Krishna Gadodiya , Anmol Kumar, Mosquito repellent textiles: An overview, http://articles.fibre2fashion.com//
29. WHO, Test Procedures for Insecticide Resistance Monitoring in Malaria Vectors; Bio-Efficacy and Persistence of Insecticides on Treated Surfaces, 1998
30. WHO/HTM/NTD/WHOPES, Guidelines for efficacy testing of mosquito repellents for human skin, 4, 2009
31. ASTM STANDARD TEST METHOD **E951-83**
32. Sarita Kumar, Naim Wahab, Radhika Warikoo, Bioefficacy of Mentha piperita essential oil against dengue fever mosquito Aedes aegypti L, Asian Pacific Journal of Tropical Biomedicine, Vol.1, Issue.2, Apr.2011, 85-88
33. B.Tuetun,W.Choochote,Y.Pongpaibul,A.Junkum,D.Kanjanapothi,U.Chaithong,A.Jitpakdi,D.Riyong, B.Pitasawat, Celery-based topical repellents as a potential natural alternative for personal protection against mosquitoes, Parasitology Research, Vol.104, Issue.1, 2008, 107–115

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

34. M. Anish Sharmila, P. Senthil Priya, S. Boobalan, L. M Karthikeyan, Development Of Mosquito Repellent Finished Cotton Fabric Using Eco Friendly Cymbopogancitros Oil, International Journal Of Science, Technology & Management, Vol.04, Issue.02, Feb. 2015, 96-101
35. A. Hebeish , Moustafa M.G. Fouda , I.A. Hamdy , S.M. EL-Sawy , F.A. Abdel-Mohdy , Preparation of durable insect repellent cotton fabric: Limonene as insecticide, Carbohydrate Polymers, Vol.74 , Issue.2, Feb.2008, 268–273