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A SYSTEMATIC REVIEW ON HERBAL MOSQUITO REPELLENT

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ABSTRACT

Mosquito management and personal protection against mosquito bites is one of the most important techniques to prevent the spread of infectious illnesses. Because of the emergence of resistance, cross-resistance, and potential toxicity risks connected with synthetic insecticides, as well as their escalating prices, interest in plant-based solutions has resurfaced in recent years. Most mosquito repellents on the market today are chemical-based and hazardous to the skin and nervous system, causing rashes, swelling, eye irritation, and other health issues. The smoke from synthetic pyrethroid mosquito coils is still disliked by the majority of people. As a result, herbal insect repellents were chosen over chemical repellents. Essential oils from a variety of plant species, as well as combinations of essential oils, have been shown to be excellent mosquito and insect repellents. Plant-based repellants, which are safe and biodegradable alternatives to synthetic chemical repellants for mosquito control, have grown in popularity as a result of their accessible availability and lower negative environmental effect. As a result, efforts have been undertaken to develop innovative formulations for mosquito repellent sticks that comprise fixatives and a blend of essential oils. Azadirachta indica, Cymbopogon nardus, Eucalyptus globulus, Cymbopogon Citrullus, Cymbopogon martini, Mentha piperita, Ocimum basilicum, Rosmarinus officinalis, Syzygium aromaticum, Cinnamomum Zeylanicum, Syzygium aromaticum, Cinnamomum Zeylanicum, Rosemarinus officinalis. Filler, binder, burning agent, adhesives, odour enhancer, and other supporting substances were used to create them singly and in various combinations. When compared to other repellent essential oils, compositions including Cymbopogon citrullus, Azadiracta indica, and Eucaluptus globulus essential oils had the most promising efficacy, demonstrating 80-95

percent repellency. When compared to other formulations, the combinations containing Azadiracta indica demonstrated longer burning and repellency. The components employed in virtually all of the formulations in this study were herbal-based and environmentally safe. As a result, it has no adverse effects on inhalation. Texture, effectiveness, and stability of the same formulations were all tested. The current study shows that essential oils from medicinal plants may be used in mosquito repellent compositions.

KEYWORD: - Low smoke herbal mosquito, different essential oils, mosquitoes control, Mosquito repellent, Herbal mosquito repellent, Herbal repellent.

INTRODUCTION

Mosquito-borne diseases continue to be a major cause of death and illness.[1] Malaria remains a serious global public health concern, despite decades of malaria control efforts, with 3.3 billion people at risk in 106 tropical and subtropical countries and territories.[2] Low birth weight, stillbirths, and early infant death are all important causes of maternal and childhood morbidity and mortality in Sub-Saharan Africa.[3] More than 50 Anopheles mosquito species are known to spread malaria through the bite of infected female Anopheles species.[4] There is currently no effective anti-malarial vaccine available for prophylaxis, and no acceptable preventative intervention other than vector control.[5]

As a result, one of the most effective ways to prevent illness incidence is to protect yourself against mosquito bites. Mosquito repellents have previously been acknowledged as part of a broader integrated insect-borne disease control approach.[6] The bulk of commercial repellents use chemicals such as N, N-diethyl-metatoluamide (DEET), Allethrin, N, N-diethyl mendelic-acid amide, and Dimethyl-phthalate.[1]

Chemical repellents have been found to be hazardous to population health and should be used with caution due to its negative effects on synthetic fabric and plastic, as well as toxic reactions like allergy, dermatitis, and cardiovascular and neurological side effects, which were reported frequently after misuse.[4] The increasing use of chemically generated synthetic repellents for mosquito control has altered natural ecosystems, resulting in pesticide resistance, mosquito population comeback, and harmful impacts on nontarget species.[4,7]

As a result, employing natural mosquito repellent products as a substitute for developing new eco-friendly repellents might be a win-win option for reducing the negative impacts on the Human health and the environment.

Because of their availability of phytochemical compounds that are both harmless and biodegradable into non-toxic by-products that might be investigated for insecticidal and mosquito repellent characteristics, plant-based repellents have reemerged in popularity in recent years.

Many research have shown evidence of plant extracts or essential oils having repellent properties against malaria vectors all throughout the world. The goal of this systematic study was to determine whether plant-based repellents can be depended on to offer long-term and predictable protection from Anopheles mosquito species without generating negative health consequences.[8]

All suitable research on the repellency effects of plant-based repellants against Anopheles spp. and other mosquito spp. were included in this systematic review.

Mosquitoes born disease

Malaria

Malaria is transmitted via a female Anopheles mosquito bite. Malaria is a protozoal infection of red blood cells that is the world's most frequent parasitic illness. There are 172 Plasmodium species, the most majority of which only infect birds, reptiles, and nonhuman mammals. **Falciparum, vivax, ovale**, and malaria are the four Plasmodium species that routinely infect people and cause clinical illness.[9]

Dengue

Dengue fever is a mosquito-borne sickness that has recently returned over the world. Dengue fever is a contagious disease that affects people all around the world. DENVs 1–4 cause dengue fever. It is a mosquito-borne sickness transmitted to humans mostly by female Aedes mosquitos. The disease is primarily found in tropical and subtropical regions, putting roughly a third of the world’s largest population at risk.[10]

Chikungunya fever

The name "chikungunya" comes from a Makonde phrase that means "to bend up" or "to become deformed," referring to the bent posture of those who are infected.The Chikungunya

virus (CHIKV) causes Chikungunya fever (CHIKF). Chikungunya is an alpha viral infection that belongs to the Gaviridae family. CHIKV, which has symptoms that are similar to dengue illness and Zika, is spread in two cycles: urban and sylvatic. The urban cycle describes transmission from human to human, whereas the sylvatic cycle describes transfer from animal to mosquito to human.[11]

Zikavirus

The Flaviviridae virus family includes the Zika virus. Aedes mosquitoes that are active during the day, such as Aedes aegypti and Aedes albopictus, spread the Zika virus. It takes its name from the Zika Forest in Uganda, where the virus was first found in 1947. The Zika virus belongs to the same genus as dengue disease, yellow fever, Japanese encephalitis, and West Nile virus. Like a weak form of dengue fever, the Zika virus infection, also known as Zika fever or Zika virus illness, generally has no or few symptoms. While there is no particular therapy for the symptoms, paracetamol (acetaminophen) and rest may assist.[12]

Yellow fever

Yellow fever (YF) is a mosquito-borne flavivirus that causes high-fatality epidemics. The predominant vectors are Aedes species, whereas key forest species in South America include Haemagogus and Sabethes, and nonhuman primates act as the reservoir. Fever, nausea, vomiting, and stomach discomfort are all symptoms of YF virus infection. In 20% of cases, the symptoms escalate to jaundice, hepatic and renal failure, and bleeding.[13]

Lymphatic filariasis

Lymphatic filariasis (LF) affects an estimated 121 million people globally, with an additional 856 million in danger of infection and in need of prophylactic treatment. Wuchereria bancrofti is the cause of the majority of lymphatic filariasis infections. Elephantiasis is a parasitic infection caused by lymphatic filariasis, which is spread through mosquito bites. Edema causes loss of function in the afflicted area as well as skin thickening, giving the individual the appearance of an elephant.[14]

Control of mosquitoes

Synthetic insecticides

Synthetic pesticides have sub-lethal effects, which can be surprising. Reduced output, for example, in Aedes aegypti. Only phenothrin and d-allethrin decreased blood engorgement among three pyrethroids tested: d-phenothrin, d-allethrin, and tetramethrin. Dieldrin,

administered topically, had dose-dependent effects on eating and egg-laying capability in Aedes aegypti, but had no effect on offspring.[15] Pyrethroids are currently the only insecticides that may be used to apply bed nets or drapes because to their high effectiveness and strong active repellent activity on mosquitoes. They can be categorised in a number of ways, depending on their chemical, toxicological action, and penetration technique. Synthetic carbamates, organochlorines, pyrethroids, and phenyl pyrazole are all examples of synthetic carbamates. To keep everything under control, pyrroles are used.[16]

- **Synthetic marketed products used against mosquitoes**

S. No.	Active Ingredients	Dosage form
1.	Cyfluthrin, Transfluthrin, Prallethrin	Spray
2.	Prallethrin	Coil, liquid & Paper
3.	Transfluthrin	Coil, liquid & Paper
4.	DEET	Coil, liquid & Paper

Harmful effects of synthetic mosquitoes insecticides on humans

Pesticides can have both **acute and chronic** health consequences on people.

Acute:- Skin and eye irritations, headaches, dizziness and nausea, weakness, difficulty breathing, mental confusion and disorientation, seizures, coma, and death are all examples of acute health problems that can occur immediately after exposure to these pesticides. It may take months or years for long-term health repercussions to manifest.

Chronic:- Nervous, reproductive, and immunological system problems, as well as cancer, are examples of such health conditions.[55]

Compounds derived from a plant used against mosquitoes

Eucalyptus, Citronella, Neem (Azadirachta indica), Clove, and other plant essential oils are commonly included in commercial repellents, either for scent or as repellents (Syzygium aromaticum). The most effective oils for resisting malaria, filarial, and yellow fever vectors for 60-180 minutes are eucalyptus oil, geraniol, and clove.

Advantages of herbal drugs

- Herbal medicines can be used for a long time and still appear to work.
- The production and processing of natural mosquito plant repellents are both environmentally friendly.

- Natural mosquito plant repellant is not a problem in developing countries like India because of the vast agro-climatic, ethnic biodiversity, and culture.
- Natural Repellent plants have an infinite supply, allowing us to keep providing affordable medicine to the world's growing population.
- Herbal repellents have a rich history of usage, are more generally recognized, and are tolerated by patients.

1. Eucalyptus

Eucalyptus is a **Myrtaceae** genus of flowering trees, shrubs, and mallees with over 700 species.[19] Eucalypts, along with numerous other genera in the Eucalypteae family, such as Corymbia, are commonly referred to as eucalypts. Eucalyptus trees have smooth, fibrous, hard, or stringy bark, leaves with oil glands, and sepals and petals fused together to create a "cap" or operculum above the stamens. The fruit is a woody capsule that is sometimes called a "gumnut."

A total of five research looked at the repellency of various eucalyptus sub-species. Narrow-leaved eucalyptus, lemonscented eucalyptus, and broad-leaved eucalyptus gave 8 hours of protection against An. stephensi, but Eucalyptus globulus provided 5.5 hours of protection, according to Amer et al.[20] Auysawasdi et al.[21] tested E. globulus essential oil against An. dirus at five different concentrations: 5%, 10%, 15%, 20%, and 25%. E. globulus demonstrated excellent repellency for 1.7 to 3.4 hours at all concentrations, depending on the concentration utilised. In a research[22] Eucalyptus globulus at 0.1 ml dosage repelled An. dirus for 1.58 hours. Furthermore, An. minimus was repelled for 0.5 hours by 100 l Eucalyptus citriodora.[23]

Seyoum et al., on the other hand, discovered that lemon eucalyptus extract had no effect on An. Gambiae.[24] Steam distillation was used to extract the essential oil, which was then tested for various **chemical compositions** using GC–MS. Eucalyptol (54.29 percent), p-cymene (10.10 percent), -pinene (7.78 percent), -myrcene (7.78 percent), -terpinene (1.73 percent), and citronellal (1.62 percent) were the most commonly identified compounds in the leaf essential oil of E.maculata, followed by p-cymene (10 percent), -myrcene (8.74 percent), Terpin.

2. Citronella

Several researcher have looked at the repellent properties of citronella. Citronella is an essential oil derived from the stems and leaves of many lemongrass (Cymbopogon spp.) species.[25]

The actual citronella plants are grasses called **Cymbopogon nardus or Cymbopogon winterianus**. It's most likely a citronella scented geranium if you buy a "citronella plant" with lace leaves instead of grass blades, which is typically touted as a mosquito repellent but is ineffectual. Citronella grass is a clump-forming perennial grass that thrives in zones 10-12.

According to Ansari et al.[26] citronella made from lemongrass has a % repellency effect against Anopheles culicifacies for 11 hours. According to Amer et al.[27] and Tawatsin et al.,[28] citronella may repel Anopheles stephensi and Anopheles dirus for 8 and 6 hours, respectively.

Furthermore, against An. minimus[29] and An. Dirus,[30] 100 l and 0.1 ml of citronella grass essential oil provided 2.16 and 0.8 hour of full protection, respectively. Citronella's percentage repellency was observed to be 52 to 85% in previous research,[31] depending on the quantity of extracts and Anopheles species.

Geraniol (28.62 percent), citronellal (23.62 percent), and citronellol (17.10 percent) were the main components found in the citronella essential oil in this study. Monoterpenes are the name given to these substances.

Neem (Azadirachta indica)

Neem is a multipurpose tree that is widely planted in India's tropical regions.[32] The mahogany tree Azadirachta indica, often known as neem, nimtree, or Indian lilac, and in Nigeria as dogoyaro or dogonyaro, belongs to the **Meliaceae** family.

In two investigations, the repellency impact of Neem against several Anopheles species was studied. Amer et al.[33] found that Te % Neem oil provided perfect protection against An. Arabiensis for 3 hours, with an average percent repellency of 71 percent. Despite this, Seyoum et al. discovered that Neem extract had no effect on An. Gambiae.[34]

Azadirachtin, which was first identified in azadirachta seed extracts in the 1960s and is employed as an insect antifeedant, growth disruptor, and pesticide, is one of the phytochemicals present in neem fruit, seeds, leaves, stems, and bark. Approximately 5 g of azadirachtin is generated by crushing 2 kg of seeds. In addition to azadirachtin and related limonoids, the seed oil contains glycerides, different polyphenols, nimbolide, triterpenes, and beta-sitosterol. With a garlic-like odour and around 2% limonoid components, the oil is yellow and harsh. The leaves include quercetin, catechins, carotenes, and vitamin C.[35]

3. Clove (Syzygium aromaticum)

Clove is a common spice with antibacterial, antioxidant, antipyretic, anti-candidal, and aphrodisiac properties.[39] Six investigations looked into clove's repellency effect on different Anopheles species. According to Phasomkusolsil et al.,[40] clove at 0.10, 0.02, and 0.21 mg/cm2 had a dose-dependent repellency of 82 percent, 92 percent, and 98 percent against An. dirus, respectively. Barnard et al.[41] evaluated 25 percent, 50 percent, 75 percent, and 100 percent clove essential oil concentrations against An. albimanus and found that all concentrations provided complete repellency for 1.25 to 3.55 hours, depending on the concentration applied. At 10 percent, 50 percent, and 100 percent concentrations, clove displayed 1.33, 2.66, and 3.5 hours of complete repellency against An. dirus, with a dose-dependent trend.[42]

Clove was found to repel Anopheles dirus for 1 hour in laboratory circumstances in Tailand.[43] Clove repels An. minimus for 2 hours, according to another study.[44]

Furthermore, a 20 percent clove gel protected against An. dirus for 4.5 hours.[45] All of these findings support the notion that clove is a mild repellent.

Essential oils as green pesticide

Essential oils are complex, volatile, naturally occurring chemicals with a strong odour that are produced as secondary metabolites by aromatic plants. They're liquid, volatile, seldom coloured, lipid soluble, and soluble in organic solvents having a density lower than water's. Apart from pesticidal potential, there are 17,500 aromatic plant species among higher plants, with around 3,000 essential oils recognised, of which 300 are economically important for medicines, cosmetics, and perfume industries. Essential oils are used in nature to preserve plants as antibacterial, antiviral, antifungal, and insecticides, as well as to deter herbivores by lowering their hunger for such plants.

They may also attract some insects to aid pollen and seed dispersal or repel undesired ones. Due to the widespread usage of natural products such as essential oils and our familiarity with them as fragrances, it is critical to have a deeper knowledge of their mode of biological activity in order to find novel uses in human health, agriculture, and the environment. Some of them are efficient substitutes or complements for synthetic chemicals used in the chemical industry, but they don't have the same side effects.[46]

According to the literature, various natural compounds such as Eucalyptus (Myrtaceae); Azadirachta indica (Maliaceae); Clove (Syzygium aromaticum), Thyme (Thymus serpyllum), and Citronella (Cymbopogon spp.) have been studied for mosquito repellent properties.

Land leeches have been observed to be repellent to Callistemon rigidus (bottle brush), A. indica (neem), and Z. armatum (timur). Mosquito repellent activity of neem oil in the form of mats and neem cream has been tested. Aedes aegypti has been observed to be repellant to benzene and methanol extracts of Artemisia vulgaris. Quelling, a mosquito repellent made in China from extracts of lemon grass and eucalyptus trees, was tested against mosquitoes. Aedes aegypti was repelled using essential oil produced from Vitex negundo. Aedes mosquito repellent effects of Lantana camara (Vervanaceae) flowers have also been observed.[47]

Citronella (Cymbopogon nardus), eucalyptus (Eucalyptus maculata), geranium (Pelargonium reniforme), lemongrass (Cymbopogon excavatus), peppermint (Mentha piperita), neem (Azadirachta indica), and soybean (Neonotonia wightii) essential oils may be found in.

Typically, these oils are liquid at normal temperature and can be easily converted from liquid to gaseous without breakdown at room or slightly higher temperatures. Plants use essential oils' aromatic properties for a variety of purposes, including attracting or repelling insects, insulating themselves from heat or cold, and using chemical elements in the oil as defensive materials.

The term "green pesticides" refers to a wide range of environmentally friendly and useful pest management products that can help to reduce pest populations. They are safer, more environmentally friendly, and more compatible with the environment than synthetic pesticides. Essential oils' pure terpenoid components are somewhat hazardous to animals, but the oils themselves or products based on oils are usually benign to mammals, birds, and fish, justifying their classification as "green insecticides".[49]

CONCLUSION

Chemical treatment of pests and vectors has resulted in a high level of pesticide resistance. Alternative vector control techniques must be researched in order to solve this challenge.

People seek mosquito repellents that are safe, enjoyable to use, and environmentally friendly, thus the area of herbal repellents is particularly rich.

Examining the usage of local for as repellents is strongly recommended, as cost is a big concern. Essential oils and plant extracts are emerging as possible Anopheles spp. control agents due to their ease of use, cheap cost, and lack of danger. L. sinense extract had the best repellency efficacy against Anopheles mosquitoes, followed by citronella, pine, D. siso, peppermint, and R. mucronata oils, with full protection times ranging from 9.1 to 11.5 hours in this systematic study.

Essential oils from plants such as, amyris, narrow-leaved eucalyptus, carotin, cedar wood, chamomile, cinnamon oil, juniper, soya bean, rosemary, Eucalyptus, Neem oil, broad-leaved eucalyptus, lavender, camphor, catnip, geranium, lemongrass, lemon scented, olive oil, sandalwood, galbanum, and C. longa also showed good repellency with 8 h complete repellency against different species of Anopheles genus.

Furthermore, unlike synthetic repellents, which pose an environmental risk, have lethal effects on non-target organisms, and have increased mosquito resistance to insecticides over the last five decades, natural repellents are typically simple, inexpensive, and accessible to communities with minimal external input. These issues have necessitated the development of alternate solutions.

The development of plant-based insecticides as an alternative to chemical insecticides has sparked a lot of interest due to its ease of use, low cost, and lower environmental impact. Essential oils have a short-term effect due to their volatility. One approach for making them long-acting is to use a polymeric slow release device containing essential oils. A smart delivery system could also be a multiple emulsion with an essential oil core.

People will find it easy to apply and discontinue such topically applied compositions. Essential oils are abundant in nature, and their application in mosquito repellent can be considered a sustainable and biocompatible delivery system as a green option, in addition to its medicinal and flavor value.

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