

Green Revolution in Vector Management

Stelson F. Quadros

Express Pesticides Pvt. Ltd., Vice President - Indian Pest Control

Abstract- The primary vectors for the spread of diseases of concern like malaria, dengue, are mosquito species, particularly *Aedes* and *Culex*. There has been an exponential use and increased reliance by smaller groups, not specific to municipal and govt health bodies, but by housing societies and private pest control companies who rely on the acceptability of Thermal Fogging, as one of the key control or management factors of mosquito in urban setup. The professional pest control agencies are forced to adopt the use of Thermal Fogging even if there are ULV based options as there is fairly low awareness and poor visible changes at municipal level where adoption of ULV is not seen for more immediate adoption at social self help groups and with housing societies or with professional pest management companies. The urgent need to induct for a more less pollutant carrier, like BIODIESEL in thermal fogging and use of Plant Extract based Larvicides in water sources having significantly low toxicity will help build a more sustainable and low toxic mosquito management program, helping the human society at large to be truly living healthy through the means of Integrated Mosquito Management. In stark contrast where the use of polluting carriers like diesel leaves more lasting environmental damage affecting many more lives, than saving a few.

Index Terms- *Aedes* sp. *Culex* sp. plant extract, biofuel, biodiesel, non-target organisms, air quality, thermal fogging.

I. INTRODUCTION

Mosquitoes transmit quite a lot of deadly diseases, including chikungunya, brain fever, dengue fever, malaria, filariasis, yellow fever, and Zika fever affecting all age groups, the ageing demographics at low income groups are affected more when compared with same age demographics in middle or high income group.

Every year, mosquito-borne diseases affect millions of people. For this very reason, mosquito control is vital for public health, especially in INDIA.

Now considering that we are a nation rapidly developing, having a rich heritage and cultural reference to take a lead from and in the day and age of 2025 it is our moral responsibility to embark on a socially responsible journey especially when we are being watched by the other growing nations as a guide to bringing them a healthy future where we know we will be closely followed and emulated by many.

INDIA has made great progress in space technology, aeronautics, child care, robotics and medical science, all of this was only possible when new groundbreaking findings and new frontiers were adopted and tried in real time, coining the term "From Lab to Life ©".

To manage mosquitoes, various synthetic chemicals are widely used, each with its advantages and disadvantages. Chemical management comes with its own risks and

boundaries however it has a satisfactory effect on reducing mosquito populations, even though mosquito resistance and the presence of pesticide residues in the environment and the development of resistance in mosquito control tactics are crucial concerns.

It is difficult to comment today on what is more concerning, the mosquito or the means of managing it, as with increased data facts and health reviews it's easily understood that diesel has a higher toxic and carcinogenic exposure on humans.

The need for adopting more low toxic alternatives while working at equal pace with the engineering industry to provide better enhanced equipment for adopting newer application alternatives for aqueous ULV applications will help to pave the way for a more environmentally sustainable service in Integrated Mosquito Management.

Alternatively, early and emerging findings from plant-based phytochemicals needs to be handheld and provided collaborative incubation for it to make it to mainstream professional-public health and government system adoption.

Plant based larvicides/adulticides will initially prove to be high on cost but since they are efficient and with enhanced use its mass production will become more economically viable, providing the much needed eco-friendly, safe for humans and environmentally low impact product, and slowly becoming an effective alternative to chemical larvicides/adulticides.

II. THE GREEN APPROACH

Botanicals are basically secondary metabolites that serve as a means of defence mechanism of the plants to withstand the continuous selection pressure from herbivore predators and other environmental factors.

Several groups of phytochemicals such as alkaloids, steroids, terpenoids, essential oils and phenolics from different plants have been reported previously for their insecticidal activities.

Insecticidal effects of plant extracts vary not only according to plant species, mosquito species, geographical varieties and parts used, but also due to extraction methodology adopted and the polarity of the solvents used during extraction and other factors revolving around the way the plant is handled or exposed.

A wide selection of plants from herbs, shrubs and large trees was used for extraction of mosquito toxins. Phytochemicals were extracted either from the whole body of little herbs or from various parts like fruits, leaves, stems, barks, roots, etc., of larger plants or trees. In all cases where the most toxic substances were concentrated upon, found and extracted for mosquito control.[1]

One viable and long-term solution to the problem of mosquito-borne diseases affecting the world's population is the use of plant extracts to suppress disease-carrying mosquito populations.

Numerous plant extracts have been shown in scientific tests to be effective at both killing and repelling mosquitoes, making them a more environmentally friendly option than synthetic chemicals.

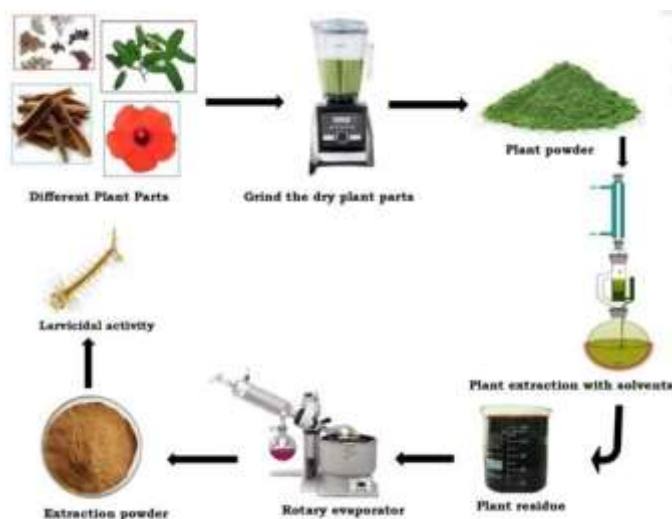
The effective incorporation of plant-based mosquito control techniques into public health programmes requires ongoing research, formulation standardisation, and community involvement. Using plant extracts to harness the power of nature may prove to be a crucial part of our attempts to create a healthier and more sustainable world as we traverse the complexity of diseases carried by mosquitoes.

The global problem of diseases carried by mosquitoes has the potential for an environmentally friendly remedy in the form of plant extracts. These extracts contain an extensive number of chemicals that can be used to target different phases of mosquito development, from larvae to adults. The use of plant extracts into all-encompassing mosquito control strategies may, as research advances, lessen dependence on artificial / synthetic pesticides and promote sustainable public health measures.[6]

In one focused study on working with nanoparticle formulations with natural extracts, an aqueous extract of *Artemisia herba-alba* Asso (Asteraceae) leaves was tested against L4 larvae strains from India and Saudi Arabia. The LC₅₀ values were 117.18 µg/mL and 614.54 µg/mL for India and Saudi Arabia larvae, respectively. When the extract was incorporated into silver nanoparticles the activity increased significantly to 10.70 µg/mL and 33.58 µg/mL, respectively. Similar results were observed against adult mosquitoes [14]. Similar focused works will be needed to isolate and formulate the most viable option for finally promoting a viable 100% safe formulation for Do It Yourself segment, Public Health Officials and Professional Pest Control Companies.

It is important to note that the volatility from plant extracts may be a disadvantage in terms of instability. However, this property can be overcome using pharmaceutical technology such as micro and nanoencapsulation [7,8]. Formulation development is therefore critical for essential oils to be used effectively and safely as pesticides. A number of studies have demonstrated that a suitable vehicle prolongs the insecticidal effect [7,9,10].

Of the plant families affording essential oils, those most tested against *Ae. aegypti* larvae were Myrtaceae, in particular *Eucalyptus* species, followed by Fabaceae, Asteraceae, Apiaceae and Lamiaceae. Asteraceae was the most important for the adulticide, repellent and oviposition effects. Regarding larvicidal activity there is currently no value specified by the WHO to discriminate whether a compound or extract is active against insects.



However, researchers usually consider that an LC₅₀ < 50 µg/mL is very active; an LC₅₀ 50–100 µg/mL is active, and an LC₅₀ > 100 µg/mL is weak/inactive [11,12,13].

The abundance of phytochemicals found in tropical plants may mean that in the future, production and manufacture of plant-based means of disease control can become a real feature of sustainable development, providing a means of income to rural farmers in the tropics and solutions to current insect-borne diseases. It is important that research into phytochemicals moves with the changing times and the recent publications using novel techniques and robust testing methodologies are certainly a cause for optimism. Furthermore, novel strategies such as environmental management of mosquito sugar resources have great promise also.[15]

The Revolution Approach

Diesel as a carrier fuel has been used for decades and in current times the heavy reliance on high speed diesel is overburdening and manifold, as the current trend to do it yourself is at an all time high. According to Volza's India Import data, India imported 3 shipments of Thermal Fogging Machine during Feb 2023 to Jan 2024 (TTM). These imports were supplied by 3 foreign exporters to 3 Indian buyers, marking a growth rate of 40% compared to the preceding twelve months.

India imports most of its Thermal Fogging Machine from China, South Korea, and Germany.[5] It said the diesel-based spray machines were not environment friendly. The government also provided two cold fogging machines to the district health department for this purpose. Earlier, the health department mixed anti-dengue delta-methrine with diesel and sprayed it to kill the mosquitoes.[16]

The ease in which an untrained, unlicensed individual, company or institution can get access to a thermal fogger is a matter of great concern because this is the start of a chain reaction where firstly the product being sold is easily assessed for use by unlicensed individuals and further more concerns are raised over the calibration of such equipments which are mostly imported where there is no central or zonal centres making good the calibration to ensure right droplet size of diesel spent is being discharged as per needed safety norms. Here we can take an analogy from the vehicle industry where it is mandatory to have a PUC certificate, here it brings about a large management over diesel vehicles and its emissions. There is ZERO control over calibration or emissions from thermal foggers.

Extensive use of hand held foggers by untrained, unregulated, uncalibrated, unlicensed application individuals will lead to more larger problems pertaining to mosquito mortality, where little will be possible to correct the wrong.

Promoting and framing clearer and stricter or mandatory guidelines for equipments can help bring about some control over pollution aspects, however in the immediate present we

can move to promote and make use of biodiesel in thermal fogging as mandatory where it will also add up to the sustainability and environmental factor when it's adopted by large government enterprises, municipal corporations and housing societies.

The world authorities overlooking fossil fuels / petroleum, have increased the global petroleum market, the demand for petroleum based fuel has also experienced a massive hike up. This led to a serious plummeting of biodiesel demand from the already installed capacity. With the abundance of the current biodiesel research, the diversification of biodiesel application should be widened to ensure the demand on this renewable energy could be maintained as the best petroleum replacement.[2]

The nameplate capacity of biodiesel production in India stood at 600 million liters in 2023. This was forecast to reach 820 million liters in 2024. The nameplate capacity is the volume of biodiesel that can be produced during a period of 12 months under normal operating conditions.[17] India has an available capacity of biodiesel which can be immediately adopted and consumed by the professional pest management industry for their thermal fogging process.

The high flash point of biodiesel enabled safer storage, transportation, and application of the formulation. According to the findings from residual experiments, biodiesel may increase the amount of active ingredient (ai) on the surface of plants because of its lipophilic characteristic, which enabled more effective pest controlling of the pesticide delivery system. In the phytotoxicity test, the use of biodiesel as the carrier did not harm plants in any application ratios and may reduce environmental risks. Therefore, for oil-soluble ais, biodiesel may be a suitable alternative carrier for EC formulations.[18]

Life cycle analysis completed by Argonne National Laboratory found that emissions for 100% biodiesel (B100) are 74% lower than those from petroleum diesel. The California Air Resources Board has reported similar values for its life cycle analysis of biodiesel from various sources.[3]

There are other unexplored advantages to the use of biodiesel where it is more effective as a liquid carrier towards the larvae as they are capable to penetrate the larvae under water, thus, making it capable of spreading the insecticide in the water.[4] the formulation was more environmentally friendly, and less hazardous to beneficial species through the application of biodiesel. Moreover, biodiesel may also provide added value, less production cost in formulation due to the increasing price in petroleum derived solvents, and reuse of waste cooking oil. Strong odors of (ai) and adjuvant can also be suppressed because of the low vaporization of biodiesel.

Therefore, biodiesel is an advantageous carrier to deliver insecticide AIs and to improve their performance.[18]

The present status and future scope of biodiesel as a carrier/diluents and alternative source to hazardous volatile organic compounds for liquid pesticide formulations. Development of user and environment-friendly liquid pesticide formulations for sustainable agriculture is the key focus of today's agrochemical industries. Organic solvents play an important role in ensuring the efficient distribution and delivery of active ingredients (ai) during application of liquid pesticide formulations. Presently used petroleum-based solvents have many disadvantages such as low flash points, high volatility, flammability, phytotoxicity, and inhalation problems to users, etc. However, at present it seems that the use of renewable resources, especially plant oils, oils ester (fatty acids alkyl ester) like biodiesel has the capacity to replace the traditional petroleum-based solvents in liquid pesticide formulations with having sustainable characteristics like high flash point, safer storage, transportation and application. Biodiesel which is easily reproducible from waste cooking oil, waste edible oil, animal fat, etc. may be a suitable alternative green solvent for liquid pesticide formulations in the near future.[19]

III. CONCLUSION

Key takeaways after having gone through the data in reference will be some highlights like (A) Biodiesel, enables better management of mosquitoes when compared to normal diesel, different works concentrated on different aspects of efficacy of biodiesel and it shows us more good when we are in direct comparison from the existing carrier used. While the properties of the carrier also contribute to the efficacy, however it goes without saying factors like nozzles, equipment calibration do play a vital role, this a missing currently, which need to be regulated with some formal certification process like PUC for vehicles which will ensure there is more calibrated application. (B) The need for working towards "LAB to LIFE ©" concept where newer formulations with novel mix plant extracts can be worked with before its introduction for professional and DIY use.

(C) The fact that the start point to make this "LAB to LIFE ©" reality will be the adoption of the concept by key Govt Bodies, working towards the PPP module to introduce an on-field study to know the impact of the use of BioDiesel and plant extracts in larviciding and adulticiding.

(D) Furthermore the concept and call for professional pest management industry, research works, academia to collaborate to take forward what can be named as "GREEN REVOLUTION in VECTOR Management" must be looked upon as a social fulfillment which will have a far wide impact on not just urban population in terms of introducing a low

toxic approach but which will have an impressionable impact on the lives of coming generations, as it will have impacted their life quality with these small changes if adopted.

(E) Some review works report the economic burden of mosquito-borne diseases. It will act as evidence for policymakers to prioritize their decisions regarding containing the prevalence of mosquito-borne diseases and the means to lowering the incidence of diseases spread by mosquitoes.[20] more dedicated and focused works will be needed in this subject to isolate the direct and indirect socio-economic impact of mosquito borne disease in urban INDIA, as a large part of Indian workforce is actively engaged in MSME sector and their loss of wage affects overall family wellbeing, furthermore when the aging demographic takes fatally ill, it leaves a larger void and pushes the family towards more hardships and this can be avoided as sanitation and public health programs are now reachable, to make it more affordable at Do It Yourself segment and to self help groups.

(F) Public Private Partnership module can be initiated where a study can be promoted bringing a dual advantage of saving lives with new technologies and providing real time data for further review to be adopted across in different segments and societies. Leading associations and private companies have consented to work together with authorities willing to dedicate themselves to this initiative which will prove to be beneficial and will bring about a new integrated approach on mosquito management.

REFERENCES

1. Plant extracts as potential mosquito larvicides Anupam Ghosh , Nandita Chowdhury , Goutam Chandra PMID: PMC3401688 PMID: 22771587
2. Application with initiative to replace common insect fuel for fogging system with biodiesel Author: Nasrul Awal Amerudin, Mohd Razealy Anuar Publication: Materials Today: Proceedings Publisher: Elsevier Date: 2020
3. [afdc.energy.gov \(Biodiesel Vehicle Emissions\) https://afdc.energy.gov/vehicles/diesels/emissions#:~:text=Life%20cycle%20analysis%20completed%20by,of%20biodiesel%20from%20various%20sources](https://afdc.energy.gov/vehicles/diesels/emissions#:~:text=Life%20cycle%20analysis%20completed%20by,of%20biodiesel%20from%20various%20sources)
4. Application of Biodiesel in Fogging System with Azadirachta indica Oil as Insecticide Towards Mosquito and Larvae <https://www.scientific.net/MSF.1077.153>
5. <https://www.volza.com/p/thermal-fogging-machine/import/import-in-india/>
6. Plant extracts in controlling disease vector mosquitoes DOI: <https://doi.org/10.22271/23487941.2024.v11.i1b.747>
7. Pavela, R. Encapsulation—A convenient way to extend the persistence of the effect of eco-friendly mosquito

- larvicides. *Curr. Org. Chem.* 2016, 20, 2674–2680. [Google Scholar] [CrossRef] [Green Version]
8. Benelli, G. Plant-mediated biosynthesis of nanoparticles as an emerging tool against mosquitoes of medical and veterinary importance: A review. *Parasitol. Res.* 2016, 115, 23–34. [Google Scholar] [CrossRef] [PubMed]
 9. Ashokan, A.P.; Paulpandi, M.; Dinesh, D.; Murugan, K.; Vadivalagan, C.; Benelli, G. Toxicity on Dengue mosquito vectors through *Myristica fragrans*—synthesized zinc oxide nanorods, and their cytotoxic effects on liver cancer cells (HepG2). *J. Clust. Sci.* 2017, 28, 205–226. [Google Scholar] [CrossRef]
 10. Gomes da Rocha Voris, D.; Dos Santos Dias, L.; Alencar Lima, J.; Dos Santos Cople Lima, K.; Pereira Lima, J.B.; Dos Santos Lima, A.L. Evaluation of larvicidal, adulticidal, and anticholinesterase activities of essential oils of *Illicium verum* Hook. f., *Pimenta dioica* (L.) Merr., and *Myristica fragrans* Houtt. against Zika virus vectors. *Environ. Sci. Pollut. Res.* 2018, 25, 22541–22551. [Google Scholar] [CrossRef] [PubMed]
 11. Cheng, S.; Chang, H.; Chang, S. Bioactivity of selected plant essential oils against the yellow fever mosquito *Aedes aegypti* larvae. *Bioresour. Technol.* 2003, 89, 99–102. [Google Scholar] [CrossRef]
 12. Kiran, S.R.; Bhavani, K.; Devi, P.S.; Rao, B.R.R.; Reddy, K.J. Composition and larvicidal activity of leaves and stem essential oils of *Chloroxylon swietenia* DC against *Aedes aegypti* and *Anopheles stephensi*. *Bioresour. Technol.* 2006, 97, 2481–2484. [Google Scholar] [CrossRef]
 13. Komalamisra, N.; Trongtokit, Y.; Rongsriyam, Y.; Apiwathnasorn, C. Screening for larvicidal activity in some Thai plants against four mosquito vector species. *Southeast Asian J. Trop. Med. Public Health* 2005, 36, 1412–1422. [Google Scholar]
 14. Aziz, A.T.; Alshehri, M.A.; Panneerselvam, C.; Murugan, K.; Trivedi, S.; Mahyoub, J.A.; Hassan, M.M.; Maggi, F.; Sut, S.; Dall’Acqua, S.; et al. The desert wormwood (*Artemisia herba-alba*)—From arabian folk medicine to a source of green and effective nano-insecticides against mosquito vectors. *J. Photochem. Photobiol. B Biol.* 2018, 180, 225–234. [Google Scholar] [CrossRef]
 15. The use of plants in vector control, London School of Hygiene and Tropical Medicine Marta Maia KEMRI-Wellcome Trust Research Programme, Sarah Moore Swiss Tropical and Public Health Institute (https://www.researchgate.net/publication/281944776_The_use_of_plants_in_vector_control)
 16. <https://www.dawn.com/news/1052311> RAWALPINDI, Oct 27: The Punjab government has directed the health department to use water-based fogging machines for the anti-dengue fumigation.
 17. Nameplate capacity of biodiesel production in India from 2010 to 2023, with a forecast for 2024 <https://www.statista.com/statistics/1052762/india-nameplate-capcity-biodiesel-production/>
 18. “Application of biodiesel as carrier for insecticide emulsifiable concentrate formulation” <https://www.sciencedirect.com/science/article/abs/pii/S1876107012000284> (Chih-Ping Chin, Chi-Wei Lan, Ho-Shing Wu) <https://doi.org/10.1016/j.jtice.2012.02.003>
 19. Biodiesel as a carrier for pesticide formulations: a green chemistry approach August 2019 *International Journal of Pest Management* 66(3):1-10 DOI:10.1080/09670874.2019.1649740
 20. Economic Burden of Mosquito-Borne Diseases in Low- and Middle-Income Countries: Protocol for a Systematic Review Published on 11.12.2023 in Vol 12 (2023) Preprints (earlier versions) of this paper are available at <https://preprints.jmir.org/preprint/50985>, first published July 24, 2023.
 21. <https://link.springer.com/article/10.1007/s13530-024-00214-y> Evaluation and efficacy of plant extracts in eradicating medically important mosquitoes: a review Mini Review Published: 21 April 2024