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Effective Mechanisms to Control Mosquito Borne Diseases: A Review

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Abstract

Mosquitoes are considered as the most fatal and lethal organisms in the world causing millions of deaths annually around the world. Deaths caused by malaria alone was reached to 4,38,000 deaths in 2015. A variety of diseases are caused by mosquitoes as vectors. The important ones are Dengue Fever, Malaria, Yellow Fever, West Nile Virus, Rift Valley Fever, Chikungunya, Japanese Encephalitis and some others. In this review we comprise and acknowledge the role of WHO in relation to efforts against the alarming situations of mosquito borne diseases. The major roles of WHO to eradicate disease risks are (1) giving evidence-based direction for monitoring vectors. (2) provide technical support to countries. (3) support countries to advance their reporting systems. (4) provide training on clinical management, diagnosis and vector control. (5) support the growth and evaluation of new tools, technologies and tactics for vector borne diseases. Here, various tactics are discussed which could be helpful in the management methods against mosquito borne diseases in a very feasible, inexpensive and eco-friendly fashion. Therefore, it was evaluated that the mosquito eating fish (*Gambusia affinis* and *Poecilia reticulata*) Copepods (*Macrocyclops albidus* Jurine), larvae of Odonata species and aquatic insects, including backswimmers (*Buenoa pallipes* Fabricius) were the most-often detected predators and it was a very simplest method to limit the mosquito populations. Source reduction is a very crucial factor. Source reduction mainly concerns with prevention of development of mosquito's larvae by eliminating their breeding sites mostly including tactics such as drainage, filling, drains and drainage of irrigation courses. After recognizing primary breeding sites accountable for disease transmission, it is quick to start a selective larval control action, which has been called species sanitation. A great variety of plants species found in the World that exerts a great impact on repelling mosquitoes. Some DEET based compounds proved an average protection from mosquitoes ranges from 22.9-94.6 minutes with different active ingredients. Some plant essential oils such as thyme oil, catnip oil, amyris oil, eucalyptus oil, and cinnamon oil were checked contrary to three mosquito species: *Aedes albopictus, Ae. aegypti,* and *Culex pipiens* Pallens and give significant results and repellent efficacy. Hence, there is a need of compatibility and integration of all above discussed mechanisms to acquire good results in context to prevention and eradication of arboborne/mosquito borne diseases.

Keywords

Mosquito Borne Diseases, Mosquito Predators, Habitat Elimination, Mosquito Repellents

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1. Introduction

Mosquitoes are known as one of the fatal living organisms in the world acting as vectors (living organisms that can transmit infectious diseases between humans or from animals to humans) for different diseases. Their ability to transmit and disseminate disease to humans causes millions of deaths

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every year. Malaria alone caused 4,38,000 deaths in 2015. The global occurrence of dengue has risen 30-times in the past 30 years, and more countries are reporting their first outbreaks of the disease [37].

Apart from all the strategies and controlling measures, mosquito borne diseases are dispersing world-widely responsible for high toll of children and adolescent's mortality and morbidity globally [36]. Malaria, Yellow Fever, Dengue Fever, West Nile virus, Rift Valley Fever, Chikungunya, Japanese Encephalitis, Venezuelan Equine Encephalitis, Murray Valley Encephalitis are common names of some important diseases caused by mosquitoes [24]. Mosquito species corresponding to diseases can be described as Aedes Chikungunya Dengue fever Lymphatic filariasis Rift Valley fever. A surveillance conducted by [12] concluded that the only mosquito species seemed to be consistently infecting in the field with West Nile Virus was *Culex pipiens* species. It was also demonstrated that the key to success for survival and reproduction of *Aedes albopictus* was its behaviour and biology. Its compensating breeding habits all its dispersant through travel and international trade.

Malaria is one of the deadliest mosquitos borne disease 350 to 500 million cases annually [20]. Malaria is an infectious disease that causes fever, trigger chills and a flu-like sickness. Within an incubation period of seven days or more after acquisition of pathogen from a mosquito bite, symptoms of disease usually start to appear [35].

Among the most common diseases transmitted by mosquitoes in the U.S, the West Nile Virus is at the top and the most common symptoms described are Body/Muscle aches, Fever, Headache, Fatigue, Joint pain, Rash, Stiff neck and Paralysis [6]. It was calculated that there were 6,030 cases of West Nile virus have been observed in California from 2003 to 2016 [9].

Chikungunya fever is a sickness caused by virus and spread by infected mosquitos bite; these mosquitoes active often in the daytime. The disease is similar to dengue fever, and is characterized by severe, sometimes persistent, joint pain (arthritis), together with fever and rash [34].

Dengue fever is the deadliest disease after malaria caused by bite of infected mosquitoes. It is a viral disease caused by dengue virus with four different serotypes. Each of the above-mentioned serotypes have the ability to cause and spread dengue fever and severe dengue fever (also known as dengue haemorrhagic fever) [7].

Yellow fever is the most lethal viral infection (haemorrhagic fever) and before the discovery of any effective vaccine it was the fearer to humans. There are round about 200 000 cases of illness reported with yellow fever and approximately 30 000 deaths occurred by yellow fever over the World. From past two decades, the number of cases of yellow has increased due to decreasing population immunity to infection, deforestation, urbanization, population movements and climate change [34].

Results concluded from a surveillance study that 86% of his study subjects told that breeding site of mosquitoes is only polluted and stranded water, percentage of people who thought that malaria is transmitted by mosquitoes is 89.5%, 84.5% public told that rigor and fever are the most often symptoms of malarial infection and 65% of them used mosquito coil for prevention from mosquitoes [27].

In this study we will collect, manipulate and analyse all the obtained information related to mosquito borne diseases and make a precise and achievable conclusion to stop and prevent the life threating and fast dispersion of these lethal diseases and to save the humans of under developed countries which are suffering and combating poorly against these diseases.

2. Important Mosquito Borne Diseases

i. Aedes

a. Chikungunya

b. Dengue fever

c. Lymphatic filariasis

d. Rift Valley fever

e. Yellow fever

f. Zika

ii. Anopheles

a. Malaria

b. Lymphatic filariasis

iii. Culex

a. Japanese encephalitis

b. Lymphatic filariasis

c. West Nile fever

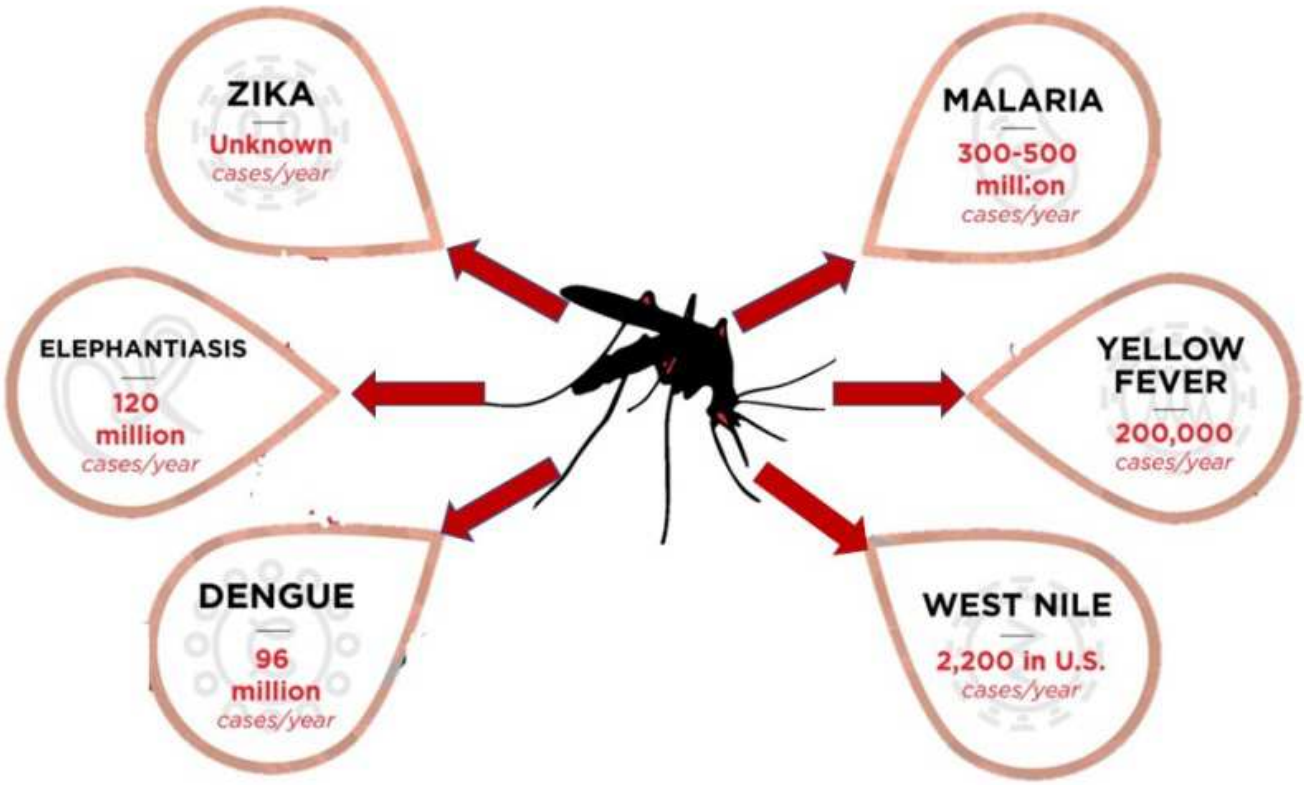

Figure 1. Number of cases around the Globe due to mosquito infection.

3. WHO Response in Context to Diseases

The Global vector control response (GVCR) 2017–2030 permitted by the World Health Assembly (2017) provides planned direction to countries and progressing associates for urgent establishment of vector control as an essential approach to prevent disease and actioning to epidemics. To achieve this, a re-building of vector control programmes is compulsory, supported by amplified technical dimensions, improved organizations, reinforced monitoring and surveillance systems, and greater community mobilization. Ultimately, this will support employment of an inclusive style to control vector that will enable the accomplishment of disease-specific national and global goals and contribute to achievement of the supportable growth goals and universal health coverage.

WHO secretariat provides premeditated, normative and technical supervision to countries and development partners for consolidation of vector control as a vital approach based on GVCR to prevent disease and actioning to outbreaks. Definitely, W.H.O. responds to vector-borne diseases by:

1. Giving evidence-based direction for monitoring vectors and defending people against infection;

2. Providing technical support to countries so that they can efficiently manage cases and outbreaks;

3. Supporting countries to advance their reporting systems and capture the true burden of the disease;

4. Providing training on clinical management, diagnosis and vector control with some of its co-operating centres throughout the world;

5. Supporting the growth and evaluation of new tools, technologies and tactics for vector borne diseases, include vector control and disease management technologies.

A critical component in vector-borne diseases is interactive change. W.H.O. works with partners to deliver education and expand awareness so that people know how to protect themselves and their groups from mosquitoes, ticks, bugs, flies and other vectors.

For many diseases such as Chagas disease, malaria, schistosomiasis and leishmaniasis, W.H.O. has started control programmes using funded or sponsored medicines. Availability to water and hygiene is a very vital factor in disease control and eradication. W.H.O works organized with many different government divisions to control these diseases.

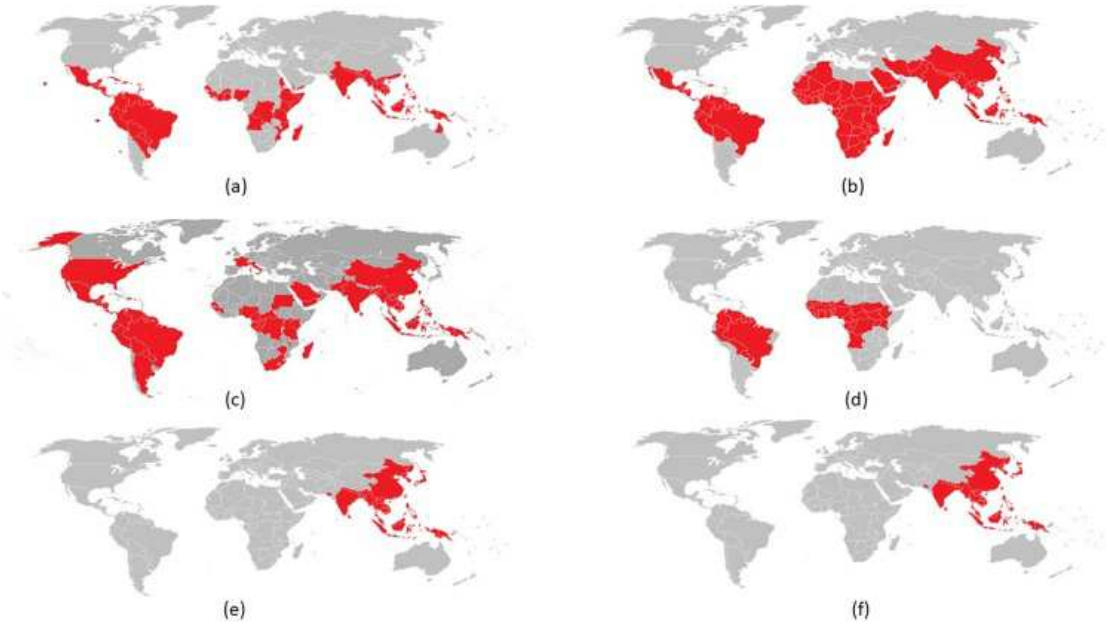

Figure 2. Risk Zones of Dengue (a), Malaria (b), Chikungunya (c), Yellow fever (d), Japanese encephalitis (e) and Zika virus (f) over the World. Photos adopted from Dept. of Health, Govt. of West. Australia with Permission.

4. Mosquitos Management Practices

4.1. Introduction of Mosquito Predators

Predation of mosquitoes by different living organisms is an important mechanism on which a great sort of literature is available. A survey is conducted on predators of immature mosquitoes on the island of Kauai, Hawaii, in taro fields, main larval mosquito habitat of *Culex quinquefasciatus* [15]. According to his observations, mosquito eating fish (*Gambusia affinis* and *Poecilia reticulata*) Copepods (*Macrocyclops albidus* Jurine), larvae of Odonata species and aquatic insects, including backswimmers (*Buenoa pallipes* Fabricius) were the most-often detected predators. However, mosquito fish and backswimmers were found with variability from different locations while copepod were observed from all locations.

Figure 3. Gambusia fish swimming among mosquito larvae.

Present situation of insecticides resistance in mosquitoes and impact of pesticides on non-target organisms have raised many questions across societies and compel scientists to evaluate the alternative mechanisms to control malarial and other mosquito borne disease vectors. Predation has been proposed as one of the vital regulation methods for malaria vectors in long-lasting aquatic habitats [19]. He also found *Anopheles gambiae* DNA in at least three out of ten midguts of all predator species examined under his experiments. A predatory fish Gambusia *affins* seemed to be an efficient predator and is three times more effective than tadpole species in selected water bodies.

A study reported that different living organisms were known to be active and efficient predators of mosquitoes. Mosquito eating fish got a very crucial status among the predators of mosquitos and other invertebrates like hydras, from insects *Muscidus scatophahgoides* and *Lispa ulginosa*, several unknown species of aquatic hemipterans, and the predaceous diving beetle *Eretes dytiscus*. The mosquito genus Megarhinus is a very vital predator complex and worldwide often discussed as a most important biological agent (currently known as *Toxorhynchites*) and includes *M. inornatus* and *M. splendens* species. Previous literature includes bats even for control of adult mosquitoes [23].

The field and semi field tests were conducted to check the efficacy and capacity of predatory fish on mosquito larvae and to test the influence of various types of chemical cues on the oviposition behaviour of female mosquitoes. Data obtained from field trails, it was observed that there were less possibilities to find out culicine larvae, where the most common floodplain fish *Tilapia guineensis* often found.

Though, the presence of any fish species was not concerned with the presence of anopheline larvae. In semi field conditions both anopheline and culicine larvae are consumed by both *T. guineensis* and *Epiplatys spilargyreius* fish within 1d. Also, it was seemed that ovipositing culicine females avoided the water areas where there were chances of presence of fish. In contrast, there is not impact on oviposition behaviour of anopheline females with the presence of fish [21].

Figure 4. A mosquitofish snacks on a mosquito larva.

Employing or announcing an auto-generating predator into the environment may offer sustained bio-control of pest populaces. Several predators of larvae of mosquito include amphibian tadpoles, dragonfly larvae, fish, mites, aquatic bugs, anostracans, malacostracans, copepods, cyclopoid and helminths. The most extensively used biological control agents of mosquito populaces are the western mosquito fish, *Gambusia affinis*, and the eastern mosquito fish, *G. holbrooki*. The impact of these fishes on faunal structure and their incapability to live in small containers, tree holes etc. which are perfect reproduction sites of important vectored mosquitoes, make them unfeasible and inefficient in regulating mosquito populations [18].

Another study concluded that predator impact on mosquito populaces sometimes rely on habitat structure and on developing effects of many predators, predominantly interference amongst predators. Predators nonfatal effects on mosquito oviposition, searching, and life history are common, and their values for populations and for mosquito-borne disease are weakly understood [16].

The best-known method to control the mosquitos and stopping of lethal diseases is the use of mosquito predators as a way to eliminate the risk of human mortality. A predator of mosquitoes likely to be unknown in research is dragon fly. Dragon fly immatures were seen to be present only in semi-permanent and alternating ponds. The results of tests recognised that dragonfly larvae were capable to eat large quantities of mosquito larvae in very short time, but development rate of mosquitoes did not look like to be significantly influenced by dragonfly larvae. Oviposition behaviour of mosquitoes was not affected significantly by the presence or absence of dragon fly larvae. These results recommend that the presence of dragon fly larvae can play a vital role in the elimination of mosquito populations [11].

Figure 5. A dragonfly waits for prey.

Another important predator Diplonychus indicus (Hemiptera: Belostomatidae) of dengue causing mosquito, Aedes aegypti (Diptera: Culicidae) attained a great attention from a study by [31]. His experiments described that when D. indicus was announced into the tyres placed in the experimental garden, an extreme reduction of 95% and 98% respectively of late instars and pupae of Ae. aegypti was detected. But the tyres placed in the control garden was not influenced. In different months of the year, early instar larvae density of Ae. aegypti varied in the tyres placed in both the gardens.

It was investigated that the baseline predation of young mosquitoes by large invertebrate predators along with Mara river to observe predator's diversity, habitats of mosquito larvae and ratio of their adaptive capability to physio-chemical parameters of water. The impact of macroinvertebrate predator presence was corelated with water quality parameters and larval densities of mosquitoes using Generalised Linear Model (GLM). Predators (n=297) from three orders of Hemiptera (54.2%), Odonata (22.9%), Coleoptera (22.9%) as mosquito larvae (n=4001) from 10 different species including An. gambiae s.l. (44.9%), Culex species (34.8%), An. coustani complex (13.8%), An. maculipalpis (3.6%), An. phaorensis (1.2%), An. funestus group (0.5%), An. azaniae (0.4%), An. hamoni (0.3%), An. christyi (0.3%), An. ardensis (0.08%), An. faini (0.07%), An. sergentii (0.05%) and 0.05% of mosquitos from Aedes Spp. which could not be recognized to specie level due to lack of a particular key. These were captured from various habitats

along Mara river. It was also concluded that attack on habitats by large invertebrate predators were carried out by the stimulation of the presence of mosquito larvae ($p<0.001$) and the predominant physio-chemical constraints (Temperature, DO, Turbidity, $p<0.001$) [8].

Toxorhynchites, a type of mosquito with intraspecies predating larvae, has paying much attention as bio-control agents. Specific types of *Toxorhynchites* mosquitoes are very helpful for the control of *Ae*. *aegypti* because they reproduce in the same types of containers. Though, it demonstrated to be ineffective in the field. Repetitive release of *Toxorhynchites* first instar larvae in drenched places among bamboo trees had no outcome on mosquito populaces in Indonesia [2-3].

4.2. Habitat Elimination

Mosquitoes elimination and management practices mostly focused on chemical involvements like residual sprayings and insecticide treated nets, and these methods are still existed in several countries. However, all these options are not considered good for living organism's health as well as for environment. A very suitable and applicable non-chemical mosquito control program using source management has been evaluated and tested in many experimental projects. Source reduction mainly concerns with prevention of development of mosquito's larvae by eliminating their breeding sites mostly including tactics such as drainage, filling, drains and drainage of irrigation courses. After recognizing primary breeding sites accountable for disease transmission, it is quick to start a selective larval control action, which has been called species sanitation. Housing circumstances might be enhanced, and water supply and sanitation services can also be taken as a main step to launch source management. Many breeding sites can be recognized along nearby banks of river, sea, or other water containing bodies for alteration and vegetation removal. Environmental management approaches might prove to be workable over the long-term allowing development of state by successfully superessing diseases. Inclusive and integrated mosquito management scheme with the use of adulticides or larvicides, source management, zoo prophylaxis, aerial space spraying and using coils, screens and repellents are mandatory. During epidemics, indoor and outdoor residual sprayings are normally applied, usually using insecticides against adults and larvae. This recommends, stimulates and announces to citizens to decrease mosquito-borne diseases through environmentally helpful approaches that demand no cost expenditure. Pest borne diseases control relies upon source management may be non-toxic, achievable and cost-effective, and determines the viability of sustainable bioenvironmental vector control [29].

The U. S. federal government had made a plan named as the federal Clean Water Act, after being amended in 1987 requested the states to imply a permanent source contamination management plan. This strict program ordered the states to construct adequate ways to get rid of polluted urban and rainwater runoffs and stormwater runoffs to avoid any misshaping and epidemics of mosquitoes. A term Best Management Practices was adopted in 1970s in the implementation of this program [26].

An explained report was presented stressing upon the community outreach program and to get familiar of public from arboborne diseases. It describes that education process must start before the onset of community health threat. It also encourages national organizations to begin and sustain credibility and community trust by giving timely, exact, and actionable data about what is known and what is not known. Increased accessibility and information of accurate data about arboviral diseases among populaces and public onset of risk and to deliver suitable action messages for each audience is very essential. Advanced information of and backing for vector control actions should be provided in communities. Increase the volume of health care stations and to share exact health info about arboviral disease prevention should be conveyed to at-risk populations (e.g., pregnant women and women of reproductive age and populations affected by Zika virus). Inspiring actions by community leaders and organizations should be done to guard at-risk populations from arboviral diseases [5].

In the Era of 19th century, it was investigated that mosquitoes were the responsible of disseminating diseases like malaria and dengue and their populations were linked with dirty water sewerage standing water. To the recent time, inadequate management plans moved the U.S citizens to destroy habitat places alongside of rivers and streams and kept struck both the animals and humans to indoors to abstain themselves from blood feeding mosquitoes. Methodologies like source reduction, predatory species and use of chemicals are very ancient. However, some advancement is added but still these are followed by old procedure introduced by Floore, 2006 [13].

It was detected from a study that mosquito put a risk to livestock and pets. Animals distressed by mosquitoes did not feed and forage well. After being bitten by mosquitoes, cows reduced the milk yield and other cattle loss their weight. So, it was very important to get rid of mosquitos and maintain the health of livestock at farm level. The basic principles found very efficient to minimise the increasing populations at farm level are to discard and avoid stagnant wastewater remains for longer than four days. Weeds should be removed around ditches, ponds and other shallow wetlands. Biological and chemical control of mosquitoes can enhance these

important preventive procedures [22].

A study conducted for three years to evaluate the mosquito populations in San Diego and Los Angeles Counties by Californian Department of Transportation. The study investigated various species of mosquitoes such as *Anopheles franciscanus, Aedes squamiger, An. hermsi, Cx. tarsalis, Culex quinquefasciatus, Cs. inornata. Cx, stigmatosoma* and *Culiseta incidens*. Different sources like stagnant water in sumps, basins and vaults were observed as the permanent sources of larval population of all species. Efforts were designed to rapid drainage mechanisms; rapid runoff flows of non-stormwater and destruction of supporting larval habitats [25].

4.3. Mosquito Repellents and Chemical Control

Mosquito repellents are mostly examined, discussed and recommended in the management programs of mosquitos instead of synthetic insecticides. There are many reasons that determines the dependency on repellents. One of the most important is the health risks of public. We know that synthetic chemicals have a strong mode of action and could cause a serious health hazards to humans and different types of abnormalities. Another problem that is highlighted from past years is the environmental degradation by synthetic pesticides which is now becoming an alarming situation for the whole Earth. So, it is very important to highlight the eco-friendlier and safer preventive measure against mosquitoes. Botanicals or plant extracts used as an insect repellent are the most appropriate options in regard to mosquito bite. Here we discuss some experimental results that describes how efficient was some plant extracts in the repulsion of mosquitoes.

According to a study it was observed that DEET-based products gave very strong protection for the lengthy period. Maximum doses of DEET provided protection lasting from minutes to hours. A formulation comprising 23.8 percent DEET provided an average complete-protection time of 301.5 minutes. An average of 94.6 minutes protection from mosquito bites was observed from a soybean oil-based repellent. An average of 22.9 minutes protection was recorded from IR3535-based repellents against mosquitos' bite. All other plant deterrents were examined provided protection for an average period of less than 20 minutes. Repellent-containing wristbands presented no protection [14].

A study demonstrated that the polymethacrylate (PMA)-stabilized silver nanoparticles were manufactured by UV irradiation, categorized by Surface Plasmon Resonance (SPR), Transmission Electron Microscopy (TEM) and Zeta Potential Measurement and assessed for their larvicidal activity to *Aedes aegypti* larvae. Over the processes of depiction and larvicidal assay, silver nanoparticles were found to be spherical and in nanoscale size (10 nm). The larvicidal action of silver nanoparticles was dependent on the concentration of nanoparticle used and seemed to rise from the infiltration of the nanoparticles into the larval body membrane. At a concentration of 5 ppm, the PMA-capped silver nanoparticles showed less than 10% survival of larvae within 3-h exposure time with targeted areas. The study recommends that the silver nanoparticles produced by UV-irradiation can be applicable in biocontrol of pests and mosquito larvae [28].

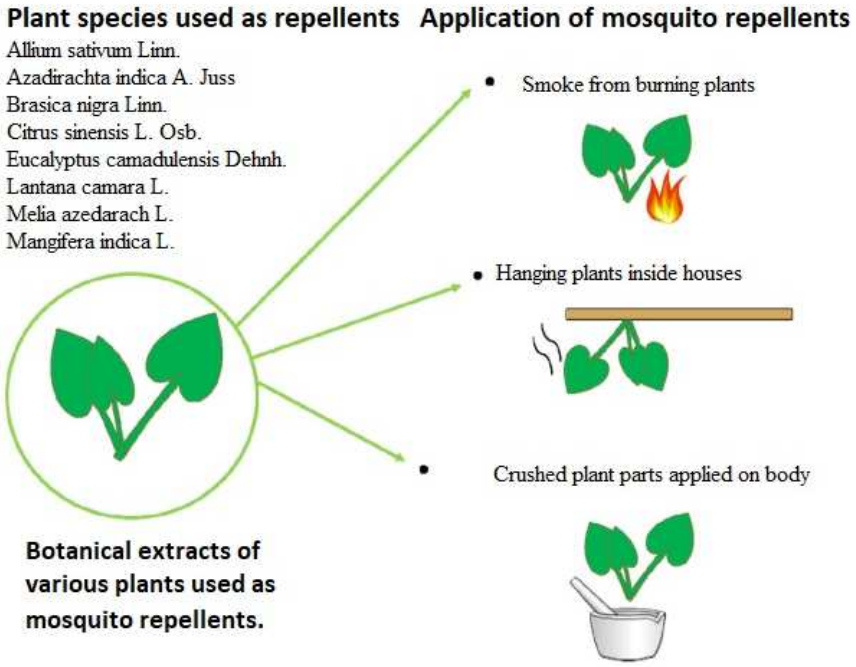

Figure 6. Different plant extracts and their application methods to repel the mosquitoes.

It was examined that the larvicidal action and repellency of five essential plant oils like as thyme oil, catnip oil, amyris oil, eucalyptus oil, and cinnamon oil were checked contrary to three mosquito species: *Aedes albopictus, Ae. aegypti,* and *Culex pipiens* Pallens. Larvicidal action of these essentials oils was assessed in the laboratory in contrast to 4th instars of each of the three-mosquito species. Amyris oil proved the greatest reduced development effect with LC50 values in 24 h of 58 µg/ml (LC90 =72 µg/ml) for Ae. aegypti, LC50=78 µg/ml (LC90 =130 µg/ml) for Ae. albopictus, and LC50=77 µg/ml (LC90 =123 µg/ml) for *Cx. pipiens* Pallens. Catnip oil appeared to be the most efficient and brought 6-h protection at duel concentrations tested (23 and 468 µg/cm2). Thyme oil had the maximum efficiency in deterring this species, but the repellency period was only 2 h. The usage of these natural essential oils and their products in mosquito control are discussed widely and frequently [38].

The bio-efficiency of *Aloe vera* plant leaf extract and insecticide characterized by bacterial activity, *Bacillus sphaericus* larvicidal action was evaluated against the 1st to 4th instar larvae of *Aedes aegypti*, under the laboratory conditions. The LC_{50} of *A. vera* contrary to the 1st to 4th instar larvae were 162.74, 201.43, 253.30 and 300.05 ppm respectively and the LC_{90} 442.98, 518.86, 563.18 and 612.96 ppm, respectively. *B. sphaericus* against the 1st to 4th instar larvae the LC_{50} values were 68.21, 79.13, 93.48, and 107.05 ppm and the LC_{90} values 149.15, 164.67, 183.84, and 201.09 ppm, respectively. Though, the collective treatment of *A. vera* + *B. sphaericus* (1:2) material presented maximum larvicidal activity of the LC_{50} values 54.80, 63.11, 74.66 and 95.10 ppm. The LC_{90} values of 145.29, 160.14, 179.74 and 209.98 ppm, against *A. aegypti* from combined experimented concentrations had clearly defined that there is a considerable amount of synergetic effect. The current examination clearly displays that both *A. vera* and *B. sphaericus* materials could represents as a probable larvicidal agent [32].

A study was conducted to examine the preparation of water dispersible Nano permethrin was explored for its larvicidal activity. The mean particle size of Nano dispersion in water was 151727 nm. The LC50 of Nano permethrin to *Culex quinquefasciatus* was 0.117 mg/L. The LC50 of bulk permethrin to *Cx. quinquefasciatus* was 0.715 mg/L. Nanopermethrin may be a good choice as a potent and selective larvicide for *Cx. Quinquefasciatus* [1].

A research was designed to explore larvicidal efficacy of three natural plant extracts such as *Aloe vera* and onion, alcohol and cloves, marigold and garlic counter to the dengue vector, *Aedes aegypti*. Onset the application of 15% of the natural extract of cloves and alcohol, all the larvae showed 100% mortality. For the onion and *Aloe vera* extract, 90% mortality was observed after 24h of bioassays when the larvae were tested with 15% extract, while 60% mortality was examined after the 24h later of the application with 15% of marigold and garlic extracts, respectively. The maximum mortality recorded after applying 15ml alcohol-clove extract was detected to be 100% [33].

Neem seeds comprise above 200 bioactive chemicals, even if consideration has been particularly fixated on limonoids (chemically known as nor triterpenes, e.g. nimbin, azadirachtins, nimbidin and nimbolides). Formulations originating from neem seeds exhibited fecundity suppression, antifeedancy, larvicidal activity and ovicidal, growth regulation and repellence against a variety of arthropods, and it is active also at very small doses [4].

Table 1. Different types of chemicals/Repellents used for certain species of mosquitoes and their result.

Chemical/Repellent	Results	Mosquito species	References
Soybean oil-based repellent + IR3535-based repellents	Mean 94.6 minutes bite protection + Mean 22.9 minutes bite protection	All biting species	Fradin, et al. (2002)
PMA-capped silver nanoparticles	10% survival of larvae within 3-h exposure time	*Aedes aegypti*	(Sap-Iam et al. 2010).
Thyme oil, Catnip oil, Amyris oil, Eucalyptus oil, and Cinnamon oil	Amyris oil (LC90 =72 µg/ml) for *Ae. aegypti,* (LC90 =130 µg/ml) for *Ae. albopictus*, and (LC90 =123 µg/ml) for *Cx. pipiens* Pallens in 24h. Thyme oil repellency period was only 2 h	*Aedes albopictus, Ae. aegypti, Culex pipiens* Pallens.	Zhu and Zeng (2006)
Aloe vera plant leaf extract	The LC_{90} of *Aloe vera* was 42.98, 518.86, 563.18 and 612.96 ppm.	1^{st} to 4_{th} instar	
Bacterial insecticide (*Bacillus sphaericus*)	LC_{90} of *Bacillus sphaericus* was 149.15, 164.67, 183.84, and 201.09 ppm. LC_{90} of combined treatment was 145.29, 160.14, 179.74 and 209.98 ppm.	larvae of *Aedes aegypti*	(Subramaniam, 2012)
Water dispersible Nano Permethrin	LC50 of Nano permethrin to *Cx. quinquefasciatus* was 0.117 mg/L. LC50 of bulk permethrin to *Cx. quinquefasciatus* was 0.715 mg/L.	*Culex quinquefasciatus*	(Anjali et al. 2010)
Aloe vera and Onion	15% extract showed 90% mortality.		
Alcohol and Cloves	15% extract showed 100% mortality.	*Aedes aegypti*	(Susheela, et al. 2016)
Marigold and Garlic	15% extract showed 60% mortality.		

5. Conclusions

Utilization of all control measures to protect mosquito infections and their synergetic effect can cause a huge impact on socio-economic health of human beings living particularly in Africa and some other poor and developing countries. Source reduction and elimination of habitat is the best option/ strategy to retard the mosquitoes as the only possible way for

mosquitoes to breed and propagate is the stagnant water. Removing of water either it is fresh or sewage is the surety of absence of mosquitoes at these places. The areas with heavy rainfall could bear some difficulties in this regard but due to efficient management, the problem can be solved. Introduction of predator species is an important step to minimize the populations of mosquitoes. Although the compatibility and predator-prey relationships are very crucial element but mosquito populations can be limited to a certain extent on following this parameter. Usage of plant extracts to repel the mosquitos is a very ancient and cheap way from a long time ago and are still be used in African and old-World countries. Various types of chemicals present in plants exhibits a special response to keep away mosquitos from the surface on which they have applied. An integration fashion of all these management tactics will elicit a great response in context to a feasible solution of mosquito infections. Besides this, some modern technologies like invention of UV traps is a superb outcome of science and is a cheap, feasible, eco-friendly and permanent answer to the arisen questions about devastating effects of mosquitos. In future, there is a great possibility to explore the simplest and environmentally safe methods to escape from the danger of mosquito borne diseases.

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Conflict of Interest

All the authors do not have any possible conflicts of interest.

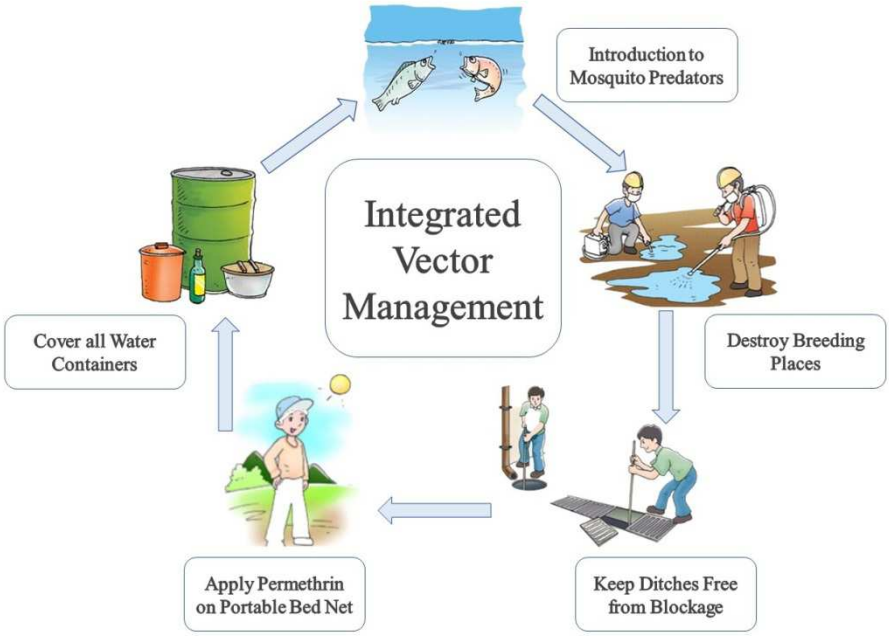

Figure 7. Integrated manner management tactics in context to overcome the exploding risk of mosquito borne diseases cases around the Globe.

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