American Journal of Clinical Neurology and Neurosurgery
Vol. 1, No. 2, 2015, pp. 126-132
http://www.aiscience.org/journal/ajcnn

Intervention Focused on Habitat Modifications for Ending up the Anopheles Mosquitoes Implicating in Malaria Transmission

Muhammad Sarwar*

Nuclear Institute for Agriculture & Biology (NIAB), Faisalabad, Punjab, Pakistan

Abstract

Nowadays, mosquito-borne diseases are among the world's leading causes of illness and death to pose significant human risks in certain parts of the population. Malaria is one of the major global health problems and has a devastating impact on many populations and particularly prevalent in voluminous parts of the world. Malaria transmitting mosquitoes mainly *Anopheles stephensi*, *A. gambia* or *A. equadrimaculatus* that tend to bite at night prefer to breed in permanent bodies of water, such as swamps, ponds, lakes and ditches that do not usually dry up. This article outlines the components of an integrated mosquito control program with emphasis on incorporating of habitat modifications into existing platform. In fact, Anopheles mosquitoes thrive in moist areas and these need damp source to flourish and breed. Their eggs are laid and hatch in or at the edge of standing or slow moving water and the larvae then live in the water until emerging as adults. Even a small amount of water left in a bucket, toy, bath, planter, or created by pooling water from a leaky channel, can provide breeding ground for hundreds of mosquitoes. Owing to this, reducing moisture around the home and neighborhood can help to keep mosquito populations down. The public's role in eliminating potential breeding habitats for mosquitoes such as getting rid of any standing water around the home is a critical step in reducing the risk of mosquito borne malaria transmission. While the patterns are quite variable for breeding of this species, other factors such as vegetation category, warrants further consideration. Recent studies have suggested that vegetation type is related to the pattern of flooding and local topography, so, similar factors may have a strong influence on the faunal composition of saltmarshes that influence mosquitoes where species forage. This could have implications for ecological control of malaria transmitting mosquitos. Simply, a habitat management approach should be the core strategy with judicious use of biorational control agents as necessary during the development phase of the environmental modification process and perhaps thereafter. For managing vectors by an integrated mosquito management (IMM) strategy, the goal is to maintain tolerable levels of mosquito populations using sound environmental practices. This goal is achieved by education, mosquito surveillance, source reduction, habitat modification, biological control methods, and treating mosquito-breeding areas with publically healthier pesticides.

Keywords

Source Reduction, Mosquito Control, Entomological Monitoring, Malaria Vector

Received: July 31, 2015 / Accepted: August 23, 2015 / Published online: September 10, 2015

1. Introduction

Some species of mosquitoes are involved in the transmission of important human diseases, for instance, encephalitis, malaria, yellow fever, dengue and filariasis are transmitted to men and animals in various regions of the world through the bite of the vector species. Some peoples exhibit an allergic reaction to mosquito bites and the secondary infections can result from scratching of vector's bite even when no disease agent is transmitted. Malaria is an infectious parasitic disease

* Corresponding author
E-mail address: drmsarwar64@yahoo.com

which has been a deadly human acquaintance for centuries. As human populations migrate from one area into another locality or across the ocean, malaria parasites move with their human hosts, as a result, malaria became a worldwide disease (Sarwar, 2014 a; 2014 b; 2014 c; 2014 d).

Mosquitoes thrive in moist areas, and in fact need wet conditions for them to thrive and breed. Their eggs are laid and hatch in or at the edge of standing or slow moving waters. Some of the most common sources of standing water include puddling from watering and irrigation areas periodically inundated from stream runoff and snow melt. The larvae then live in the water until emerging as adults and even a small amount of water left in a bucket, sandbox toy, bird bath, planter, or created by pooling water from a leaky hose, can provide breeding ground for hundreds of mosquitoes. It is because of this, reducing moisture around the homes and neighborhood can help to keep mosquito populations down (Sarwar, 2015 a; 2015 b; 2015 c; 2015 d; 2045 e). An essential key in reducing mosquitoes in and around habitat is eliminating the source of infestation and this article tells how to do this.

2. Parasites and Vectors of Malaria

Malaria is an extremely multifarious disease caused principally by four parasites of genus Plasmodium (*P. falciparum, P. vivax, P. malariae* and *P. ovale*), and are vectored by a large number of anopheline mosquito species. All parasites produce fevers and anemia to pose severe risks for human health. Two of these are by far the most important i.e., *P. falciparum* and *P. vivax,* wherein the later malaria Plasmodium produces temporary debilitation during the course of morning and in the aftermath of the fever. Malaria infections are a consequence of an intricate series of ecological interactions between malaria parasites, mosquitoes and humans. The infection of the human host with a Plasmodium parasite begins with the bite of an infected Anopheles mosquito. Malaria-transmitting Anopheles mosquitoes is found in swampy or marsh areas, and can be found during the daytime resting in both natural and artificial shelters usually houses, barns, sheds, privies, bridges, culverts, hollow trees, overhanging cliffs and foliage. Adult females require blood meals for egg production. Sporozoites are transmitted via the saliva of a feeding mosquito, these rapidly access the human blood stream and enter the host's liver. After cellular division merozoites generate and invade the blood. Repeated cycles of multiplication take place in red blood cells, destroying invaded cells and infecting others. Periodic blood cell invasion and bursting every two or three days produce the classic human malaria symptoms of recurrent fevers and chills (Webb, 2009; Laumann, 2010).

3. Management Strategies

Mosquito control continues to be an important program in public health because human activities can greatly affect the ecology of mosquito populations. Mosquito control is undergoing major changes and instead of just routinely spraying weekly, mosquito control personnel are now trying to get the most control with the least amount of pesticides. This involves source reduction to eliminate mosquito breeding areas; therefore, it is very important for mosquito control personnel to know exactly what species of mosquito is found within their area in order to develop an effective control strategy. Historically, environmental management effectively reduced malaria, and models suggest that dramatic reductions in malaria transmission are possible with environmental management (Killeen et al., 2004). Source reduction, also known as physical or permanent control, typically is one part of an integrated mosquito control program. The construction of man-made lakes and the use of irrigation agriculture have increased the numbers of many mosquitoes such as malaria mosquitoes (Anopheles). Malaria mosquitoes (Anopheles) usually prefer permanent bodies of water, such as moist or wetland areas, thus requiring different control tactics (Attaran et al., 2006; Thang et al., 2009).

Traditional methods of managing salt marsh mosquitoes focus primarily on maximizing the reduction of mosquito populations, with minimizing environmental impact as a secondary consideration. An environment oriented approach to salt marsh management for mosquito control, runnelling, is described and compared with other forms of habitat modification such as ditching and open marsh water management. Runnelling alters the salt marsh as little as possible while causing significant reductions in mosquito numbers. The effect of runnelling on the environment is monitored via the following variables, water table level, substrate characteristics (moisture, salinity and pH), vegetation (height and density of each *Sporobolus virginicus*) and the numbers of mosquito larvae. Runnelling has a statistically significant effect on only two of the seven variables. These are the heights of Sporobolus, which increase near runnels and the number of mosquito larvae, which decrease. The main difference between ditching, open marsh and runnelling lies in the magnitude of the habitat modification. Ditching involves the greatest alteration to the marsh and runnelling the least. Consequently, runnelling has a smaller effect on the estuarine environment as a whole than does either ditching or open marsh water management (Hulsman et al., 1989).

There are various options available to reduce mosquito populations in saline wetlands, and habitats can be eliminated by draining or filling, modified with water management, or treated with a control agent to kill the mosquito larvae. The choice is usually determined by a consideration of the target mosquito species, the nature of the habitat, operational factors, and various external environmental and political imperatives. Proposals for the complete elimination (through draining or filling) of major saline habitats are usually both desirable and tenable. Modification through impoundment is unlikely to be suitable for many areas as it can have undesirable environmental impacts, but modification to manage water movement, through what is called open marsh water management or the use of shallow ditches (runnels), with or without the accompaniment of larvicides, can be an acceptable, practical and effective approach. Mosquito control in saline wetlands (mangroves and saltmarshes) can be complex and is usually beyond the capacity of an individual. Notwithstanding the difficulties associated with persuading the various levels of government to undertake mosquito management in these sensitive habitats, the general principles for mosquito control in mangrove and saltmarsh areas can be listed as tidal flushing within stands of mangroves should be maintained so that stagnant impounded water does not provide mosquito habitat. Natural dewatering of the surface of the saltmarsh should be maintained so that water does not persist in depressions filled by the highest monthly tides. Structural management (channeling or runnelling) of water flow through the mangroves and onto and off the marsh, providing for natural flushing and dewatering, and access for predators, can be effective in reducing mosquito populations and can be environmentally acceptable. Use of biorational control agents, such as bacterial products and growth regulators, to reduce mosquito populations can be effective and environmentally acceptable. However, the issue of mosquito production from saline wetlands must be considered on a case by case basis. Expert advice on the relative nuisance values and health risks, and the acceptable and effective options appropriate for particular sites should be sought from relevant experts (Barat, 2006).

4. Guidelines on Habitat Modifications

Extensive ago, prior to the invention of synthetic insecticides and their introduction as adulticide, anti-larval, preventive measures have been the only method for control of mosquito borne diseases and as well as mosquito reduction. Anti-larval measures are broadly categorized into source reduction and environmental manipulation.

4.1. Source Reduction

Anti-larval operations causing the reduction or permanent elimination of mosquito breeding places or sites are demarcated as source reduction methods. Source reduction primarily aims to prevent development of aquatic stages of mosquito larvae reducing breeding source. These methods are economical, environment friendly in the long term with minimum maintenance and surveillance efforts. Source reduction measures undertaken would not only solve the problem of malaria and other vector borne diseases in an area, but also would bring socio-economic and financial benefits, and general wellbeing of communities and overall environmental up-gradation. Source reduction methods are further classified into elimination or reduction of breeding sites primarily involving engineering methods (Kitron, 1989; Killeen et al., 2004: Yohannes et al., 2005) as cited underneath.

4.1.1. Filling

Filling can be on minor scale for elimination of burrow pits, ditches, small unused irrigation canals, unused and abandoned wells, in and around human habitations or villages for prevention of mosquitogenic habitats. These activities require minimum or no engineering skill and can be under taken by field workers employed for routing activities. Filling operations should be undertaken only for evaluation of malaria endemicity, prevailing vector mosquitoes and their breeding behavior. Garbage sometime may be used to advantage into a place that require filling provided adequate measure are taken by keeping in view hygiene, flies nuisance and offensive smell, and compost can be made from garbage.

Sanitary land fill method is also recommended for land reclamation. This is achieved by dumping a layer of refuse/ garbage in a selected area followed by earth cover daily after compaction. Land thus reclaimed can be used for recreational park, playing ground and storage. Natural fills in an area with high rainfall for a considerable period during monsoon months, run off streams, carrying very high sediments with suitable engineering methods, sediments is trapped and allowed to settle. This sedimentation can be used as natural filling material to permanent elimination of intermittently flooded areas or swaps. This source reduction method requires geographical reconnaissance, vector prevalence, feeding behavior of vector mosquitoes in relation to malaria endemicity and seasonal malaria transmission.

4.1.2. Drainage

Drainage is used in eliminating breeding sites by draining away the water collections or reducing vector breeding by channeling water to a few places which can be easily controlled. Construction of surface ditches, sub-surface drains, vertical drains, pumps and tide gates are some of the methods used in drainage. Type of ditch or drain, best suited for a particular situation, will depend upon topography, source of water and soil properties, further, the availability of funds for the works will be an important factor.

4.1.3. Drains

Drainage can be of three following types:-

1. *Surface Ditches:* Ditching is the most widely used method of drainage in source reduction programs. The cost of construction is modest and benefits are considerable. Proper choice of side slopes and grades can reduce maintenance. However, regular maintenance is necessary to ensure adequate flow capacity. This also includes channel improvements, so that mosquito breeding pockets will not be created.
2. *Sub-Surface Drains:* A well designed sub-soil drainage requires a minimum of maintenance and can function satisfactorily for many years. For small installations, either concrete or clay pipes may be used. But for large installations concrete pipes are commonly used. This method has the advantage of converting water logged areas into suitable land for framing or other purposes.
3. *Vertical Drains:* When water is held on the surface by an impervious stratum which is known to overlie one that is previous, it may be economical and effective to utilize vertical drainage which is simply boring a hole through the impervious layer so that the water will drop to pervious layer and be taken off. When installing vertical drainage, local sanitary authorities must be consulted, regarding the danger of contaminating subsurface water supplying wells from which the drinking water may be drawn.

4.1.4. Drainage in Irrigation Schemes

Drainage in irrigation schemes can be further classified into ensuing lines:

1. Drainage in Irrigation Schemes: Source reduction measures required in irrigated areas are water management. This may be diversion of water, effective distribution system, drainage of excess water, or regulation in such a way that a dry day is kept in a week's irrigation. Such control or water has to be from the head gates to the field turn out.
2. Coastal Drainage: Drainage of coastal swamps and lagoons requires care in design and construction of sea outlets.
3. Drainage by Tide Gates: The gates are used for drainage of salt marshes along the sea. The gates are opened at low tide to allow water to flow out and closed at high tide to prevent sea water from flowing in. The construction of the gates is a specialized job and should include construction of ditches and dykes to control tidal waters.
4. Drainage by Pumps: When water accumulates in low lying areas and cannot be drained, it may be pumped out by installation of temporary diesel or electric pumps.

It is important that in all water development projects, in the towns under the urban malaria scheme, measures should be undertaken to reduce or prevent the creation of mosquito breeding sites and for this the Biologist or Anti-Malaria Officer should be associated at the planning and at execution levels. All the governments of various states and ministry of health are responsible to advise their territories to constitute committees for carrying out survey of the mosquito breeding sources and prepare a blue print for their elimination by minor engineering works. The local bodies of the states should give the required importance to the committees and make provision in their budgets for implementation of the recommendations of the committees.

4.2. Environmental Manipulation

Environmental manipulations are activities that reduce larval breeding sites through temporary changes. Under this heading the measures are included by which changes are effected in the natural conditions under which mosquitoes exist, rendering them unfavorable to the life and activities of these insects either in their aquatic or adult stages. These measures are conveniently classed as chemical, physical or biological measures. The examples are pollution of water, changing the salt content of water, silting, flooding, fluctuating water levels, agitating of the water surface, mudding, shading and other measures (Utzinger et al., 2001; Ghosh et al., 2006; Castro et al., 2009).

4.2.1. Prevention of Egg Laying

Egg laying in suitable breeding habitats preferred by different disease vector mosquitoes, is the first step in the life cycle of mosquitoes. Prevention of clean water collections or removal or elimination of clean water collections is the environment friendly cost effective and easy to implement option. Throwing of disposable or used tea cups, glasses, buckets, tyres ad utensils is a very common habit of the community particularly in residential settlements, irrespective of slums or organized localities. During monsoon and post monsoon months these small thrown away containers become enormous potential breeding sources for both Anopheles and Aedes vector mosquitoes. Open tanks, overhead and underground tanks, and unused wells in urban, peri-urban or semi-urban locality are also potential breeding sources for vectors of malaria or other diseases. Storage of potable water has been a common practice both in urban and rural areas. Shortage of potable water to slums dwellers, forces to store water in containers and construction sites are with high breeding potentials. Laborers engaged in construction activities are often from malaria endemic areas harbouring malaria parasites. High breeding potentials in construction sites with asymptomatic carriers of malaria parasites can cause severe malaria outbreaks in Municipal Corporation and elsewhere.

Concrete roof and terrace without proper drainage may lead to water collections; during monsoon months forming vector's breeding sites. The above described breeding sources in urban, semi or peri urban, in and around human settlements in villages, should be taken into surveillance for comprehensive source reduction involving communities, residential welfare associations, various religious groups or organizations, schools, hospitals, panchayats, office buildings, local public works departments, railways and municipal bodies and corporations.

4.2.2. Practices of Environmental Manipulation

The subsequent steps are suggested for implementation of source reduction methods, necessarily; never throw any containers in open surroundings capable of holding water for more than a week. The lids of overhead tanks must be checked and maintained on monthly basis. Any leakage should be repaired immediately and cover-up of underground and open tanks, and open tanks used for animals should be dead dried once in week. The construction sites require special attention. Building bye-laws must be implemented to prevent fault in designs, water flow on roof, and gully types open tanks for curing should be treated with larvicides on weekly basis. The unused wells either be closed or treated with larvicides, while, wells in use may be covered with mosquito proof nets and village panchayats be involved. The ornamental tanks and fountains should be checked periodically and larvivorous fish be introduced.

The public health engineers should be involved for proper drainage, building designs, periodic flushing of water logged areas and drainage. In urban, semi urban or peri-urban localities and slums, Culex mosquito breeds in high density and in urban situation it is highly anothropophagic. Also Armigeres in urban situation bites throughout day and night in high biting density. Both these mosquitoes are highly irritating and breed in high density mainly in drains and septic tanks with organic pollution. The municipal Corporations or local community bodies should take up this challenge with public health engineers for permanent solutions of breeding problem. Weekly cleaning of drains, netting of vents of septic tanks and larvicidal treatment may be considered (Sarwar, 2015 f; 2015 g; 2015 h; 2015 i; 2015 j).

5. Integrated Vector Control

Mosquito control activities are important to the public health, and responsibility for carrying out these programs rests with state and local governments. Integrated vector management (IVM) approach to controlling mosquitoes within the boundaries is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. The IVM program uses several techniques to maximize their mosquito control efforts, current comprehensive information on the life cycles of pests and their interaction with the environment. These also include physical control, public information, biological control, and chemical control, remove standing water, and carefully timed, strategically placed insecticides aimed at the adult mosquitoes. The federal government might assist to states in emergencies and provide training and consultation in vector and vector-borne disease problems when requested by the states. The current interests in ecology and environmental impact of mosquito control measures, and the increasing problems that have resulted from insecticide resistance, emphasize the need for integrated control programs. Experts encourage maximum adherence to integrated vector management (IVM) that is an ecologically based strategy which relies heavily on natural mortality factors and seeks out control tactics that are compatible with or disrupt these factors as little as possible. The IVM uses pesticides, but only after systematic monitoring of pest populations indicates a need. Ideally, an IVM program considers all available control actions, including no action, and evaluates the interaction among various control practices, cultural practices, weather and habitat structure. This approach thus uses a combination of resource management techniques to control mosquito populations with decisions based on surveillance. Fish and game specialists and natural resources biologists should be involved in planning control measures whenever delicate ecosystems is impacted by mosquito control practices (Goddard, 2003; Castro et al., 2004; Van den Berg, 2007; Van den Berg and Takken, 2008; Sarwar, 2015 k; 2015 l).

6. Conclusion

Mosquito borne diseases are one of the major public health problems in every developing country. The planned source reduction program developed is highly effective in mosquito control especially in the control of Anopheles mosquito. There is an intimate ecological relationship between humans and mosquitoes. By inadequately managing land and water resources, and failing to solve the problems of liquid waste management, larger and more productive habitats for mosquitoes can continue to grow and to cause disease and intolerable annoyance. In the present study, it has been established an efficient sampling protocol for tackling common malaria vectors and care should be taken to include some knowledge on the foraging behaviour of target species to maximize sampling probability. Also, the protocol requires specific definition before meaningful recommendations on the potential and perceived impacts of habitat modification for mosquito control. The community should watch mosquito-breeding areas and conduct routine surveillance, treat areas of concern for mosquitoes that can carry diseases, and coordinate surveillance and control efforts with other local governmental agencies. Mosquito and vector controls utilize an integrated distributes of mosquito fish (*Gambusia affinis*) to the county residents for use in their ornamental ponds, water troughs and other potential breeding areas. The public is also encouraged to make sure that window screens and screen doors are in good repair. When venturing into areas with high mosquito populations, the public should wear personal protection such as long sleeve shirts and long pants, preferably treated with a repellent. Peoples should use mosquito repellents when necessary and always follow label instructions. Environmental mosquito control program also includes provision of education in the community, identifies mosquito-breeding areas and conducts routine surveillance, treats areas of concern for mosquitoes that can carry diseases, and coordinates surveillance and control efforts with other local governmental agencies.

References

[1] Attaran, A., Barnes, K. I., Bate, R., Binka, F., D'Alessandro, U., Fanello, C. I., Garrett, L., Mutabingwa, T. K., Roberts, D., Sibley, C. H., Talisuna, A., Van Geertruyden, J. P., Watkins, W. M. 2006. The World Bank: False financial and statistical accounts and medical malpractice in malaria treatment. Lancet, 368 (9531): 247-252.

[2] Barat, L. M. 2006. Four Malaria success stories: How Malaria burden was successfully reduced in Brazil, Eritrea, India and Vietnam. The American Journal of Tropical and Medicinal Hygiene, 74 (1): 12-16.

[3] Castro, M. C., Grala, K. and Wallis, R. C. 2004. Integrated urban malaria control: A case study in Dar es Salaam, Tanzania. The American Journal of Tropical and Medicinal Hygiene, 71 (2): 103-117.

[4] Castro, M. C., Atsuko, T., Shogo, K., Khadija, K. and Sixbert, M. 2009. Community-based environmental management for malaria control: Evidence from a small scale intervention in Dar es Salaam, Tanzania, Malaria Journal, 8 (57).

[5] Ghosh, K., Rajan, R. P., Satyanarayan, T. and Aditya, P. D. 2006. A community-based health education programme for bio-environmental control of malaria through folk theatre (Kalajatha) in rural India. Malaria Journal, 5 (123).

[6] Goddard, J. 2003. Setting Up a Mosquito Control Program. Medical Entomologist Bureau of General Environmental Services Mississippi State Department of Health P. O. Box 1700, Jackson, Mississippi. 42 p.

[7] Hulsman, K., Dale, P. E. R. and Kay, B. H. 1989. The runnelling method of habitat modification: An environment focussed tool for salt-marsh management. Journal of the American Mosquito Control Association, 5: 226-234.

[8] Killeen, G. F., Aklilu, S. B. and Knols, G. J. 2004. Rationalizing historical successes of malaria control in Africa in terms of mosquito resource availability management. The American Journal of Tropical and Medicinal Hygiene, 71: 87-93.

[9] Kitron, A. S. 1989. Suppression of Transmission of Malaria through source reduction: Antianopheline Measures Applied in Israel, the United States and Italy. Reviews of Infectious Diseases, 11 (3): 391-406.

[10] Laumann, V. 2010. Environmental strategies to replace DDT and control malaria. 2nd extended edition, Editor: Weber, C., Pestizid Aktions-Netzwerk (PAN), Nernstweg 32, Hamburg. 40 p.

[11] Sarwar, M. 2014 a. Dengue Fever as a Continuing Threat in Tropical and Subtropical Regions around the World and Strategy for Its Control and Prevention. Journal of Pharmacology and Toxicological Studies, 2 (2): 1-6.

[12] Sarwar, M. 2014 b. Proposing Solutions for the Control of Dengue Fever Virus Carrying Mosquitoes (Diptera: Culicidae) *Aedes aegypti* (Linnaeus) and *Aedes albopictus* (Skuse). Journal of Pharmacology and Toxicological Studies, 2 (1): 1-6.

[13] Sarwar, M. 2014 c. Proposals for the Control of Principal Dengue Fever Virus Transmitter *Aedes aegypti* (Linnaeus) Mosquito (Diptera: Culicidae). Journal of Ecology and Environmental Sciences, 2 (2): 24-28.

[14] Sarwar, M. 2014 d. Defeating Malaria with Preventative Treatment of Disease and Deterrent Measures against Anopheline Vectors (Diptera: Culicidae). Journal of Pharmacology and Toxicological Studies, 2 (4): 1-6.

[15] Sarwar, M. 2015 a. Controlling Dengue Spreading Aedes Mosquitoes (Diptera: Culicidae) Using Ecological Services by Frogs, Toads and Tadpoles (Anura) as Predators. American Journal of Clinical Neurology and Neurosurgery, 1 (1): 18-24.

[16] Sarwar, M. 2015 b. Elimination of Dengue by Control of Aedes Vector Mosquitoes (Diptera: Culicidae) Utilizing Copepods (Copepoda: Cyclopidae). International Journal of Bioinformatics and Biomedical Engineering, 1 (1): 53-58.

[17] Sarwar, M. 2015 c. Reducing Dengue Fever through Biological Control of Disease Carrier Aedes Mosquitoes (Diptera: Culicidae). International Journal of Preventive Medicine Research, 1 (3): 161-166.

[18] Sarwar, M. 2015 d. Control of Dengue Carrier Aedes Mosquitoes (Diptera: Culicidae) Larvae by Larvivorous Fishes and Putting It into Practice Within Water Bodies. International Journal of Preventive Medicine Research, 1 (4): 232-237.

[19] Sarwar, M. 2015 e. Role of Secondary Dengue Vector Mosquito *Aedes albopictus* Skuse (Diptera: Culicidae) for Dengue Virus Transmission and Its Coping. International Journal of Animal Biology, 1 (5): 219-224.

[20] Sarwar, M. 2015 f. Commonly Available Commercial Insecticide Formulations and Their Applications in the Field. International Journal of Materials Chemistry and Physics, 1 (2): 116-123.

[21] Sarwar, M. 2015 g. The Killer Chemicals as Controller of Agriculture Insect Pests: The Conventional Insecticides. International Journal of Chemical and Biomolecular Science, 1 (3): 141-147.

[22] Sarwar, M. 2015 h. The Killer Chemicals for Control of Agriculture Insect Pests: The Botanical Insecticides. International Journal of Chemical and Biomolecular Science, 1 (3): 123-128.

[23] Sarwar, M. 2015 i. The Dangers of Pesticides Associated with Public Health and Preventing of the Risks. International Journal of Bioinformatics and Biomedical Engineering, 1 (2): 130-136.

[24] Sarwar, M. 2015 j. Usage of Biorational Pesticides with Novel Modes of Action, Mechanism and Application in Crop Protection. International Journal of Materials Chemistry and Physics, 1 (2): 156-162.

[25] Sarwar, M. 2015 k. Source Reduction Practices for Mosquitoes (Diptera) Management to Prevent Dengue, Malaria and Other Arboborne Diseases. American Journal of Clinical Neurology and Neurosurgery, 1 (2): 110-116.

[26] Sarwar, M. 2015 l. Stopping Breeding of Dengue Virus Spreader Aedes Mosquitoes (Diptera: Culicidae) with Environmental Modifications. International Journal of Bioinformatics and Biomedical Engineering, 1 (2): 169-174.

[27] Thang, N. D., Annette, E., Le, X. H., Le, K. T., Nguyen, X. X., Nguyen, N. T., Pham, V. K., Marc, C., Nico, S. and Umberto, D. A. 2009. Rapid decrease of malaria morbidity following the introduction of community-based monitoring in a rural area of central Vietnam. Malaria Journal, 8: 3.

[28] Utzinger, J., Yesim, T. and Burton, H. S. 2001. Efficacy and cost-effectiveness of environmental management for malaria control. Tropical Medicine and International Health, 6 (9): 677-687.

[29] Van den Berg, H. 2007. Reducing vector-borne disease by empowering farmers in integrated vector management. Bulletin of the WHO, 85 (7): 501-568.

[30] Van den Berg, H. and Takken, W. 2008. Evaluation of integrated vector management. Trends in Parasitology, 25 (2): 71-76.

[31] Webb, J. L. A. 2009. A global history of malaria. Cambridge University Press, New York, USA.

[32] Yohannes, M., Mituku, H., Tedros, A. G., Karen, H. W., Asefaw, G., Peter, B. and Steve, W. L. 2005. Can source reduction of mosquito larval habitat reduce malaria transmission in Tigray, Ethiopida? Tropical Medicine and International Health, 10 (12): 1274-1285.