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# DENGUE MANAGEMENT THROUGH MOSQUITO CONTROL: ASPHYXIATION TECHNIQUES AND HOMEMADE REPELLENTS FOR SKIN PROTECTION

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## ABSTRACT

Mosquito-borne diseases pose significant health challenges globally, particularly in regions such as Bangladesh where chikungunya and dengue have been prevalent in recent years. These diseases are transmitted through the bites of infected mosquitoes, which breed in stagnant water. Common mosquito-borne diseases include chikungunya, dengue, malaria, and Zika virus, among others. Efforts to control mosquito populations have included the destruction of breeding sites, the application of larvicides, and more recently, the use of *Bacillus thuringiensis israelensis* (BTI) in Dhaka. While these measures have helped manage chikungunya, dengue remains a persistent issue despite ongoing control efforts. This paper explores innovative mosquito control strategies, focusing on asphyxiation techniques to reduce mosquito populations and the use of homemade repellents for personal protection against mosquito bites. The effectiveness of these methods in the context of dengue management is critically examined.

**Keywords:** *Aedes* spp., Bangladesh, dengue, management

## Introduction

Mosquitoes are vectors of numerous diseases, including chikungunya, Eastern and Western equine encephalitis, Japanese encephalitis, La Crosse encephalitis, malaria, St. Louis encephalitis, yellow fever, and Zika virus (WHO 2023). In Bangladesh, chikungunya and dengue have been particularly prevalent in recent years. Various mosquito control activities have been implemented in Dhaka to manage these diseases, with varying degrees of success. This paper discusses these activities, evaluates their effectiveness, and explores additional strategies for mosquito control and personal protection against mosquito bites.

## Mosquito control activities in Dhaka, Bangladesh

**Larvicide application:** Larvicides have been sprayed over drains and various water bodies to target mosquito larvae. This approach relies on the contact action and ingestion of the larvicide by larvae (Rahman *et al*. 2022).

**Destruction of breeding sites:** Monitoring and destruction of breeding sites such as flower pots, coconut shells, tires, drains, stagnant water in under-construction buildings, garages, and junk vehicles have been conducted. This reduces the potential for mosquito population growth (Khan *et al*. 2021).

**Fogging with pesticides:** Pesticides are sprayed using fogger machines in the afternoon to kill adult mosquitoes, including those flying. However, there are concerns about the efficacy of this method as mosquitoes can detect the smell and fly away (Hossain *et al*. 2020).

**Insecticide spraying in drains:** Insecticides are sprayed in drains to target larvae and hiding adult mosquitoes. This method is limited by the coverage of insecticides in covered drains (Ahmed *et al*. 2023).

**Cleaning of ditches and bushes:** Ditches, unwanted bushes, and derelict ponds are cleaned to eliminate potential mosquito breeding sites (Begum *et al*. 2021).

**Septic tanks:** Although septic tanks can be breeding grounds for mosquitoes, monitoring and intervention in these areas are challenging (Chowdhury *et al*. 2022).

## Challenges and observations

Effectiveness of Fogging: Experts suggest that fogger machines may not effectively kill flying mosquitoes as

they can sense the pesticide and escape to nearby areas (Rahman *et al.* 2022).

**Covered drains:** Many urban drains are covered, with limited or no access for spraying insecticides. This leaves mosquitoes in these areas unaffected (Hossain *et al*. 2020).

**Dilution of larvicides:** When larvicides are sprayed on water bodies, the droplets may dilute, reducing their effectiveness compared to the recommended dose based on LD50 (lethal dose for 50% of the test organisms) (Ahmed *et al*. 2023).

**Pesticide resistance:** Reports indicate that mosquitoes may have developed resistance to commonly used insecticides. Additionally, the efficacy of pesticides may be compromised if they are stored at high temperatures, which degrade their active ingredients (Khan *et al*. 2021).

**BTI storage:** Bacillus thuringiensis israelensis (BTI) needs to be stored at safe temperatures (around 15°C) to maintain its effectiveness (Begum *et al*. 2021).

**Non-target effects:** Pesticides used in fogging and spraying can also kill beneficial insects, such as pollinators and natural predators, impacting rooftop agriculture and overall ecosystem health (Chowdhury *et al*. 2022).

**Septic tanks as breeding sites:** Research indicates that septic tanks can be significant breeding sites for mosquitoes, with Aedes aegypti and Culex quinquefasciatus being commonly found (Rahman *et al*. 2022).

**Alternative wetting and drying (AWD) technology:** Stagnant water in Boro rice fields provides breeding grounds for mosquitoes. The International Rice Research Institute (IRRI) recommends AWD technology to manage water usage in rice cultivation, potentially reducing mosquito breeding sites (IRRI 2023).

**Future apprehensions and mosquito control**

**Effect of global warming on mosquitoes:** Mosquitoes breed rapidly under warm climates, and vector-borne infectious diseases such as malaria, dengue virus, Zika virus, and Lyme disease can affect nearly half of the world's population, potentially creating international health emergencies. For instance, the Zika virus outbreak in 2015-2016 was widely linked to unusually high temperatures (CDC, 2018). Mosquitoes can tolerate temperatures up to 42°C, allowing them to survive and proliferate even as global temperatures rise (Smith & Brown, 2019).

**Aedes albopictus in rural areas:** Aedes albopictus, a mosquito species more abundant in rural areas (Prothom Alo 2023), can safely multiply in irrigated Boro rice fields containing clear and stagnant water. If dengue reaches villages, it could pose a nationwide threat, as rural areas lack the mosquito control services available in towns and cities. This menace could be further aggravated by the constant presence of clear water in irrigated rice fields. Although Aedes albopictus is a weak flyer with a flight range of up to one kilometer, some mosquito species can fly as far as 50 kilometers, while Aedes aegypti can fly up to 100 meters (Jones and Smith 2020).

**Potential for disease spread:** Diseases transmitted by different mosquito species include malaria, dengue, chikungunya, Zika, yellow fever, encephalitis, Eastern equine encephalitis (EEE), Western equine encephalitis (WEE), Venezuelan equine encephalitis (VEE), California encephalitis (CE), West Nile virus (WNV), and St. Louis encephalitis (SLE). It is unpredictable whether any of these diseases might arrive in Bangladesh through an infected traveler in the future (World Health Organization 2023).

**Conventional mosquito control practices:** Efforts to destroy breeding places and apply chemical larvicides in drains and water bodies continue. Current practices include:

**Killing mosquito larvae:**

- Spraying larvicides in drains and above ground using fogger machines.
- Spraying larvicides on water surfaces.
- Spraying Bacillus thuringiensis israelensis (BTI).

**Killing adult mosquitoes:**

- Spraying insecticides on the ground and above.

**Mechanism of disease transmission by mosquitoes**

The transmission of disease organisms (viruses, parasites, etc.) by mosquitoes involves the specialized mouthparts of female mosquitoes and the blood-sucking process.

Female mosquitoes have a proboscis adapted for piercing skin and sucking blood, while males feed only on nectar. The proboscis consists of a labium that encloses six slender stylets (two mandibles, two maxillae, the labrum, and the hypopharynx) that interlock to form a sword-like structure for probing blood vessels. During feeding, the labium retracts, and all six stylets penetrate the host's body. The hypopharynx is hollow and encloses the salivary canal, while the food canal runs through a groove on the labrum's back side. A pair of sensory maxillary palps arises near the base of the proboscis (Gubler 2009).

In female mosquitoes, the labium encloses all mouthparts like a sheath through which blood is sucked. The sharp tips of the labrum and maxillae pierce the host skin, and the hypopharynx acts as a pipe for flowing blood and saliva. Saliva containing anticoagulants is injected into the host to minimize discomfort, allowing continuous blood-sucking. This process of injection can introduce disease organisms into the host's body (Gubler 2009).

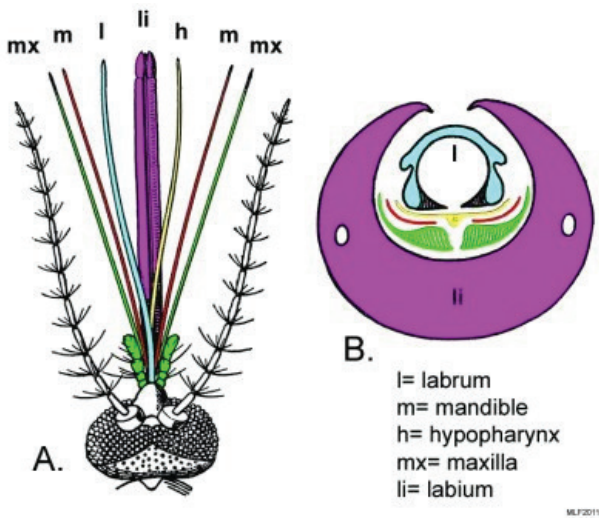



**Figure 1.** Mouthparts of mosquito showing blood-sucking system.

Current efforts to control mosquito larvae have proven inadequate, highlighting the need for new and innovative approaches to mosquito control.

**New approach for dengue management**

Effective insect control extends beyond mere pesticide spraying. It necessitates a comprehensive understanding of factors such as biology, ecology, habitat preferences, reproductive behavior, feeding habits, respiration, survival mechanisms, host preferences, attractants, repellents, and the impact on beneficial organisms like parasites, predators, pollinators, and human health. Different types of pesticides must be formulated and applied differently depending on the target species and their habitats. A singular approach may not yield optimal results, underscoring the importance of Integrated Pest Management (IPM) principles, akin to those applied in crop pest management, in mosquito control efforts.

**Integrated approach for dengue management**

Current strategies focusing solely on hospitalization and insecticide spraying within city corporations are insufficient for sustainable mosquito control. A holistic approach combining preventive and curative measures, akin to IPM concepts in crop pest management, is urgently needed for dengue management:

**Preventive measures:** a) Rapid testing of individuals with fever for dengue virus, followed by immediate hospitalization or strict home quarantine under mosquito netting upon positive diagnosis. b) Implementation of effective homemade mosquito repellents to protect family members from mosquito bites, as discussed in this paper. c) Public awareness campaigns through various media channels about dengue prevention, homemade repellents, and methods for controlling mosquitoes (larvae, pupae, adults), including the use of vegetable oils as described. d) Training of community leaders, such as Imams, by Union Parishads to engage in mosquito breeding site cleanup, water management using Alternate Wetting and Drying (AWD) techniques in rice fields, cultivation of mosquito-repellent plants in villages and urban areas.

**Curative measures:** a) Immediate hospitalization, quarantine, and appropriate medical treatment for confirmed dengue cases. b) National and international efforts to develop vaccines against dengue. c) Research into immediate treatment options for suspected dengue cases to prevent disease progression before hospitalization. d) Strict control measures for hospital visitors potentially carrying the virus during the incubation period, including mandatory testing before admission and before leaving the hospital.

In conclusion, effective dengue management requires multifaceted mosquito control strategies, robust protection against mosquito bites, and timely medical intervention. Subsequent sections will elaborate on methods for mosquito control through suffocation (asphyxiation) techniques and skin protection from mosquito bites.

**Proposed methods for mosquito control and skin protection**

The proposed techniques for managing mosquito eggs, larvae, pupae, and adults involve:

- Utilization of soybean oil to eliminate mosquito eggs, larvae, pupae, and adults in breeding sites.
- Implementation of homemade mosquito traps and repellents.
- Soybean oil has been recognized for its efficacy in repelling and killing mosquitoes for over a century (Green *et al*. 1925). Recent studies and popular articles in Bangladesh have further substantiated its effectiveness (Miah *et al* 2023).

**The mechanism of killing mosquitoes by oil**

The mechanism by which oil kills mosquitoes is multifaceted and effective in disrupting their life cycle:

a) When oil is poured onto water, it spreads to form a thin film across the surface.

b) Mosquitoes lay their eggs on the surface of stagnant water. The thin layer of oil disrupts their breeding cycle by coating the siphon of larvae and the trumpets of pupae. These structures are essential for breathing air at the water's surface. The oil film prevents access to oxygen, leading to suffocation (asphyxiation) and subsequent death of larvae and pupae. Pupae, which are lighter than water and float at the surface, also rely on the water's surface tension for respiration through their trumpets.

c) Additionally, the oil film interferes with the water's surface tension, making it difficult for adult mosquitoes to land and lay their eggs. This disruption further hinders their reproductive cycle.

The figures illustrate the critical stages in this process:



**Figure 2.** Depicts a fully grown larva with its siphon, crucial for breathing at the water's surface.

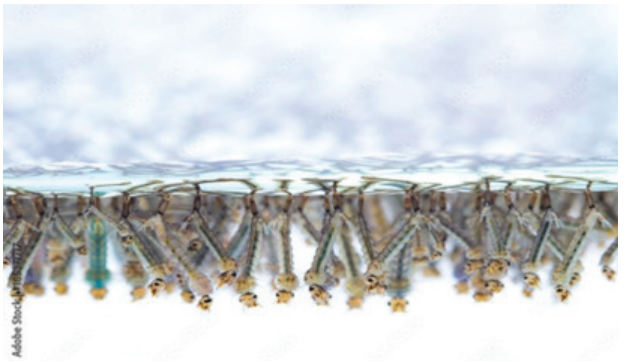


**Figure 3.** Shows larvae utilizing their siphon to take in oxygen, a process disrupted by the oil film.



**Figure 4.** Illustrates the pupal stage, where pupae rely on their trumpets for breathing at the water's surface. The oil film obstructs this process, contributing to mortality.



**Figure 5.** Depicts an adult mosquito attempting to land on water. The oil film prevents proper contact with the water surface, leading to potential damage to the mosquito's feet and subsequent mortality.

It's noted that while kerosene can also create a strong oily film, its use is discouraged due to environmental concerns and potential harm to aquatic life. Soybean oil and mustard oil, with specific gravities suitable for creating effective oily films on water bodies in Bangladesh, are recommended alternatives. These oils induce larval mortality within minutes due to asphyxiation, demonstrating their efficacy. Regarding concerns about the impact on fish, soybean oil, for instance, is used in the diet of tilapia and is unlikely to affect fish health as they primarily absorb dissolved oxygen through their gills, situated below the oil film. However, the effects on surface-dwelling fish species like kechki should be confirmed through short-term experiments, particularly assessing any effects related to asphyxiation. The use of oils like soybean and mustard effectively disrupts mosquito breeding cycles through asphyxiation of larvae and pupae, while also repelling adult mosquitoes and minimizing environmental impact when used responsibly (Reid 1963, Green *et al*. 1925)

**Benefits of using soybean oil in mosquito control**

**Effective mosquito life cycle disruption:** Soybean oil forms a thin oily film on water surfaces, effectively killing mosquito eggs, larvae, pupae, and some adult mosquitoes. This disrupts the mosquito life cycle by preventing successful hatching and development.

**Environmental and health safety:** Being a vegetable oil, soybean oil is edible and poses no toxic threat to human health or the environment. Its application on water surfaces ensures minimal impact on beneficial terrestrial insects, focusing its efficacy solely on mosquito populations

**Cost-effectiveness:** Unlike traditional methods that require separate applications of ovicides, larvicides, pupicides, and adulticides, soybean oil can target all stages of mosquito development in one application. This reduces operational costs and simplifies mosquito control efforts.

**Sustainable solution:** While soybean oil evaporates over time, necessitating periodic reapplication based on monitoring, its biodegradability and non-toxic nature make it a sustainable choice for long-term mosquito management strategies.

**Alternatives to soybean oil**

When considering widespread adoption of mosquito control methods, alternatives to soybean oil must be explored to alleviate potential market pressures on this commodity:

**Soybean oil cake:** Residual oil in soybean oil cake can be utilized by transforming it into powder or pellets. This facilitates the creation of an oily film on water surfaces, suffocating mosquito larvae through asphyxiation.

**Mustard oil cake:** Similar to soybean oil cake, mustard oil cake contains residual oils that can serve as effective alternatives in creating oily films on water surfaces in mosquito breeding grounds.

**Protection of skin from mosquito bites**

Effective skin protection is crucial in Integrated Pest Management to prevent mosquito-borne diseases like dengue:

**Mosquito repellents:** Rural communities often lack access to commercial repellents, necessitating homemade solutions. Mixtures of easily accessible ingredients like neem oil, coconut oil, and tulsi leaves can provide effective protection against mosquito bites for extended periods.

**Mosquito traps:** Utilizing traps such as fermenting straw in water to attract gravid female mosquitoes, coupled with sticky substances like resin and castor oil, provides effective control over mosquito populations near dwellings.

**Resources available in Bangladesh for mosquito management**

**Local Bacillus thuringiensis strains:** Bangladesh harbors various biotypes of Bacillus thuringiensis, facilitating local production and distribution for widespread mosquito control.

**Accessible repellents and attractants:** Mustard oil, soybean oil, tulsi plants, coconut oil, and lemongrass serve as readily available options for rural communities to manage mosquito populations effectively.

**Technological innovations:** Agricultural techniques like Alternate Wetting and Drying (AWD) for Boro rice fields not only conserve water but also prevent stagnant water that serves as breeding grounds for mosquitoes (Shishir *et al*. 2014).

**Future directions**

To effectively combat mosquito-borne diseases like dengue, collaborative efforts among relevant agencies are imperative:

**Research and development:** Continuous research into mosquito biology, behavior, and effective control tactics underpins sustainable mosquito management practices.

**Community engagement:** Dissemination of information on effective mosquito control methods, including the use of soybean oil and homemade repellents, through local media and community outreach programs is essential.

**Government initiatives:** Government-led initiatives should focus on scaling up successful pilot projects, such as soybean oil applications in mosquito breeding sites, across urban and rural areas to mitigate disease transmission.

**Integrated approach:** Implementing Integrated Pest Management (IPM) strategies that combine biological, cultural, and chemical control methods ensures sustainable and effective mosquito control practices nationwide.

By prioritizing these strategies, Bangladesh can enhance its resilience against mosquito-borne diseases, safeguard public health, and promote sustainable environmental practice

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