# Training Module- 4

## Integrated Vector and Pest Management

**Developed under GEF Funded Project on**

**Development and Promotion of Non-POPs Alternatives to DDT**
(GEF Project ID: 4612)

**Training Programme on**
**Integrated Vector Pest Management (IVPM)**

**Executed by**
**Central Pollution Control Board (CPCB)**
**Ministry of Environment, Forest and Climate Change (MoEFCC)**

**Developed by**

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| | |
|---|---|
| a.i | active ingredient |
| ABER | Annual Blood Examination Rate |
| AESA | Agro Ecosystem Analysis |
| AFI | Annual Falciparum Incidence |
| API | Annual Parasite Incidence |
| ASHA | Accredited Social Health Activist |
| BCC | Behaviour Change Communication |
| BI | Breteau Index |
| BL | Bacterial Larvicide |
| *Bti* | *Bacillus thuringiensis* var. *israelensis* |
| CBO | Community Based Organization |
| CDC | Centre for Disease Control and Prevention |
| CI | Container Index |
| CS | Capsule Suspension |
| cu. mm | cubic millimetre |
| DDT | Dichlorodiphenyltrichloroethane |
| DEET | N, N-Diethyl-m-toluamide |
| DF | Dengue Fever |
| DHF | Dengue Haemorrhagic Fever |
| EC | Emulsifiable Concentration |
| EW | Oil in Water Emulsion |
| FAO | Food and Agriculture Organization |
| FBO | Faith Based Organization |
| FFS | Farmer Field School |
| FFs | Farmer Facilitators |
| FRT | Fever Radical Treatment |
| GR | Granule |
| HBI | Human Blood Index |
| HCH | Hexachlorocyclohexane |
| HI | House Index |
| IEC | Information Education and Communication |
| IGRs | Insect Growth Regulators |

| | |
|---|---|
| IPM | Integrated Pest Management |
| IRS | Indoor Residual Spray |
| ITN | Insecticide Treated Net |
| IVM | Integrated Vector Management |
| IVPM | Integrated Vector and Pest Management |
| IUCN | International Union for Conservation of Nature |
| KAP | Knowledge Attitude Practice |
| KD | Knockdown |
| $LD_{50}$ | Lethal Dose 50% |
| LFFS | Livestock Farmer Field School |
| LLINs | Long Lasting Insecticidal Nets |
| MDA | Mass Drug Administration |
| mf | microfilaria |
| mfd | microfilaria density |
| PMHD | Per Man Hour Density |
| MPHW | Multi-Purpose Health Worker |
| PSI | Per Square Inch |
| PPE | Personnel Protective Equipment |
| USHA | Urban Social Health Activist |
| TNAU | Tamil Nadu Agricultural University |

# 1. Integrated Vector and Pest Management

**Learning Objectives**

By the end of the training programme, participants should be able to ……

- Learn the role of Integrated Vector and Pest Management
- Describe different control measures used to control vectors and pests
- Learn organization and management of IVM in different sectors including FFS
- Learn how IVM improves the awareness in the community through BCC

## 1.1 Introduction

Integrated Vector and Pest Management (IVPM) is a combination of Integrated Vector Management (IVM) as well as Integrated Pest Management (IPM) techniques, which are beneficial for reducing vector and pest populations. Integrated Pest Management (IPM) is practised and promoted in the agriculture sector, whereas, Integrated Vector Management (IVM) is being promoted for vector control in the National vector-borne disease control programme. Both IPM and IVM require a thorough understanding of the local ecosystem, pest/vector bionomics and effective tools. Integrated Vector and Pest Management (IVPM) encompasses both IVM and IPM to widen the scope of awareness on vectors and pest management and judicious use of chemicals (pesticides/insecticides).

## 1.2 Integrated Vector Management

Integrated Vector Management (IVM) is defined as a rational decision-making process to optimize the use of all available resources for vector control. It promotes various interventions, alone or in combination, selected on the basis of local knowledge about the vectors, diseases and disease determinants. The IVM approach, therefore,facilitates tackling the area under influence of single or multiple vectors simultaneously.

IVM is encouraged globally by World Health Organization (WHO) as it ensures benefits to community through judicious and evidence-based use of chemicals as vector control measures. While promoting the combination of novel tools, IVM also advocates elimination of Persistent Organic Pollutants (POPs), which have long run impacts on the environment. DDT is one of the POPs and it's phasing out for Indoor Residual Spray (IRS) under malaria contol programme and development of alternatives as per commitments under the Stockholm Convention is crucial for the successful implementation of IVM strategy.

IVM comprises following five key elements as depicted in Figure- 1.

- Advocacy, social mobilization and legislation
- Collaboration within the health and non-health sectors
- Integrated approach to disease control
- Evidence-based decision-making
- Capacity building

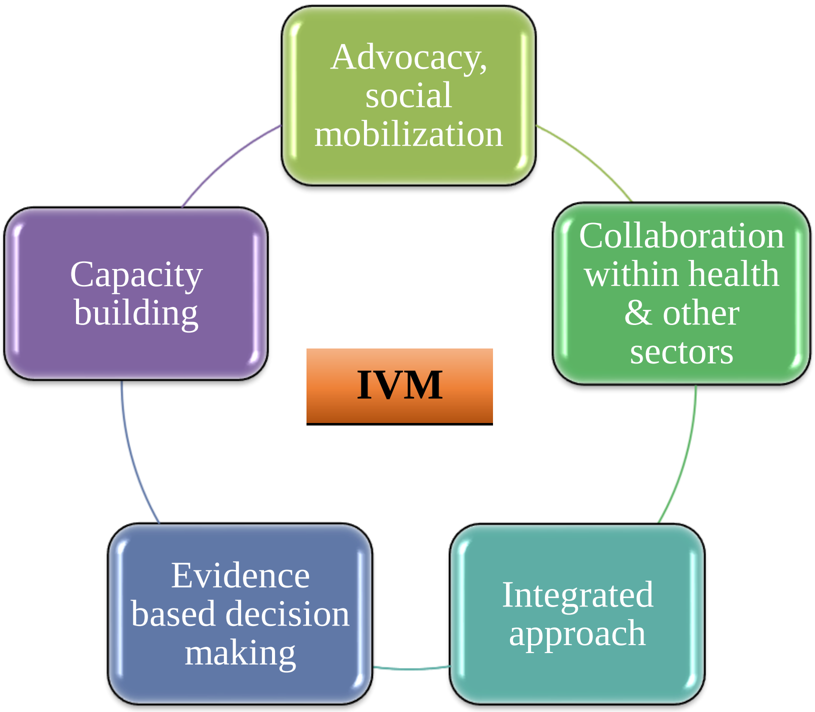



**Figure- 1: Key elements of IVM**

### 1.2.1 Integrated vector control methods

The IVM aims to improve efficacy, cost-effectiveness, ecological soundness and sustainable disease-vector management. The strategies under IVM being advocated for major VBDs like malaria, dengue, chikungunya,zika, Japanese encephalitis, lymphatic filariasis and visceral leishmaniasis (Kumari et al., 2014) have been elaborated in Figure- 2.

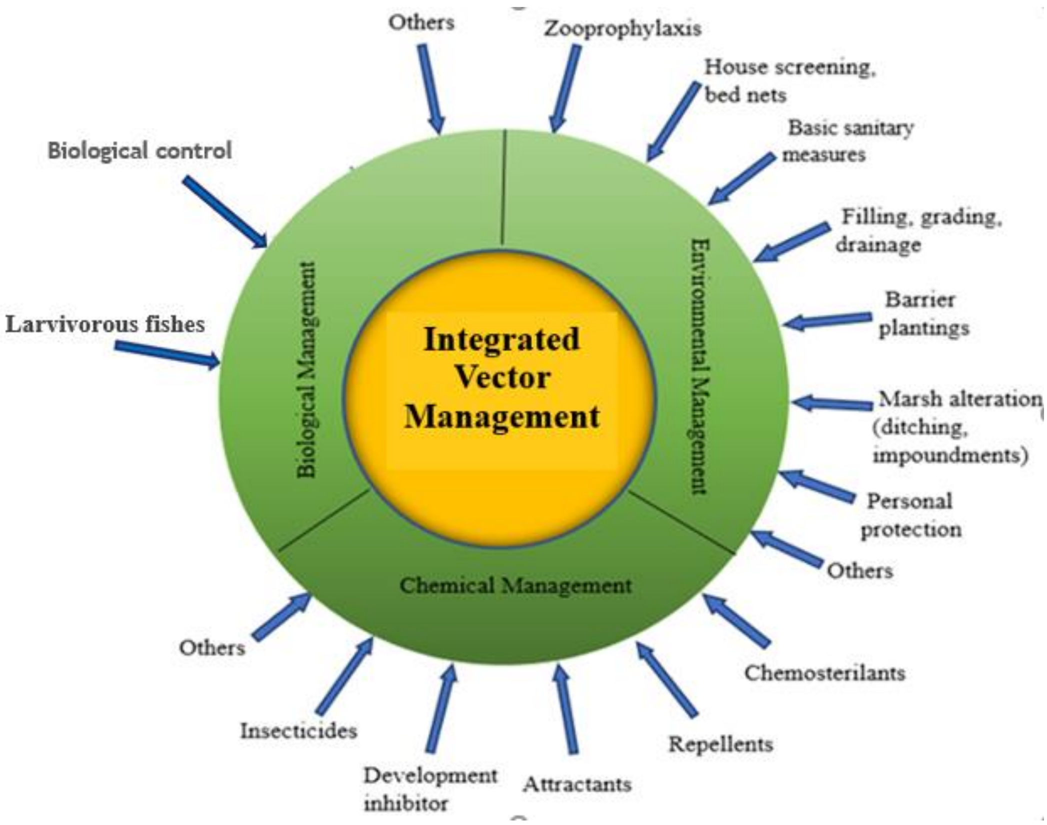



**Figure- 2: Integrated Vector Management (Source: WHO)**

### 1.2.1.1 Environmental management

Environmental management is a modification or manipulation of environmental factors to prevent or minimize vector propagation and to reduce human-vector contact. This includes planning, organization, process and monitoring of all the activities involved, including human interaction for creating a congenial environment for vectors (WHO, 1982).

### 1.2.1.2 Environmental modification

Environmental modification includes the permanent or long-lasting physical transformation of land, water and vegetation to prevent, eliminate or reduce breeding without causing undue adverse effects on the quality of human habitats. Examples are land levelling, alteration of drainage margins, flattening of breeding sites, maintenance of open ditches, free flow of water through the proper gradient, etc.

### 1.2.1.3 Environmental manipulation

Environmental manipulation consists of planned recurrent activity so that temporary breeding conditions are made unfavorable for breeding of vectors. Environmental manipulation activities include stream flushing, regulation of the water level in reservoirs, dewatering or flooding of swamps, clearing vegetation, etc.

### 1.2.1.4 Changes to human habitation or behavior

- **Improved water supply**: Insufficient water supply during a limited duration leading to water storage in various containers results in more breeding sites of mosquitoes. The proper supply of potable water will reduce storage practices and thus breeding as well.
- **Mosquito proofing of overhead tanks/cisterns/underground reservoirs/wells**: These structures should be properly covered with tight lids or using wire mesh to prevent mosquito breeding.
- **Flower pots/vases, ant traps and water bowls**: Water collection in flowerpots, ant traps etc. are also breeding sites for mosquitoes, therefore water collection in these should be refilled after proper scrubbing once a week. Similarly, water bowls for bird baths and pets' water bowls need to be cleaned properly.
- **Emptying water storage containers and coolers**: Desert water coolers, condensation collection pans under refrigerators, air conditioners, drip trays, etc. should be regularly inspected, drained and cleaned once a week.
- **Design of buildings**: Proper slope to prevent water stagnation at the rooftop, sunshades, porticos, gutters and flat roofs need to be ensured no stagnation of water in such areas, which become breeding sites for mosquitoes.
- **Mandatory water storage for firefighting:** Fire prevention regulations may require mandatory water storage; such storage tanks need to be kept mosquito-proofed. Similarly, petrol pumps, public entertainment & assembly, hospitals, hotels, underground shopping complexes and timber merchants having water tanks for firefighting should be properly covered to avoid any mosquito breeding inside them.
- **Solid waste disposal**: Solid waste like tins, bottles, paper cups, coconut shells, waste poythenes, buckets or any other waste material scattered around houses should be removed and treated as per Solid Waste Management Rules, 2016. Household and garden utensils (buckets, bowls and watering devices etc.) should

be turned upside down to prevent the accumulation of rain water, also plant waste e.g., coconut shells should be disposed of properly.

- **Used tyre management**: Rain water accumulation in a large number of improperly stored discarded tyres acts as ideal breeding site for mosquitoes. To minimize the risk of mosquito breeding, tyres can be stored under a roof or covered to prevent the collection of rainwater; a hole can be made in tyres or filled with soil to avoid the collection of water, and larvicides/ oil can be applied, which kills larvae present in accumulated rainwater in tyres.

- **Filling of cavities of fences**: Fences and fence posts made from hollow trees such as bamboo should be cut down to the node and concrete blocks should be filled with packed sand or concrete to eliminate potential *Aedes* larval habitats.

**1.2.1.5 Personal protections:** These are one of the important components under IVM, however, these are used differently in different situations. Certain items are available in the retail market while some can be attributed to human behaviour.

- **Protective clothing**

Clothing can reduce the risk of mosquito biting viz. long sleeves and long trousers with stockings may protect the arms and legs from mosquito bites. School children and working persons should adhere to these practices.

- **Mats, coils and aerosols**

Household insecticidal products such as mats, mosquito coils, liquid vaporizers and aerosols are used for personal protection against mosquitoes.

- **Repellents**

Repellents are mainly used as a topical application on exposed body parts for personal protection to prevent insect bites. They prevent human-insect contact for short duration and do not knockdown or kill. Therefore, these are useful for plantation workers, army people, labours, etc. who work outdoor and travellers.

#### 1.2.1.6 Chemical control

Chemical control measures are still considered the most important component in the integrated control of vector borne diseases. These measures are recommended in permanent water containers where water has to be conserved or stored because of the scarcity of water. Chemicals have been used to control vector-borne diseases by attacking both larvae and adults of the vector species.

### A. Larvicides

Larvicides are used at an interval of week/fortnight to avoid emergence of adult mosquitoes because mosquito vector requires 7-14 days for their completion of life cycle depending on the temperature. Chemical larvicides are used in situations where disease vector surveillance indicates the existence of certain periods of high risk in localities where outbreaks might occur. Different larvicides, which can be used are mentioned in Table- 1.

#### a) Mosquito Larvicidal Oil (MLO)

This oil was and continues to remain the classic larvicide. It kills all aquatic stages of mosquitoes. The oil not only suffocates but also poisons the mosquito larvae. Its action on larvae is due to causing suffocation by producing a surface film, which cuts off their supply of air, blocking respiratory tubes with particles of oil, and reduction of surface tension, making it difficult for larvae to remain at the surface and thus causing them to be drowned. The oiled breeding sources tend to deter the adults from depositing their eggs.

#### b) Temephos

Temephos is an organophosphorus compound with the least mammalian toxicity. The chemical is being used as 50% emulsion concentrate (EC) (NVBDCP, 2016). It acts as contact poison, which has a prolonged residual effect. Temephos sand granules (1%) is applied to containers using a calibrated plastic spoon to administer a dosage of 1 ppm. This is recommended to apply in stored water like desert coolers, which are the main source for *Aedes aegypti* and *Anopheles stephensi* breeding.

#### c) Insect Growth Regulators

Insect Growth Regulators (IGRs) interfere with the development of the immature stages of the mosquito by the interference of chitin synthesis during the moulting process of larvae or disruption of pupal and adult transformation processes. Most IGRs have extremely low mammalian toxicity. Two compounds *i.e.*, pyriproxyfen (0.5%) granular and diflubenzuron (25%) WP are recommended under the programme (NVBDCP, 2016).

**d) Bio-larvicide**

The bio-larvicides includesome species of bacteria viz. *Bacillus thuringiensis* var. *israeliensis* and *Bacillus sphaericus*. The bacteria produce toxin, which form crystalline body. The insect and larvae feed on these bacteria, get their digestive system blocked and result starvation of the insect within few hours of indigestion and also rupture the gut. These bacteria act as as narrow range insecticide and do not harm the natural enemies of insects and pollinating insects critical to agroecological system.

**Table-1: Dosage and formulation of different larvicides (Source: NCVBDC)**

| Sl.No | Name of larvicide | Class of insecticide | Commercial formulation | Preparation of ready to spray formulation | Dosage of suspension made for per | | | Frequency of application | Equipment required |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | One sq. mtr. | 50 Linear mtr. | Hectare | | |
| 1 | MLO | | 100% Petroleum product | As it is | 20 c.c. | 1 litre | 200 litres | Weekly | Mop and bucket |
| 2 | Temephos (EC) | Organophosphate | 50% EC | 2.5 cc in 10 litres of potable water | 20 c.c. | 1 litre | 200 litres | -Do- | Knapsack/Hand compression Sprayer |
| 3 | Diflubenzuron 25% WP | Insect Growth Regulator | 25% Wettable powder | 100 gms (25 gm a.i.) in 100 litres of water (10 g in 10 litres) | - | - | 100 litres | Weekly | Knapsack/Hand compression Sprayer |
| | | | | 200 gms (50 gm a.i.) in 100 litres of water (20 g in 10 litres) | | | 100 litres | Weekly | Knapsack/Hand compression Sprayer |
| 4 | Pyriproxyfen GR | Insect Growth Regulator | 0.5% Granular | Ready -to- use | - | - | 2 kg<br>4 kg | 3 Weekly | Manual |
| 5 | *Bacillus thuringiensis var israelensis* 12 Aqueous Suspension (12AS) | Bio- larvicide | Aqueous Suspension | 1 litre in 200 litres of water (50 cc in 10 litre) (Clean water)<br>2 litre in 200 Litres of water (100 cc in 10 litre) (Polluted water) | - | - | 200 litres | Weekly | Knapsack/Hand compression Sprayer |

### B. Adulticides

Methods of chemical control that target adult vectors are intended to impact on mosquito densities, longevity and other transmission parameters. Adulticides are applied either as residual surface treatments or as space treatments.

#### a) Insecticide-treated mosquito nets, curtains and long-lasting insecticidal nets (LLINs)

The insecticide-treated bed nets (ITNs), insecticide-treated curtains and long-lasting insecticidal nets (LLINs) not only provide better and more effective protection from mosquito bites by keeping away and also killing them. Thus, they are important tools to reduce the risk of indoor transmission. Insecticide treatment is recommended for synthetic nets (nylon, polyester), as treatment of cotton nets is not cost-effective and the effect of insecticide is not long-lasting (NCVBDC). On the other hand, LLINs are mosquito nets, which have the insecticide incorporated in their fibers, so these remain effective for as many as 20 washes. Due to an even and quality-controlled insecticide application, LLINs are generally more effective than conventional ITNs. LLINs are more cost-effective (can be used for 3 years) than conventional bed nets, which require treatment with insecticide once or twice a year. Also, wide mesh in LLINs permits better ventilation and light. The colour, size and shape of the mosquito nets play an important role. Rectangular net is best rather than circular nets, wedge-shaped nets and self-supporting nets (for babies and infants).

The size of the openings in the net should not exceed 0.0475 inches in diameter. The number of holes in one square inch is usually 150. Insecticide-treated nets are prepared by soaking the net in an insecticidal solution and dried. Synthetic pyrethroids e.g., permethrin, deltamethrin, cyfluthrin and lambda-cyhalothrin are used for the treatment of mosquito nets and curtains, while other insecticides used for impregnation of mosquito nets are given in Table- 2.

The insecticide-treated nets (ITNs) have limited utility in the dengue control programme, since the vector species bites during the day but have maximum sustainability and effectiveness against malaria.

**Table- 2: Insecticides formulation and dosage for impregnation of mosquito nets (Source: NCVBDC)**

| S.No. | Insecticide | Formulation | Dosage | Frequency of reimpregnation |
|---|---|---|---|---|
| 1 | **Deltamethrin** | 2.5% | 25 mg per sq. m | 6 months |
| 2 | **Lambdacyhalothrin** | 10% | 25 mg per sq. m | 6 months |
| 3 | **Cyfluthrin** | 10% | 50 mg per sq. m | 5 months |

**b) Insecticidal Residual Spray**

Insecticidal Residual Spray is one of the most cost-effective control measures for malaria and kala-azar in India. Its success depends on planning and implementation. The objective of IRS is to ensure the safe and standardized application (uniform and complete) of a residual insecticide on indoor surfaces of all houses and animal shelters selected in targeted areas to obtain a significant reduction in vector populations, and consequently a considerable reduction of disease transmission. Presently different formulations of synthetic chemical insecticides are in use for vector control shown in Table- 3.

**Manpower requirement**

To cover houses of one million population with 2 rounds of synthetic pyrethroid spray:

- It is estimated that 52 spray squads are required for 5 months
- 87 squads are required for 4½ months for 3 rounds of Malathion spraying (two coats applied simultaneously in one round)
- Each spray squad consists of five field workers (with two stirrup pumps) and one superior field worker (SFW). It is expected that a spray squad can spray, on average, 60 to 80 houses per day. Spray operators should ideally work for 5-6 hours a day. One squad will take 12 to 17 days to cover a sub-center area with an average population of 5,000 depending on local settings and climatic conditions.

**Table- 3: Formulation, doses, preparation and application of synthetic insecticides for IRS (Source: NCVBDC)**

| Insecticide | Quantity of Insecticide for Preparation of suspension in 10 lit of water | Dosage per Sq. metre of active ingredient | Residual effect in weeks | Area to be covered by 10 lit of suspension (Sq. m) | Requirement of insecticide per million population (MT) |
|---|---|---|---|---|---|
| **DDT 50% WP** | 1 kg | 1g | 10-12 | 500 | 150.00 |
| **Malathion 25% WP** | 2 Kg | 2g | 6-8 | 250 | 900.00 |
| **Deltamethrin 2.5% WP** | 400 gm | 20mg | 10-12 | 500 | 60.00 |
| **Cyfluthrin 10% WP** | 125 gm | 25mg | 10-12 | 500 | 18.75 |
| **Lambdacyhalothrin 10% WP)** | 125 gm | 25mg | 10-12 | 500 | 18.75 |
| **Alphacypermethrin 5% WP** | 250 gm | 25 mg | 10-12 | 500 | 37.50 |
| **Bifenthrin 10% WP** | 125 gm | 25 gm | 10-12 | 500 | 18.75 |

**Equipment:**

Each squad requires the following equipment, which must be kept ready before spraying rounds start:

- Stirrup pumps - 2
- Spray nozzle tips for spray pumps - 2
- Bucket (capacity-15 liters) - 4 (as per MAP)
- Bucket (capacity-10 liters) - 1
- Bucket (capacity-5 liters) - 1

- Asbestos thread - 3 meters
- Measuring mug - 1
- Straining cloth - 1 meter
- Pump washers - 2
- Plastic sheet (3x3 meters) - 1

The squad supervisor must have extra spray pumps, nozzle tips, washers, asbestos threads and a set of tools for minor repairs, which should include a pipe wrench, pliers, screwdrivers and spanners. Good quality nozzles should be used. Each squad must be provided with personal protection equipment including masks and soap to wash.

**Preparation of insecticide suspension**

- Add the required quantity of insecticide issued to the squads each day by the supervisor after checking the balance stocks available from the previous day's supplies.
- The preparation of the spray suspension should be made just before the start of the spray operations every day. The suspension must be made correctly so that the correct dose is applied on the surfaces.
- The procedure for the preparation of the suspension is same irrespective of the insecticide. However, the quantity of the insecticide used per 10 liters of water will depend on the insecticide used.
- Required quantity of the insecticide is measured with a plastic mug and poured into a 15 liters bucket.
- A paste is made with a small quantity of water. The remainder of the water is then poured slowly into the bucket and the insecticide water mixture is stirred vigorously at least every hour to obtain a uniform suspension.
- Suspension is then poured into another bucket through a cloth sieve to remove any matter that might clog the nozzle of the spray pump.

**Spraying**

- All food, cooking utensils, bedding and clothes must be protected from the insecticide by taking them outside the house before spraying starts.
- The barrel of the stirrup pump remains dipped in the bucket containing the spray suspension. One man operates the pump and the other man sprays.
- The spray lance should be kept 45 cm (18 inches) away from the wall surface.
- The swaths should be parallel.
- Spray is applied with horizontal swaths 75 cm (29 inches) wide. Successive swaths should overlap by 7.5 cm (3 inches).
- Spray is done from roof to floor, using a downward motion, to complete one swath (Figure- 3); then stepping sideways and spraying upwards from floor to roof. The spray should not drip to the floor. Spraying is done only on inner surfaces, including eaves and roofs. It takes about 5 minutes to spray a house with an average surface area of 150 sq. meters.
- The discharge rate should be 740 to 850 ml per minute. To obtain the above discharge rate, 20 to 26 strokes should be given per minute with 10-15 cm plunger movement at a pressure of 10 PSI (0.7 kg/sq.cm) at the nozzle tip.

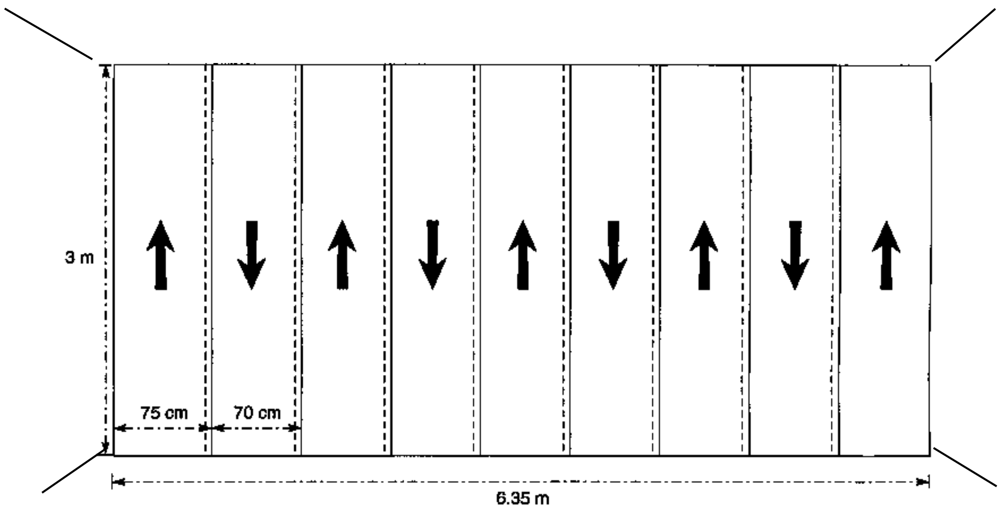



**Figure- 3: Residual spraying on the wall (Source: WHO)**

- Spraying into a bucket for one minute and measuring the quantity of the suspension in a graduated mug will check the correct discharge rate (740 to 850 ml/minute). The nozzle tip should be discarded if the discharge rate exceeds 850 ml per minute.

- In case of blockage, run-off or fall-out of insecticide from the nozzle (Figure- 4), the nozzle cap should be unscrewed to remove the blockage and replaced with a new one. The blocked nozzle should be put in a container with water for a few hours before the blockage is removed with a fine wire.

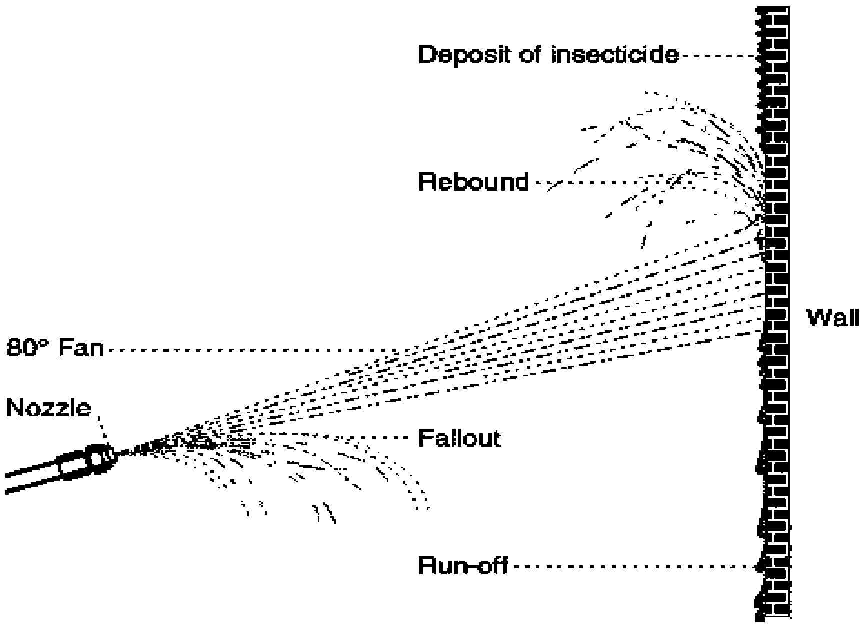



**Figure- 4: Insecticide run-off down the wall (Source: WHO)**

- A good quality spray should lead to uniform deposits on walls and other sprayed surfaces (Figure- 5). This is easy to verify for DDT and malathion sprays as the insecticide deposits are visible. Deposits of synthetic pyrethroids are visible on wooden structures. The supervisor through physical verification should verify the quality and coverage of the spray randomly. A summary of spray operations in each village should be maintained by the SFW and verified by the health worker showing the areas covered and room coverage.

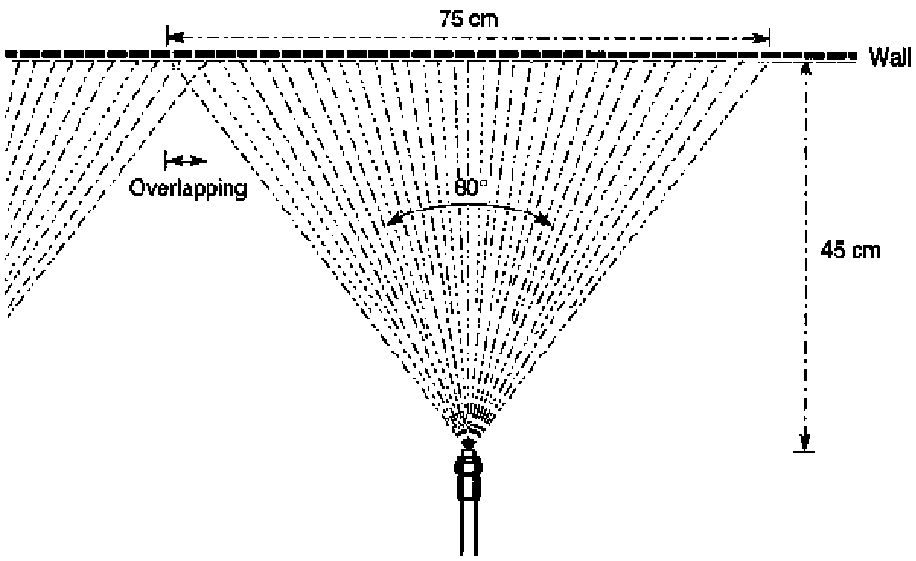



**Figure- 5: Nozzle discharge pattern (Source: WHO)**

**Guidelines to be followed during spraying activity**

- The squad supervisor should identify the location for staging the spraying operation for the day. The staging area should be 2-5 meters from the source of water or any other water body and agricultural field (Figure- 6). Multiple staging areas can be selected for larger villages.

**Figure- 6: Suspension preparation**

- For the purpose of staging, a plastic sheet measuring 3x3 metres should be spread on the ground. All the activities like preparation of suspension, storage of insecticides, etc. should be performed in the staging area.

- When the activities of a particular staging area are completed, the plastic used for staging should be folded upper surface inwards in such a manner so that no chemicals spill on the ground (Figure- 7).


**Figure- 7: Folding of plastic sheet**

- The water required for the preparation of the suspension should be obtained from public sources.
- Spray workers should remove or assist the house owner in removing all calendars, papers, and photo frames that are placed on the walls before starting the spraying operation.
- Spray workers should ensure that all food items and utensils are removed from the house where the spraying operation would be carried out.
- Immovable property or furniture, which cannot be removed should be gathered in the middle of the room and covered with a polythene sheet. Heavy furniture that cannot be moved or household items, which cannot be taken out of the house should be covered.
- A double-coloured polythene sheet should be used for covering the furniture. Double-coloured (blue and red or yellow and blue) polythene sheets or single-coloured sheets duly marked (with cross signs) should be spread on the stockpile before spraying (Figure- 8). The red or yellow or marked side should be the bottom surface, *i.e.,* the surface facing the stockpile or the furniture.
- In case there is any stockpile of food grain in the house, it should be covered before spraying is carried out.
- Avoid spraying insecticides for IRS near water bodies, tube wells, drains, agricultural fields, irrigation canals, swamps, outside houses (eaves of houses to be

sprayed), animal sheds, etc. Cattle sheds (only in the case of Kala-azar) and unused rooms.

**Figure- 8: Covering household Items**

- granary, sericulture, beekeeping, tobacco leaves, etc. should not be sprayed. This should be monitored by the supervisor.

- The supervisor should invigilate the spraying pump from time to time to check that there are no leaks along the lance or the pipe. He should ensure that the spray pattern is even and without streaks. Dripping and paddling should be checked and corrective measures should be taken (Figure- 9).

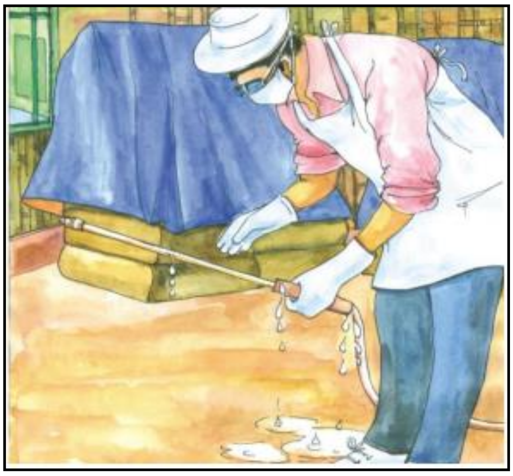


**Figure- 9: Dripping of insecticide**

- If there is clogging, the clogged nozzles should be immersed in a container with water for several hours, and then the blockage should be removed by a soft brush. Nozzles should not be cleared with a hard pin or a piece of wire and a nozzle should never be put into the mouth for blowing air through it.

**Health and safety of spray workers**

- All spray personnel should wear appropriate PPE during the entire operation.
- The squad supervisors should ensure that the spray worker never works alone, eat and drinks while applying insecticides (Figure- 10).

**Figure- 10: Eating & drinking prohibited**

- After completion of spraying the personnel should remove the PPE, take bath and wear a fresh set of clothes (Figure- 11).

**Figure- 11: Bathing post-spray**

- In case of poisoning by insecticides, the following antidotes should be used and consult the medical practitioner at the earliest-
  - **Organophosphorus** (Esterase inhibitor)

    In case of organophosphate poisoning, 2-4 mg of atropine should be given intravenously (for children 0.5 to 2 mg according to weight). Depending on symptoms, further doses of 2 mg should be given every 15 minutes for 2-12 hours in severe cases.

- **Synthetic Pyrethroid** (affects every part of the nervous system)

  Vitamin E oil preparations can be given for prolonged paraesthesia. Only in cases of definite allergic symptoms, corticosteroids should be administered. On the occurrence of convulsions after sever intoxication, an intravenous injection of 5-10 mg Diazepam (or other Benzodiazepines derivatives) should be given.

- If skin-contact with insecticides is witnessed, the affected area should be immediately washed off with soap and water. If insecticide goes into the eyes, they should be immediately flushed out with plenty of water (Figure- 12).

**Figure- 12: Wash face in case of emergency**

**Guidelines for post-spray operations**

The supervisor should be responsible for monitoring the proper washing of equipment (buckets, spray lance and stirrup pump). Progressive triple rinsing of the spray pumps, lance and the buckets are essential. The supervisor should ensure that the workers wash off after a day’s activity before they eat or drink.

**Progressive triple rinsing**

Progressive triple rinsing is a procedure by which the equipment is washed repeatedly for three times with a view to economize the use of water. This is done basically by using the waste water to wash other containers/equipment. For every rinsing, the supervisor should monitor that not more than 2 litres of water is used for the rinsing activity. After every rinsing, the waste water should be disposed off in the pit constructed at the villages.

**Soak pits**

A soak pit is a specially designed hole in the ground for disposing of insecticide remnants after the day's IRS activities. A properly sited and constructed soak pit protects the environment from getting contaminated with insecticides. All the wash water and excess suspension should be disposed of in the soak pit.

**A. Space sprays**

Space spray technically a fog (sometimes referred to as an aerosol) is a liquid insecticide dispersed into the air in the form of hundreds of millions of tiny droplets up to 25 µm in diameter. It is only effective when the droplets remain airborne. When planning a space spray operation, it is necessary to identify the location and magnitude of the pest or vector-borne disease problem and the epidemiological situation.

**a) Indoor space spray**

Indoor space spray is recommended for control only in emergencies to interrupt an ongoing epidemic or to prevent an incipient one. The objective of space spray is the massive, rapid destruction of the adult vector population. Any control method that reduces the number of infective adult mosquitoes, even for a short time should reduce pathogen transmission during that time, but it remains unclear whether the transient impact of space treatments is epidemiologically significant in the long run.

It is necessary to calculate the time required to spray a house or room. With a flow rate of 20 ml/minute, and the area of a house being 0.04 hectare (400 $m^2$), the target application rate of 0.5 litre per hectare (500 x 0.04) is delivered in one minute (WHO, 2003).

Personnel conducting this work (Figure- 13) require training on the safety measures to be followed. Several precautions need to be taken before the spray operation and it is necessary to:

- Switch off electricity through the master switch
- Turn off all heating and cooking equipment, including pilot lights and allow for a cool-down time before spraying
- Cover all water containers and foodstuffs
- Remove fish or cover fish tanks
- Ensure all occupants and animals remain outside the house during spraying and stay outside for 30 minutes after spraying
- Ensure that the building is ventilated before reoccupation
- Close all doors and windows before spraying and keep them closed for 30 minutes after spraying to ensure maximum efficacy
- Spray operators should work backwards and away from the fog to minimize exposure

Some simple rules for spray are as follows:

- For small single-storey houses, the spray can be delivered from the front door or through an open window without having to enter every room of the house, provided that adequate dispersal of the insecticide droplets can be achieved.

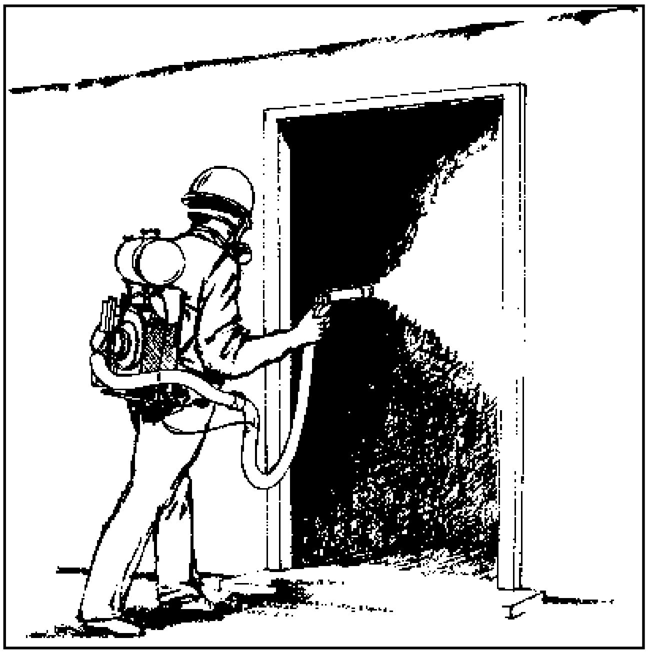


**Figure- 13: Indoor space spray (Source: WHO)**

- For large single-storey buildings, it may be necessary to apply the spray room by room, beginning at the back of the building and working towards the front.

- For multi-storey buildings, spraying is carried out from the top floor to the ground floor and from the back of the building to the front. This ensures that the operator has good visibility at all times.

Different indoor space spray insecticides and their formulations are shown in Table- 4 below:

**Table- 4: Indoor space spray and formulation (Source: NCVBDC)**

<table>
<tr><th>Sl. No.</th><th>Name of insecticide</th><th>Class of insecticide</th><th>Commercial formulation</th><th>Preparation of formulation</th><th>Equipment required</th></tr>
<tr><td>1</td><td>Pyrethrum extract</td><td>Plant extract</td><td>2.0% extract</td><td>1:19 i.e.,1 part of 2% pyrethrum extract in 19 parts of kerosene (50 ml in 950 ml kerosene oil)</td><td rowspan="2">Pressurized spray machine or fogging machine</td></tr>
<tr><td>2</td><td>Cyphenothrin</td><td>Synthetic pyrethroid</td><td>5% EC</td><td>0.5 mg a.i. per sq.mt. (5 ml in 200 ml kerosene oil)</td></tr>
</table>

**b) Outdoor fogging**

An outdoor space spray technically a fog is a liquid insecticide dispersed into the air in the form of hundreds of millions of tiny droplets less than 20 µm in diameter. These droplets are intended to be distributed through a volume of air over a given period of time. These droplets deliver a lethal dose of insecticide to target mosquitoes upon impact. It is only effective when the droplets remain airborne.

To calculate the output rate of vehicle-mounted equipment, the vehicle speed and width of the track spacing are needed. Thus a 50-metre track spacing and a vehicle speed of 12 km/hour, 50 x 12,000 m/hour, will permit the treatment of 6,00,000 $m^2$ per hour, equivalent to 10,000 $m^2$ (1 hectare) per minute (WHO, 2003).

When using portable equipment, at a walking speed of 60 metres per minute and with track spacing of 10 metres, 600 $m^2$ can be sprayed in one minute (0.06 hectares per minute). For an application rate of 0.5 litre per hectare, the flow rate must therefore be 30 ml/minute (500 ml x 0.06) (WHO, 2003)

It requires a combination of vehicle-mounted and hand carried or knapsack equipment in areas with difficult or limited vehicle access.

Consideration must also be given to the following:

- Spraying should not be undertaken when it is raining when winds exceed 15 km/hour, or in the heat of the day.
- Doors and windows of houses and other buildings should be open to allow penetration of the spray cloud for improved efficacy.
- For vehicle-mounted equipment, in areas where the roads are narrow and the houses are close to the roadside, the spray should be directed backwards from the vehicle. In areas where the roads are wide, with buildings far from the roadside, the vehicle should be driven close to the roadside and the spray should be directed at an angle (downwind) to the road rather than directly behind the vehicle.
- The nozzle of vehicle-mounted cold fog machines may be directed upwards at an angle when there are barriers that impede airflow, e.g., boundary walls and fences; for vehicle-mounted thermal foggers, the nozzle should be directed horizontally.
- The distance between successive passes through a built-up area will be largely dependent on the layout of roads. A track spacing of 50 meters is generally recommended, with the vehicle moving upwind so that the fog drifts downwind away from it and the operators.
- As far as possible, the predetermined speed of the vehicle should be maintained and the spray must be turned off when the vehicle is stationary.
- The downwind side of the spray area should be treated first, working systematically from downwind to upwind (Figure- 14).
- To avoid driving into the spray cloud, dead-end roads must be sprayed only on the way out.
- Try to avoid directly spraying shrubbery and expensive floral areas unless using a water-based/water-diluted product.

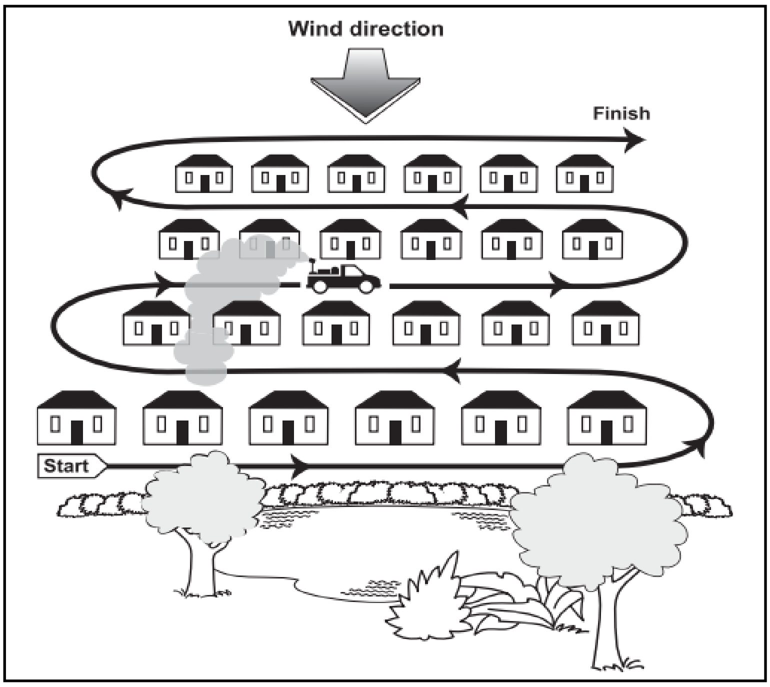



**Figure- 14: Spray application from downwind to upwind (Source: WHO)**

Outdoor fogging insecticides and their formulations are shown in Table- 5 below:

**Table- 5: Outdoor fogging and formulation**

| Sl. No. | Name of insecticide | Class of insecticide | Commercial formulation | Preparation of formulation | Equipment required |
|---|---|---|---|---|---|
| 1 | Malathion | Organophosphate | Technical malathion (95%) | 1:19 i.e.,1 part of malathion in 19 parts of diesel (50 ml in 950 ml diesel) | Shoulder-mounted fogging machine or vehicle-mounted thermal fogging machine |
| 2 | Cyphenothrin | Synthetic pyrethroid | 5% EC | 3.5 gm a.i. per hectare (70 ml in 500 ml diesel) | |

### 1.2.1.7. Biological control

Biological control agents are effective against the larval stages of mosquitoes and they should be used in sufficiently large numbers. Usually, the indigenous species biological agents should be given priority. The introduction of exotic species calls for caution since unexpected adverse effects on local fauna and the environment have resulted from such introductions in the past.

## A. Larvivorous fish

The *Gambusia affinis* fish is a voracious feeder of mosquito larvae and if introduced in sufficient numbers in pools, ponds and marshes, it can consume large quantities of mosquito larvae and pupae. The fish is small, capable of penetrating vegetative protective cover and can survive in the absence of mosquito larvae as a source of food. They multiply rapidly (200-300 per female) and don't need special habitat for oviposition since they are viviparous. *Gambusia affinis* is resistant to wide ranges of water temperature and water quality. Another larvivorous fish commonly used for mosquito control is the guppy (*Poecilia reticulata*). Information given below is derived from NCVBDC guidelines for use of larvivorus fish.

### a) *Gambusia affinis*

It is an exotic species and has been distributed throughout the warmer and temperate parts of the world (NVBDCP, 2015). *Gambusia affinis* can survive in waters with little oxygen, in high salinities (including twice that of sea water) and in temperatures of up to 42°C for short periods (IUCN). *G. affinis* (Figure- 15) breeds throughout the year after maturity, especially in tropical conditions. In the relatively colder climate, which is found in the north and north-west India, the breeding period lasts from May to September and in the warmer climate of southern India, it is from April to November. The maximum size attained by a male is 4.5 cm and a female is 5.2 cm to 6.8 cm. Its life span is approximately 4 (±1) years.

**Figure- 15: *Gambusia affinis* fish**

**Larvivorous efficiency**

A single full-grown fish eats about 100 to 300 mosquito larvae per day. *Gambusia* is a surface feeder, hence, it is suitable for feeding on both anophelines and culicines. It frequently occurs along the margins of the water containers, ponds or other ground water collections, except where there is dense vegetation at the margins of the water body.

### b) *Poecilia reticulata* (Guppy)

Guppy is also an exotic fish, which is easy to care for and it reproduces quickly and prolifically (Figure- 16). It is now widely distributed in India and is an important larvivorous fish. The male is 3 cm long, whereas the female is up to 6 cm in length. The Guppy lives for 3-4 years. The female gives birth to young ones in broods of 5 to 7 at a time. About 50 to 200 young ones are released by the female every four weeks.

**Figure-16: *Poecilia reticulata* fish**

**Larvivorous efficiency**

A single fish eats about 80 to 100 mosquito larvae per day. It is a surface feeder. Negotiates margins of ponds more easily. It is highly carnivorous and parents or older brood may eat up their young ones. Therefore, a fair number of weeds is required in the water so that young ones can hide and survive. It can easily survive and reproduces when introduced into new water bodies. Once well established, it can be found in the habitat even after many years.

## B. Bacteria

Bacterial larvicides (BL) include products based on the insecticidal crystal proteins produced by *Bacillus thuringiensis* var. *israelensis* (*Bti*) and *Bacillus sphaericus* (*Bs*). Upon ingestion by mosquito larvae, these proteins are modified by enzymes in the larval midgut and then bind with specific receptors on the midgut epithelium, resulting in spore formation and interruption of feeding and homeostasis. This unique mode of action accounts for the specificity of bacterial larvicides and their utility in managing mosquito resistance to chemical insecticides.

The frequency of re-treatment with bacterial larvicides can range from 1 to 2 weeks for *Anopheles* depending on formulation, habitat, temperature, and species. Typical re-treatment intervals with *Bti* are 7–10 days. For maximum efficiency, the re-treatment interval should be determined by recovery of late $4^{th}$ instar larvae to established thresholds, or the first appearance of pupae. Formulation, preparation and frequency of dosage for different *Bacillus thuringiensis* var. *israelensis* strands are as mentioned in Table- 6.

**Table- 6: Formulation and dosage for bio-larvicides (Source: NCVBDC)**

| Sl. No. | Name of larvicide | Class of insecticide | Commercial formulation | Preparation of ready-to-spray formulation | The dosage of suspension made for per | | | | Frequency of application | Equipment required |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *Bacillus thuringiensis* var. *israelensis* 5 % WP strain - 164, serotype H-14 | Bio-larvicide | 5% Wettable powder | 5 kg in 200 litres of water (250 gms in 10 litre of water) | 20cc | 1 litre | 200 litres | | Fortnightly | Knapsack/hand compression sprayer |
| 2 | *Bacillus thuringiensis* var. *israelensis* 5 % WP strain - ABIL, serotype H-14 accession No 01318 | Bio-larvicide | 5% Wettable powder | 7.5 kg in 200 litres of water (375 gms in 10 litres of water) for clean water | Do | Do | 200 litres | | Weekly | |
| | | | | 10 kg in 200 litres of water (500 gms in 10 litre of water) for Polluted water | Do | Do | 200 litres | | | |
| 3 | *Bacillus thuringiensis* var. *israelensis* 12 aqueous suspensions (12AS) | Bio-larvicide | Aqueous suspension | 1 litre in 200 litres of water (50 cc in 10 litre) for clean water | Do | Do | 200 litres | | Weekly | |
| | | | | 2 litre in 200 litres of water (100 cc in 10 litre) for polluted water | Do | Do | 200 litres | | | |

### 1.2.2. IVM in different situations

#### I. Epidemic situation

IVM is the primary strategy for preventing and managing outbreaks. It is used in order to minimize vector density and/or vector-human interactions to a level not posing public health risks. IVM is planned to use the best cost-benefit combination of all available control methods in a sustainable way. Some of the methods of IVM in disease outbreak situations such as environmental management, anti-larval measures, adult control and personal protection are effective in epidemic situations. Prevention and control of outbreak infections are complex therefore, multidisciplinary integrated surveillance systems and response plans are required.

#### i) Epidemic preparedness and response for malaria

Malaria outbreaks need to be prevented because, besides mortality, these inflict significant financial losses as well as time. The aim of public health personnel should be in the first place to perceive the impending epidemics as outlined and then make all efforts to prevent its outbreak (Figure- 17).

In epidemic-prone areas, a close collaboration must be established between the specialized anti-malarial services and the emergency preparedness teams. The specialized anti-malarial services can then assist in the identification of epidemic prone areas, the main risk factors, alarm signals, monitoring of risk factors, planning, implementation and evaluation of prevention or control measures. Measures for epidemic prevention and control can be implemented effectively by inter-agency co-ordination, with well-trained personnel, and with adequate supplies and equipment.

The recognition of an alarm signal in a situation of impending epidemic should be followed by the implementation measures, which consist of strengthening and initiation of vector control measures. The actions suggested are:

- Interrupt the transmission by undertaking appropriate space spray followed by Indoor Residual Spray (IRS) with a suitable insecticide. If regular spraying is not possible, focal spraying may be carried out.
- Intensify IEC to increase awareness about malaria, its control, motivate community to adopt preventive measures for vector control and to protect themselves from mosquito bite.

- In case of water logging, district administration may be approached to ensure drainage of the area immediately, taking help of concerned departments, since water standing beyond 7 to 10 days is likely to provide vector mosquito breeding.
- Close entomological monitoring may be done to assess the impact of intervention measures and vector bionomics (e.g., density, resting, feeding, breeding etc.).

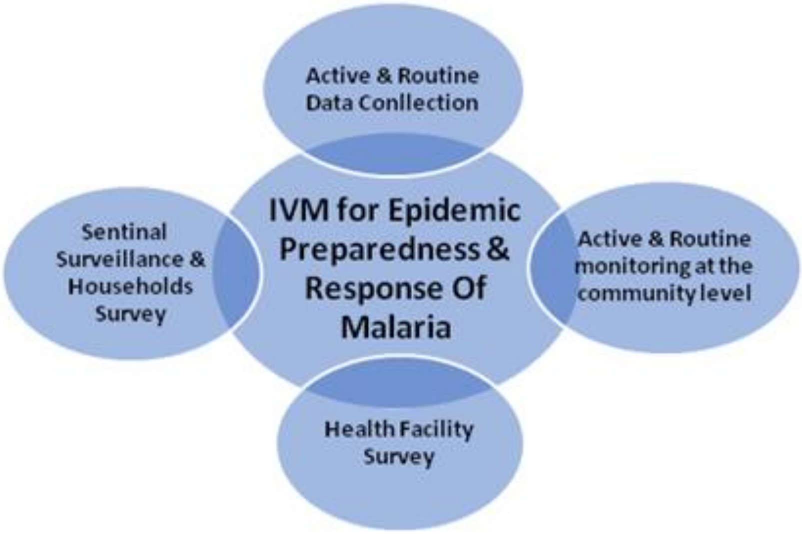



**Figure- 17: Role of IVM in epidemic preparedness and response of malaria**

- **Rapid Response Team (RRT)**

  RRTs should work in collaboration with the programme officer/consultant, with the aim of undertaking urgent epidemiological investigations and providing on-the-spot technical guidance and logistic support. The RRT at the district level will comprise of an epidemiologist, VDB consultant/Entomologist or VBD officer. At CHC/PHC level, RRTs may comprise a medical officer, health supervisors, laboratory technicians, IRS squads, insect collectors/field workers etc. The main function of the RRTs is rapid assessment and to support rapid response. It includes the following:

  - Rapid situation assessment
  - Carry out health education activities and community mobilization to sensitize and motivate the community for active participation in epidemic investigations and control.

- Support for the deployment of mobile workers and community health workers/volunteers to conduct household screening, treatment and targeted mass drug administration as required.
- Supervise implementation of repeated vector control measures and elimination of breeding places.
- Emergency logistic support for additional vector control, diagnostic and drug supplies at community level as well as to health facilities.
- Undertake epidemiological and entomological investigations to prepare outbreak reports.

**ii) Epidemic preparedness and response of dengue and chikungunya**

For any emergency regarding epidemics and outbreaks of diseases like dengue and chikungunya, preparation should be made well in advance. Entomological surveillance of larvae and adults should be carried out on a routine basis. A larval survey comprised of implementing anti-larval measures like source reduction, using chemical or biological larvicide, adopting larvivorous fish and proper environmental management to keep ourselves well prepared. At the same time, implementation of anti-adult measures like indoor space spraying, and fogging is also very important.

Different forms of supporting interventions are very important components of epidemic preparedness and response. Capacity building includes the availability of skilled technical and medical staff for emergencies, bringing changes in behaviour regarding hygiene and mosquito elimination. Social and community-level awareness regarding vector control measures and conducting awareness programmes is also recommended. At the same time, there should be resource sharing and co-ordination between different stakeholders.

**II. Endemic situations**

In endemic situations, the most common forms of IVM approaches used are environmental management like modification and manipulation of vector breeding habitats, chemical control e.g., larvicide and adulticide, and biological control agents can be used to kill vectors. IRS is a highly effective and proven measure for controlling malaria and kala-azar disease epidemics. It involves spraying residual insecticides on the interiors of house walls to kill mosquitoes, thereby interrupting the transmission of disease to humans. When insecticide resistance to one class of insecticide is detected, rotating or switching to another class of insecticide suggested for mitigating resistance in vectors population.

### 1.2.3 Organization and management

#### 1.2.3.1 Introduction

IVM requires the integration of various vector control methods covering numerous diseases with many partners in order to attain its objectives by using resources efficiently and safely. IVM approach requires new organizational structures, roles and responsibilities in the health sector, between other partner sectors as well as community participation. Following section defines how IVM can be incorporated and organized within the health systems, and how partnerships and links for IVM with other public sectors and institutions can be established and managed (Manga et al., 2004).

**Techniques used in the implementation of IVM**

IVM involves the optimal use of three elements, which are local information, methods of proven effectiveness and the evidence-based further innovation. For example, human resources and institutional capacity might require strengthening as the problem-solving approach might be weak, or opportunities for learning and participation might be lacking (WHO, 2011). In the IVM management approach, three basic components, each with sub-elements are shown in Figure- 18.


**Figure- 18: Model for IVM**

#### 1.2.3.2 Collaboration of the health sector

**At central level**

It is normally the health sector and its entomological units, which take the lead in an IVM strategy at the central level. Internal relations decide how to coordinate vector control, when to make operational decisions and how to integrate vector control and emergency response into a single disease system. There are two basic scenarios where the preferable one is the existence of a substantive unit or core group for vector control at the central level (national/state) with cross diseases and the less preferable is disease-specific vector control unit. When health systems build capacity for disease control, opportunities for control and emergency response to multiple diseases borne by vectors are developed. IVM approach is supportive in health sector reformation although, in a decentralized system, the central ministry maintains an important role as mentioned in Table- 8 in terms of:

- Preparing policy and guidance
- Reviewing job descriptions and terms of reference
- Facilitating planning and implementation in districts
- Preventing and responding to epidemics
- Providing supplies and technical support

**At local level**

IVM involves the integration of disease-specific vector control programmes and surveillance services within a decentralized health system. This embedding of IVM in local health systems requires new skills and capacities for analysis and decision-making. Nevertheless, public health staff in districts and villages could be trained in the technical, operational and managerial aspects of IVM, giving rise to the local leadership of IVM. The IVM thus contributes to making health offices more capable and less dependent on centralized expertise, because it adds analytical and decision-making skills and contributes to partnerships with other sectors and communities.

The reach of health services will be extended through the new structures, partnerships and community participation in the IVM strategy, and this extended reach could result in cost savings and synergies. For example, vector control and vector surveillance activities in villages could become a platform for the delivery of other community health services. This brings health services closer to the community, and these changes will also increase motivation.

**Table- 7: Core functions required for IVM at central and local levels**

| Level | Function |
|---|---|
| **National/State** | - Advocacy<br>- Setting strategic directions and conducting overall evaluation<br>- Advising on policy and institutional arrangements<br>- Conducting epidemiological and vector assessment, stratification<br>- Supervising decentralized planning and implementation<br>- Supervising decentralized monitoring and evaluation<br>- Supervising decentralized organization and management<br>- Preparing curricula and training trainers<br>- Ensuring preparedness to coordinate emergency response<br>- Advising on research priorities |
| **District/Village** | - Advocacy<br>- Establishing intersectoral partnerships and networking,<br>- Planning and implementing local IVM strategy<br>- Implementing health interventions, monitoring and evaluating<br>- Organizing and managing<br>- Undertaking local vector surveillance and providing training<br>- Education and awareness-raising |

### 1.2.3.3 Intersectoral collaboration

An IVM strategy calls for collaboration between the health, other sectors and civil societies as shown in Table- 9. This implies new links, roles and responsibilities, which may require changes in job descriptions or terms of reference.

**Table- 8: Intersectoral collaboration between sectors and their roles**

| Sl. No | Sector/Agency | Roles |
|---|---|---|
| **1** | Agriculture | • Pesticide management and judicious use of pesticides<br>• Farmer field schools to implement Integrated Pest and Vector Management<br>• Popularizing the concept of dry-wet irrigation through extension education |
| **2** | Water resource development | • Maintenance of canal system in intermittent irrigation<br>• Design modifications and improvement of canals lining<br>• De-weeding for proper flow<br>• Creating small check-dams away from human settlements |
| **3** | Water supply | • Repairing leakages to prevent pooling<br>• Restoration of taps<br>• Diversion of wastewater to ponds/pits<br>• Staggering of water supply<br>• Mosquito proofing of water harvesting devices<br>• Repairing of sluice valves |
| **4** | Urban development | • Improved designing to avoid undue water logging<br>• Issue of building use permission after clearance from the health department<br>• Safe rainwater harvesting<br>• Mosquito-proof design of dwellings |
| **5** | Industry/mining | • Improving drainage and sewerage systems<br>• Safe disposal of used containers / solid wastes<br>• Mosquito proofing of dwellings<br>• Safe water storage and disposal<br>• Use of ITNs/LLINs |
| **6** | Railways | • Proper excavations<br>• Maintenance of yards and dumps and anti-larval activities in areas within their jurisdiction<br>• Housing for health safeguards<br>• Promotion of the use of ITN/LLINs amongst the railway employees |
| **7** | Environment/ forest | • Pesticide management policy<br>• Environment management policy<br>• Reclamation of swampy areas<br>• Social forestry |
| **8** | Fisheries | • Institutional help<br>• Training in mass production of larvivorous fishes<br>• Promotion of composite fish farming schemes at the community level |

| | | |
|---|---|---|
| **9** | Road and building sector | • Proper planning<br>• Merging pits by breaking bunds<br>• Excavations in line with natural slope/gradient<br>• Making way for water to flow into natural depressions/ ponds/river<br>• Follow-up action after excavations |
| **10** | Remote sensing | • Technical help and training in mapping environmental changes and VBD risk using GIS |
| **11** | Education | • Vector control teaching in educational curriculum<br>• Issuing directions for the monthly drive on cleaning school premises, cleanliness of surroundings and checking water containers for mosquito breeding<br>• Incorporation of vector control activities in the training curriculum of ICDS functionaries under the Department of Women & Child Development as well as their involvement in vector control activities |
| **12** | Mass media | • IEC activities<br>• Advocacy |
| **13** | Local self-government (panchayati raj institutions) | • Monitoring of surveillance and interventions<br>• Advocacy on vector control<br>• Community education and awareness<br>• Motivating the community for the acceptance of IRS<br>• Promotion of larvivorous fish in permanent water bodies |
| **14** | Village councils | • Overall cooperation in the ongoing malaria programme like IRS, ITN<br>• Ensuring public participation as and when needed |
| **15** | Local governments/ corporations/ municipality | • Coordinated action for vector control in urban areas |
| | Health (NRHM) | • Promoting ITNs/LLINs through health and family welfare services, IMCI, IMNCI |
| **16** | Village health and sanitation committee | • Coordinated action for vector control in villages by utilizing untied funds |
| **17** | Rogi kalyan sammittee (block) | • Improved referral services by providing transport facilities for complicated cases<br>• Coordinated action for malaria control activities by utilizing funds under flexipool |
| **18** | IMCI, IMNCI | • Promoting ITNs/LLINs through Health and Family Welfare services, IMCI, IMNCI |

| | | |
|---|---|---|
| **19** | ICMR/Medical colleges | • Need based operational research |
| **20** | NGOs/ FBOs/CBOs | • Community mobilization<br>• Promotion of programme activities<br>• Village level training<br>• Distribution of IEC material, monitoring and evaluation<br>• Feedback on achievements |
| **21** | Military/Police | • Improved referral services by providing transport facilities for complicated cases<br>• Coordinated action for vector control in inhabitation areas<br>• Promoting ITNs/LLINs<br>• Safe water storage and disposal<br>• Removal of junk yard of old/accidental vehicles<br>• Complying with full sleeves dress code |

All sectors should be strongly encouraged to conduct a health impact assessment of their activities to identify any risks for vector-borne diseases in order to reduce the risks (Herdiana et al., 2018). For example, irrigation management and certain agricultural practices; rural development programmes or construction projects could prevent vector breeding by adopting new standards or educating communities.

**a) Establishing collaboration**

Establishing formal collaboration between the health and other public sectors is an important step in increasing the participation of those sectors in vector control. As mentioned above, collaboration at the national level could take the form of an intersectoral steering committee on IVM, with a memorandum of understanding.

Partnerships at district or sub-district levels could include representation from both public sectors and civil society.

Partnerships at the village level usually consist of:

i. Civil society organizations
ii. Community representatives
iii. Village leaders

To achieve their vector control objectives in each sector, village-level partnerships should establish strong links with public sector offices and district authorities.

Training on basic IVM is required through partners before conducting IVM activities. The purpose of training includes necessary knowledge and skills for the participants, increasing their status, and motivation and fostering group or team spirit needed to establish partnerships. The role of partnerships is:

- To conduct joint planning, evaluation and mapping
- To collaborate in an implementation where appropriate
- To comply with the agreed actions and timetables

The partnership, probably with the health office as its leading entity, must ensure that vector control activities are planned, implemented and evaluated in a coordinated way, to ensure that the joint efforts are consistent and complementary for achieving common goals. To reinforce the partnership, measures could be instituted to ensure that all partners adhere to the agreed standards and activities. Formal village-level partnerships should be recognized officially by district authorities and their actions recognized in the context of the national IVM strategy. Conceptual framework of intersectoral collaboration is explained in Figure- 19.

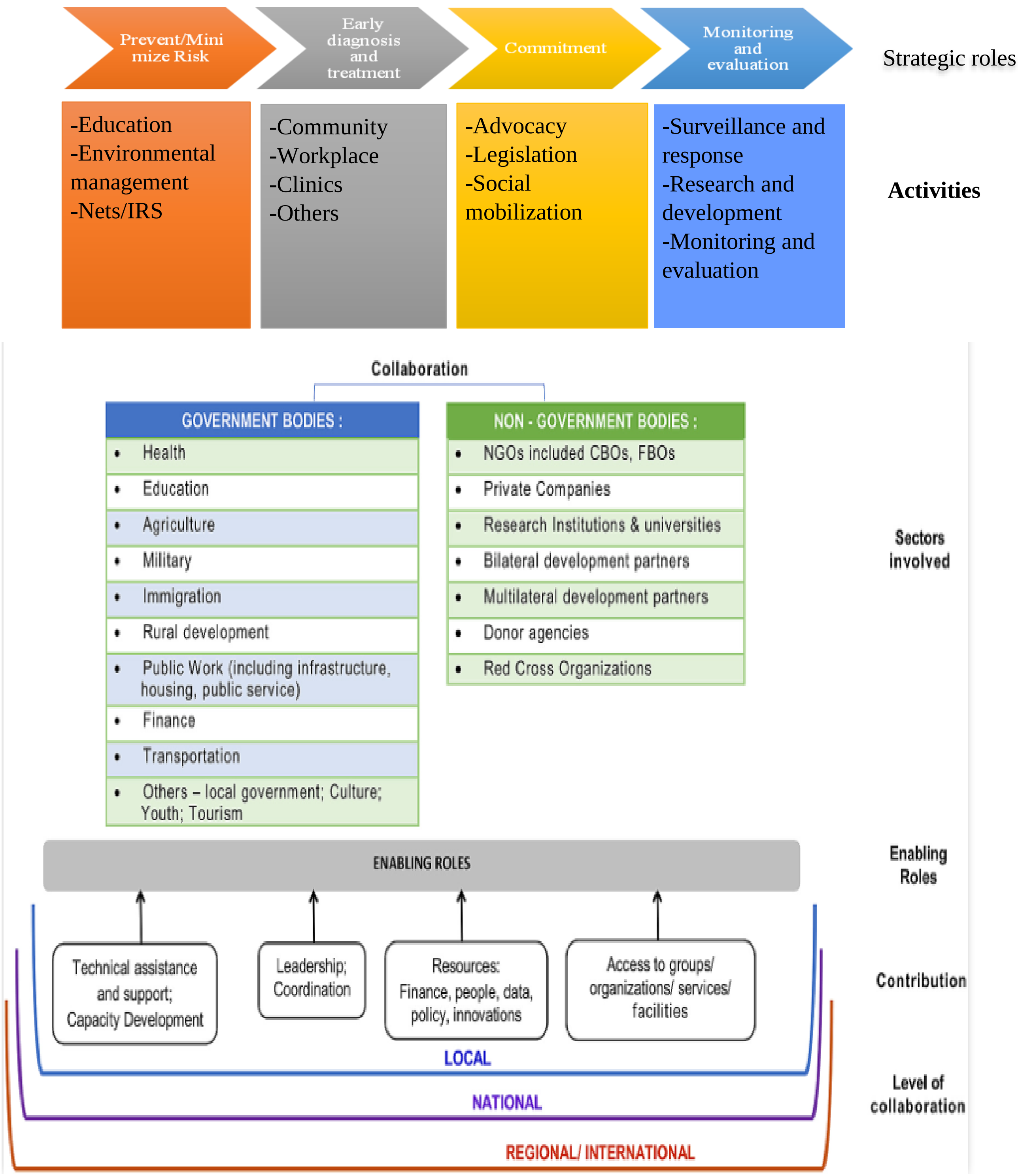



**Figure- 19: Conceptual framework of intersectoral collaboration**

### 1.3 Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is an ecosystem-based strategy that focuses on the long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. IPM is a process to solve pest problems while minimizing risks to people and the environment. Pesticides are used only after monitoring according to established guidelines with the goal to remove only the target organism in a manner that minimizes risks to human health, beneficial organisms, and the environment. Indiscriminate and injudicious use of chemical pesticides in agriculture has resulted in several associated adverse effects such as environmental pollution, ecological imbalances, pesticides residues in food, fruits and vegetables, fodder, soil and water, pest resurgence, human and animal health hazards, destruction of bio-control agents, development of resistance in pests etc. Therefore, Govt. of India has adopted Integrated Pest Management (IPM) as a cardinal principle and main plank of plant protection in the overall Crop Production Programme since 1985. IPM is an eco-friendly approach, which encompasses cultural, mechanical, biological and need-based chemical control measures. (http://ppqs.gov.in/divisions/integrated-pest-management/ipm-glance).

Department of Agriculture, Cooperation & Farmers Welfare (DAC&FW) in the Union Ministry of Agriculture & Farmers Welfare promotes the Integrated Pest Management (IPM) approach under the scheme "Strengthening & Modernization of Pest Management" through 35 Central Integrated Pest Management Centres (CIPMCs) located in 28 States and 2 Union Territories. The mandate of these Centres is pest/disease monitoring, production and release of bio-control agents, conservation of bio-control agents and Human Resource Development in IPM by imparting training to Agricultural Extension Officers and farmers at the grassroots levels by organizing Farmers' Field Schools (FFSs) in the farmers' fields (http://ppqs.gov.in/divisions/integrated-pest-management/overview-and-activities).

IPM can be used to manage all kinds of pests anywhere in urban, agricultural, and wild land or natural areas. IPM offers the opportunity to eliminate or drastically reduce the use of pesticides, and to minimize the toxicity and exposure to any product, which is used.

With IPM, we can take actions to keep pests from becoming a problem, such as by growing a healthy crop that can withstand pest attacks, using disease-resistant plants, or caulking cracks to keep insects or rodents from entering a building. Following are some of the integrated pest control measures:

**a) Biological control**

Biological control is the use of natural enemy predators, parasites, pathogens, and competitors to control pests and their damage. Invertebrates, plant pathogens, nematodes, weeds, and vertebrates have many natural enemies.

**b) Cultural control**

Cultural controls are practices that reduce pest establishment, reproduction, dispersal, and survival. For example, changing irrigation practices can reduce pest problems. Mud plastering/white wash/painting on festival occasions.

**c) Mechanical and physical control**

Mechanical and physical controls kill a pest directly, block pests out, or make the environment unsuitable for it. Traps for rodents are examples of mechanical control. Physical controls include mulches for weed management, steam sterilization of the soil for disease management, or barriers such as screens to keep birds or insects out.

**d) Chemical control**

Chemical control is the use of pesticides. In IPM, pesticides are used only when needed and in combination with other approaches for more effective, long-term control. Pesticides are selected and applied in a way that minimizes their possible harm to people, non-target organisms, and the environment. With IPM use, the most selective pesticide that will do the job and will be the safest for other organisms and air, soil and water quality; use pesticides in bait stations rather than sprays, or spot sprays a few weeds instead of an entire area.

### 1.3.1 IPM programme

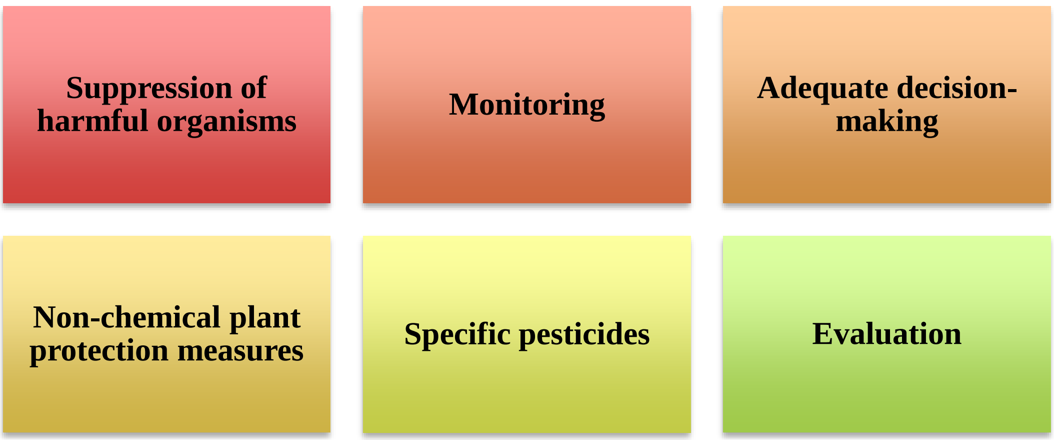
IPM principles and practices are combined to create IPM programmes. While implementing IPM each situation is different and generally, six major components are common to all IPM programmes (https://www2.ipm.ucanr.edu/What-is-IPM/):

1. Pest identification
2. Monitoring and assessing pest numbers and damage
3. Guidelines for when management action is needed
4. Preventing pest problems
5. Using a combination of biological, cultural, physical/mechanical and chemical management tools
6. After the action is taken, assess the effect of pest management.

The government of India promotes IPM for:

- Development of infrastructure; establishment of Central Integrated Pest Management Centers (CIPMCs).
- Human resource development through a three-tier programme that consisted of season-long training for subject matter specialists.
- Establishment of Farmer Field Schools (FFSs) to train farmers and conduct demonstrations for the adoption of field-tested IPM technologies.
- Policy support to promote needs-based pesticides and phase out the use of hazardous pesticides.

Following are factors are to be considered:




### 1.3.2 IPM implementation

Prevention or suppression of harmful organisms should be targeted and achieved by combining various options such as:

- Crop rotation and intercropping;
- Use of adequate cultivation techniques (e.g., Seedbed sanitation, sowing/planting time and plant densities, under-sowing, conservation tillage, pruning and direct sowing);

- Where appropriate, the use of resistant/tolerant cultivars and standard/certified seed and planting material;
- Providing balanced nutrient supply and optimal water management;
- Preventing the spread of harmful organisms through field sanitation and hygiene measures (e.g., removal of infected plants, plant parts and plant debris and regular cleaning of machinery and equipment);
- Protecting and enhancing beneficial organisms (e.g., utilization of "ecological services" inside and outside production sites).

### 1.3.3 Monitoring

Harmful organisms should be monitored with adequate methods and tools, wherever available. These should include observations in the field (e.g., occurrence of pests, appearance of symptoms) and, where feasible, scientifically sound warning, forecasting and early diagnosis systems (consisting of traps, weather stations etc.) (Figure- 20). Regular consultancy with professionally qualified advisors is also recommended (for further information on monitoring see chapter 3).

**Figure- 20: Monitoring and evaluation of IPM (National Institute of Plant Health Management- NIPHM)**

#### a) Adequate decision-making

Based on the results of the monitoring and the consideration of local conditions (e.g., cropping system, weather) proper decisions should be made about the need for, timing and methods of pest management. Where feasible, threshold values for harmful organisms should be defined and considered, taking considering the given growing conditions before any treatments.

**b) Non-chemical plant protection measures**

Sustainable physical, biological and other non-chemical methods should be preferred to chemical ones, and also provide satisfactory pest control. As chemical pesticides are designed to be toxic to living organisms, are dispersed in the environment and are applied to food crops, their use should only be a last resort; used only if there are no adequate non-chemical alternatives and if it is economically justified. If the application of pesticides is foreseen, a pest management plan needs to be prepared.

**c) Specific pesticides**

If the use of chemical pesticides is deemed to be justified, then careful and informed consideration should be given to the selection of pesticide products. Factors to be taken into account include hazards and risks to users, selectiveness and risks to non-target species, persistence in the environment, efficacy and the likelihood of development or presence of resistance in the target organism. The pesticides to be applied should be specific to the target agent and have minimal effects on human health, non-target organisms (e.g., predators, parasitoids, pollinating insects) and the environment (e.g., water, soil) (Figure- 21). Their use should be kept to a minimum by reducing the application frequency or using partial applications. If repeated application of chemicals is justified and required, pesticides with different modes of action (see WHO and EPA toxicity classification schemes) should be applied as part of an anti-resistance strategy to maintain the effectiveness of the available products (WHO, 2008).

| |
|---|
| Note: The products to be applied should be registered in the country of use, or specifically permitted by the relevant national regulatory authority, if no registration exists. The use of any pesticides should comply with all the registration requirements including the crop and pest combination for which it is intended. |

**Figure- 21: Farmers learning IPM (Source: NIPHM)**

### 1.3.4 Evaluation

The efficacy of the applied plant protection measures should be checked and evaluated based on the records on the use of pesticides and the monitoring of harmful organisms. This will help farmers to improve future pest management methods by making use of their knowledge and experience gained (FAO/WHO, 2002).

## 1.4 Vector management through the FFS approach

Farmer Field School approach under the advent of IPVM provides an opportunity to test and/or establish a community-based surveillance system. Surveillance could benefit from the involvement of communities through the development of local capability for monitoring and evaluation. This would provide better coverage and intervals of data collection. Stronger knowledge based and sustained community participation in managing disease vectors is of utmost importance. Despite their different goals of raising agricultural productivity and reducing health risks due to VBDs, the sectors of health and agriculture share the future objective of enhancing the role of rural communities in sound ecosystem management.

### 1.4.1 Concept of Farmer Field School (FFS)

The IPM using the FFS approach includes providing practical, field-based education to farmers at weekly meetings. Through these sessions' farmers learn the requisite skills to evaluate their ecosystems and make evidence-based decisions to grow healthier crops while relying less on agrochemical inputs (Figure- 22). The FFSs introduced in Sri Lanka in 1995 with technical assistance by FAO of the United Nations. An 82%

reduction in the frequency of insecticide applications and a 23% increase in yield have been attributed during five years period. A pilot project on IPVM that started in Sri Lanka in 2002 has been unique in educating farmers about agriculture and public health by involving farmers in vector-management activities, which was funded by FAO, UNEP and WHO (Van Den et al., 2006).

**Figure- 22: Farmers Field School programme**

FFS is group-based learning process that has been used by a number of government institutions, NGOs, and international agencies to promote IPM (Figure- 23). The first FFS was designed and managed by the UN Food and Agriculture Organization in Indonesia in 1989, since then, more than two million farmers across Asia have participated in this type of learning. The FFS approach is an innovative, participatory and interactive learning approach, which highlights problem solving and discovery-based learning. FFS aims to build farmers' capacity to analyze their production systems, identify problems, test possible solutions and eventually encourage participants to adopt the practices most suitable to their farming systems. FFS also provides an opportunity for farmers to practice and evaluate sustainable land use and introduce new technologies by comparing their conventional technologies developed with their local traditions and culture.

FFS is usually a time bound activity (generally one agricultural production cycle or a year), involving a group (commonly 20 to 30 farmers). It is facilitated by extension staff or increasingly by farmer facilitators (FFs). The method emphasizes - group observation, discussion, analysis, presentation, collective decision making and actions.

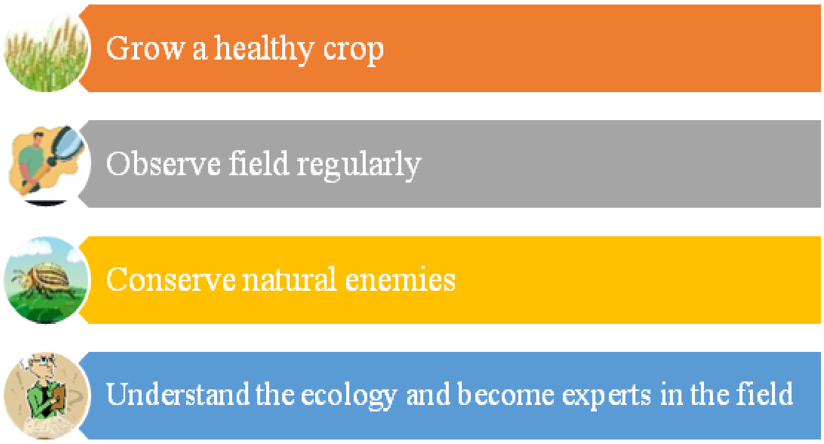
**Figure- 23: Participation of farmers in FFS**

**Problems in agricultural fields**

Irrigated cultivation on the field level raises many public health threats associated with human disease vectors. Therefore, the judicious use of pesticides in agriculture is vital to protect public health. Paddy field, irrigation systems and peri-domestic environment promote the breeding of vectors of malaria, lymphatic filariasis, Japanese encephalitis and dengue (Amerasinghe, et al., 1999; Ijumba, et al., 2001; Keiser, et al., 2005; Erlanger TE et.al., 2005). In addition, the use of insecticides can cause acute poisoning and leave toxic residues in food; resistance may develop in vector populations against the insecticides used for control and biodiversity can decline, which may lead to the resurgence of mosquitoes (Service, 1977). Convergence between IPM strategies and IVM strategies is therefore required to help farmers develop their agricultural practices while minimizing environmental health risks.

### 1.4.2 Farmer Field School principles

FFS training methodology is based on learning by doing, through discovery, comparison and a non-hierarchical relationship among the learners and trainers, which is hence carried out almost entirely in the field. Following are the major steps (Figure-24) and principles of Farmer Field School:



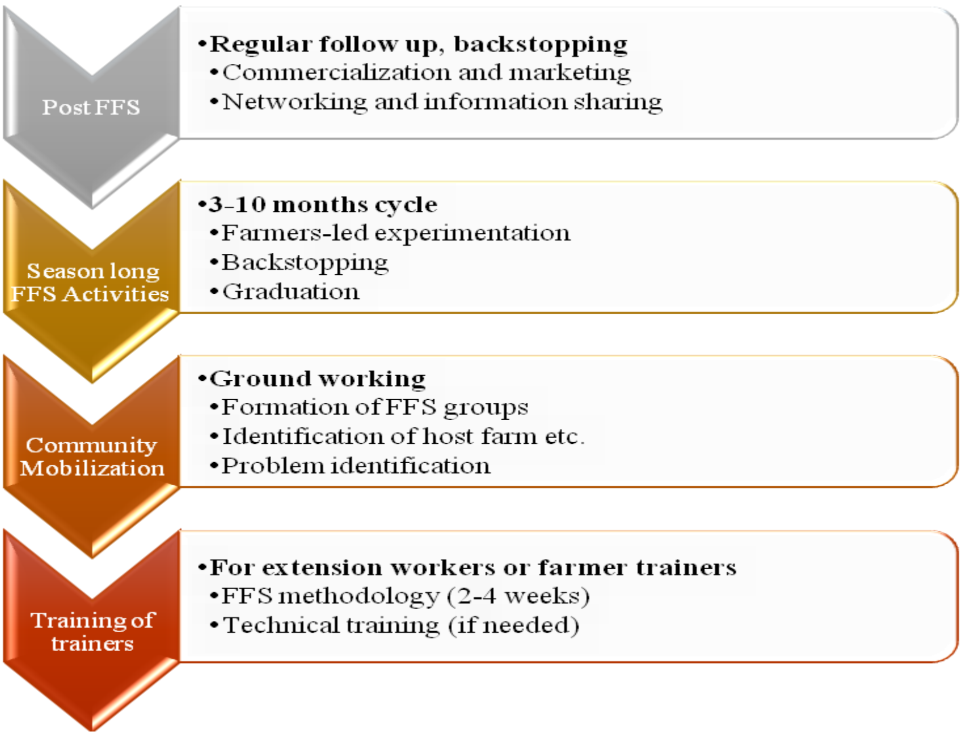




**Figure- 24: Major steps in FFS implementation (NIPHM)**

### 1.4.3 Convergence between agriculture and health

IPM Farmer Field Schools have been implemented by the agricultural sector without direct linkages with the health sector. In parallel, the anti-malaria, filaria and kala-azar campaigns being conducted are their health-related activities. Its regular activities by the malaria officers and their entomological teams are:

- Routine entomological surveys for the major VBDs
- Community health activities to distribute bed nets and increase awareness about personal protection
- Coordination of spray operations (in high transmission risk areas)

FFS have been effective in addressing pest problems in irrigated rice production systems in Asia. As farmers' understanding of ecological interrelationships grew, they realized that the reduced use of pesticides permitted the development of larger populations of beneficial species capable of controlling pests. Figure- 25 depicts possible field-level effects, indirect outcomes and ultimate health effects of Farmer Field Schools on IPVM.

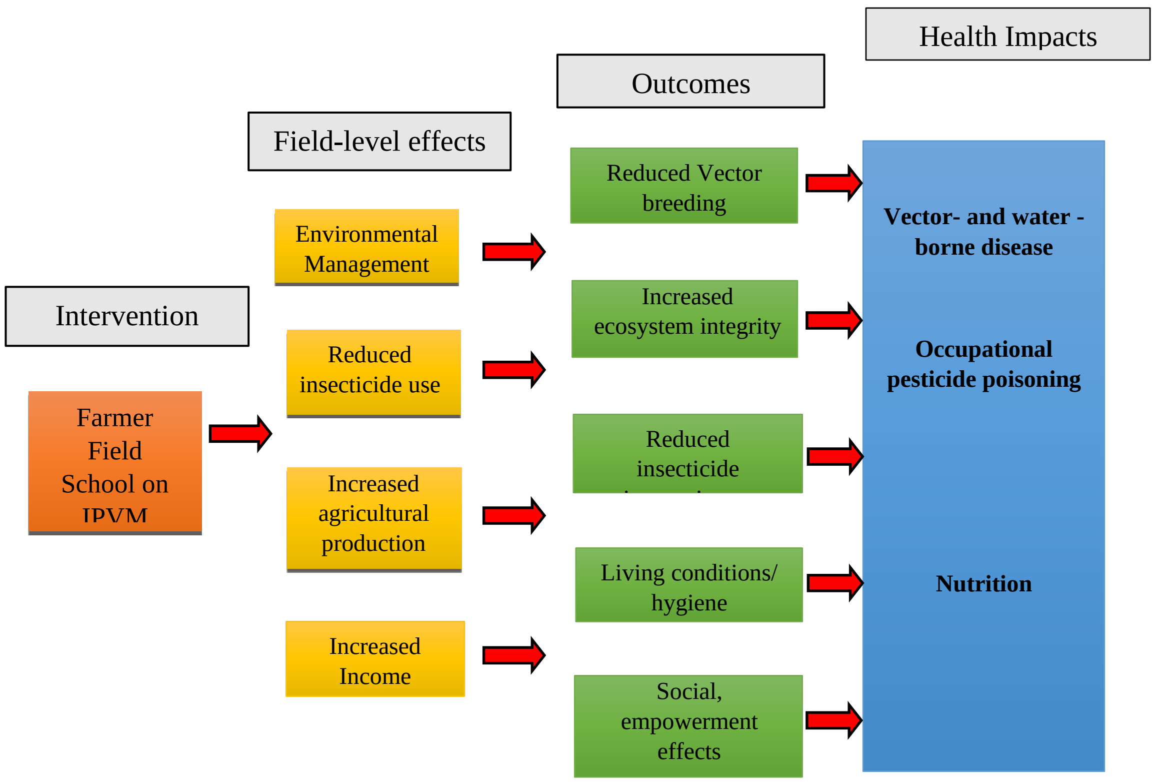



**Figure- 25: Farmer Field School effects on IVPM (Source: WHO)**

IPVM Farmer Field Schools are expected to affect environmental management and crop management practices. The consequences of these effects are reduced vector breeding, increased ecosystem integrity, reduced risk of insecticide resistance, increased personal protection, living conditions, and social and empowerment effects. These outcomes influence health with regard to VBDs, pesticide poisoning, food safety, nutrition and mental health.

### 1.5 Behavior Change Communication (BCC)

#### 1.5.1 Introduction

It is based on information, education and communication strategies, with components of inter-personal communication between community and health workers, which comprises social and community mobilization. BCC strategy is to focus targets on specific individual households and communities to optimize health intervention outcomes.

BCC is a proved component for VBD control by the community through its participation. BCC's efficiency can be used to develop better methods for vector control and reduce transmission of the disease. The peripheral staff like ASHA, USHA, MPHW and so on should be used for improving BCC (Bilal et al., 1994).

#### 1.5.2 Objective

The objective is to improve access to information, and service and change the behavior in the community. BCC changes human behavior to reduce vector population and disease transmission, increasing compliance with interventions and motivation for vector control activities and removing incorrect and wrongly guided methods of vector control. It is important to provide access to information and services on VBDs and ensure mutual interaction and communication.

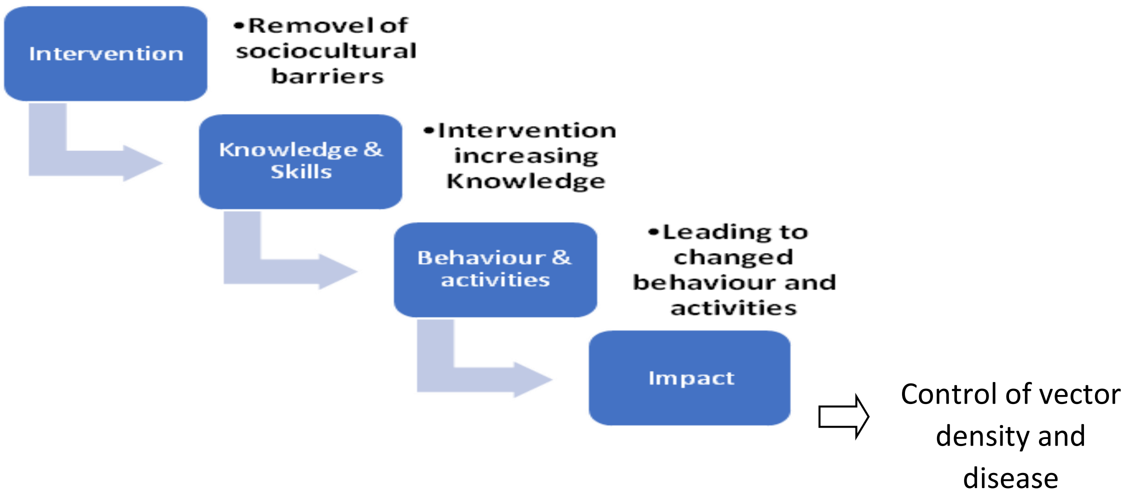



**Figure- 26: Outcomes of intervention**

Designing intervention to remove socio-cultural barriers generally focus on improving the knowledge and skills of the community. This leads to a change in the behavioral activities that will reduce the VBDs (Figure- 26).

### 1.5.3 Tools of BCC

There are four tools discussed in this part such as media information; education and communication; communication for behavioral impact; Farmer Field Schools.

#### a) Media information

The media such as radio and television broadcasts can be used to create awareness about IVM and IVPM in the community.

#### b) Education & communication

Information, Education and Communication (IEC) approach empowers the society as a whole to improve its attitude and behavior to protect their health.

#### c) Communication for behavioral impact

Communication for behavioral impact is an education-based approach to communication and social mobilization. It analyses to determine behavioral barriers in a certain group and is based on the principles of integrated marketing communication used in the private sector to influence consumer behaviour. It is a tool of proven efficacy for achieving desired behavior in relation to vector-borne disease. This is useful for achieving the desired behaviour.

#### d) Farmer Field Schools (FFS)

First FFS was established in 1989 and now this concept has widespread in 87 countries. FFS were set by the food and agriculture organization of the United Nations in Asia to educate farmers about IPM. Farmers learn to adapt to the practices of IPM and contemporary conditions such as crop cycles. Groups of farmers meet weekly to observe the agro-ecosystem and to discuss the results of the methods adopted. Based on the findings through observations and analysis, FFS adopt appropriate methods of vector control suitable to the conditions of that particular area (Hagiwara et al., 2011; FAO 2006 and 2019).

### 1.5.4 Accredited Social Health Activist (ASHA)

ASHA is one of the largest community-based health workforces in the health activities, as a volunteer of the national rural health mission in the government of India. The ASHA will be involved in the diagnosis, treatment, prevention and control of infectious diseases especially malaria on a day-to-day basis. ASHAs are trained under the national health mission (NHM) on the prevention and control of VBDs by NCVBDC along with special training in high malaria endemic areas. The skill-based training lays special focus on correct use of RDT, preparation of quality blood slides and treatment of positive cases with appropriate treatment as per the national drug policy.

ASHA submits the information regarding slides prepared, RDT performed and treatment completed based on records maintained by her in the register. ASHA's performance is monitored by MO, PHC and other officers, which provides supportive supervision to ASHA and improves her skills.

### 1.5.5 Multipurpose Health Workers (MPHW)

The concept of MPHW was introduced in 1974 for the delivery of preventive and promotive health care services to the community at the level of sub-health centres (SHCs). The multipurpose health worker is the grass root health functionary for the control of communicable diseases including VBDs, as well as environmental sanitation, health education, detection of disease outbreaks and their control as per the national guidelines (NVBDCP, 2012; Ministry of Health and Family Welfare, 2010). MPHWs educate the community about the signs, symptoms, treatment, prevention and control of VBDs.

# 2. Planning and implementation

**Learning Objective**

By the end, participants should be able to describe……

1. Planning of IVM on the basis of epidemiological and entomological parameters
2. Different vector control tools in IVM
3. Implementation of vector control methods with involvement of public health sector
4. Concept and implementation IVPM in district level and coordination with Farmer Field School (FFS)

## 2.1 Introduction

Integrated Vector Pest Management (IVPM) implementation depends on types of intervention, management of resources and stakeholder's participation. Programme should be based on valid, accurate observations, data and proper analysis at the local level. The operational steps to be conducted at the district or village level comprises analysis and mapping of local disease determinants, selection of vector control methods, assessment of available resources, implementation of a local IVM strategy, monitoring and evaluation (Figure- 27).

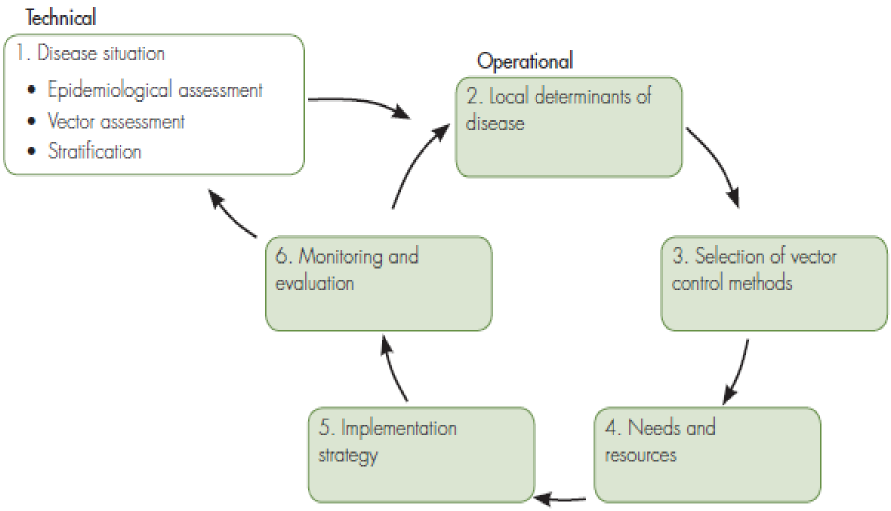



**Figure- 27: Planning and implementation of vector control management (Source: WHO)**

### 2.2 Epidemiological assessment

Epidemiological assessment is a process to determine the actual burden of disease. The purpose is twofold:

i. To assist in decision-making on resource allocation
ii. To allow evaluation of the impact of the intervention strategy

Epidemiological investigations can provide strong evidence linking exposure to the incidence of infection in a population. Without a solid epidemiological assessment, it will be difficult to plan IVM effectively (WHO, 2012).

#### a) Measures of disease occurrence

The two predominant measures of disease occurrence are prevalence and incidence. The burden of disease is measured from data on disease incidence, prevalence and mortality, supplemented with information on work days lost, school days lost, seasonal variation, sub-populations affected and the proportion of outpatients affected.

| Concept | | Definition | Formula |
|---|---|---|---|
| Prevalence | Point Prevalence | Proportion of people in a population having disease at a particular point in time | $\frac{\text{Number of persons having disease at a particular point in time}}{\text{Total number of persons in apopulation}}$ |
| | Period Prevalence | Proportion of people in a population having disease over a period time | $\frac{\text{Number of persons with disease at start of the period + No. of persons develoing disease over the time}}{\text{Total number of persons in apopulation}}$ |
| Incidence | Risk | Probability of developing a disease | $\frac{\text{Number of persons developing disease during a time period}}{\text{Numberof subjects followe for the time period}}$ |
| | Incidence rate | Ratio of the number of cases to the time at risk for disease | $\frac{\text{Number of persons developing disease}}{\text{Total time at risk for the subject followed}}$ |

#### b) Estimation of disease occurrence

There are different approaches for estimating disease occurrence in a population as mentioned in Table- 9. The choice of approach will depend on many different factors such as the number of resources available and the accuracy of the result required.

**Table- 9: Different approaches for estimating disease occurrence**

<table>
<tr><th>Sl. No.</th><th>Approach</th><th>Details</th></tr>
<tr><td>1</td><td>Case study</td><td>• Enable the researcher to know whether or not a particular health event should be included in the analysis<br>• Based on symptoms<br>• Include age ranges, geographical location or dates of onset</td></tr>
<tr><td rowspan="3">2</td><td>Primary survey</td><td>• Where prior information is not available or suspected to be unreliable, it is essential to collect data directly from the population concerned<br>• Involves a questionnaire</td></tr>
<tr><td>Cross-sectional studies</td><td>• Estimate of disease incidence or prevalence in a community.<br>• Can be conducted using various ways of contacting the participants.<br>• Choice of approach will depend on resources available, costs and existing communications.</td></tr>
<tr><td>Cohort study</td><td>• Follows a group of individuals over a period of time<br>• Researchers monitor for the appearance of the disease outcome of interest<br>• Simplest method is to repeat the visit of the researcher who may contact the participant by phone, post or visit everyone or more weeks</td></tr>
<tr><td>3</td><td>Sampling</td><td>• Part of statistical practice concerned with the selection of individual observations intended to yield knowledge about a population of concern, especially for purposes of statistical inference<br>• The sampling method will depend upon a number of factors, including time, resources and study design<br>• The sample chosen for analysis should be representative of the population under study and large enough to make statistical inference<br>• Different sampling methods:<br>    • Simple random sampling<br>    • Systematic random sampling<br>    • Stratified random sampling<br>    • Cluster random sampling<br>    • Multistage random sampling<br>    • Sampling for telephone interviews</td></tr>
</table>

## 2.3 Entomological assessment

Surveillance of vectors is important in determining the distribution, population density, larval habitats, and insecticide resistance in order to prioritize vector control in terms of time and space. The selection of appropriate sampling methods depends on surveillance objectives, levels of infestation and availability of resources. The collection of adult mosquitoes is made for

i. **Qualitative studies**- To study the prevalence, distribution, and behaviour of different mosquito species in different macro and micro environmental conditions
ii. **Quantitative studies**- To study the vector density and abundance, longevity, infectivity, impact of anti-vector measures on vector population and impact on transmission

Several methods for sampling mosquitoes, which are undertaken alone or in combination with others depending on the objective of the survey are given in Table-10.

**Table- 10: Different methods and collection strategies for targeted insects**

| Sl. No. | Targeted insect | Types of collection | Methods |
|---|---|---|---|
| 1 | **Collection of mosquitoes** | Hand collection | Aspirator tube/ mechanical aspirator |
| | | | Test tube |
| | | | Catches off baits |
| | | | Spray sheet collection |
| | | Trap collection | Window trap |
| | | | Magoon trap |
| | | | Light trap |
| | | | Hop cage |
| 2 | **Collection of larvae** | Hand collection | Dipping |
| | | | Netting |
| | | | Pipetting |
| 3 | **Collection of adult Sandfly** | Trap collection | Sticky trap |
| | | | Illuminated sticky trap |
| | | | Light traps |
| | | | Funnel traps |

### 2.3.1 Xeno-monitoring or xeno-surveillance

Entomological techniques are also useful for the lymphatic filariasis programme in a more indirect way. Direct assessment of worms in vector mosquitoes with polymerase chain reaction (PCR) techniques is increasingly used to detect the recurrence of new infections during post-MDA surveillance. This tool is called xeno-monitoring or xeno-surveillance. Samples are usually examined in pools; the pool size is determined by the estimated prevalence of infection. The collection sites must be representative and widespread because of the heterogeneity in infection rates in humans. A standard protocol for sampling and testing needs to be made available with more diagnostic centers and facilities. Vector incrimination consists of determining whether a species acts as a vector of disease in real-life circumstances. It involves:

- Studying the association of the species with humans in space and time
- Direct contact with humans
- Evidence of pathogens inside the vector

Vectors have preferences for breeding in certain microhabitats. The seasonal fluctuations of vector species should also be known. The time of biting and whether biting occurs indoors or outdoors have important implications for selecting an intervention method. A preference for feeding on humans rather than animals is a factor in the transmission of disease. It is also critical to determine where to do the adult vectors rest, particularly mosquito vectors.

## 2.4 Determinants of local diseases

The epidemiology of VBDs is complex and depends on a variety of local factors, which determine the spread of VBDs and are the determinants of the disease. It is important to understand all the determinants of disease, so that appropriate actions can be taken to reduce risk. This will lead to a comprehensive approach to disease prevention. In planning and implementation, determinants of disease can be divided into four categories:

i. Related to the parasite
ii. Related to the vector
iii. Related to human activities
iv. Related to the environment

VBD control programmes usually address only two categories of determinants: the parasite and the vector. In contrast, the aim of an IVM strategy is to address all determinants of disease, when possible. If the human and environmental determinants are ignored, people will continue to be at risk for infection, and the vectors will continue to proliferate in the environment. "Participatory mapping" is useful for understanding the spatial dimension of the determinants, *i.e.*, where the vectors breed and where people or other hosts live. As the risk for the disease can vary over a small area, local mapping improves the targeting and efficiency of vector control. The entomological analysis identifies the local determinants of the transmission and prevalence of the vector-borne disease. The interrelationship between humans, vectors, parasites and the environment is shown in (Figure- 28).

### 2.5 Selection of vector control methods

Vector control methods can be environmental, mechanical, biological and chemical to reduce vector populations or to reduce human vector contact.

#### 2.5.1 Selection criteria

Each method of vector control has its advantages and disadvantages, and an evaluation of the method guides the selection of the most appropriate method for the local context.

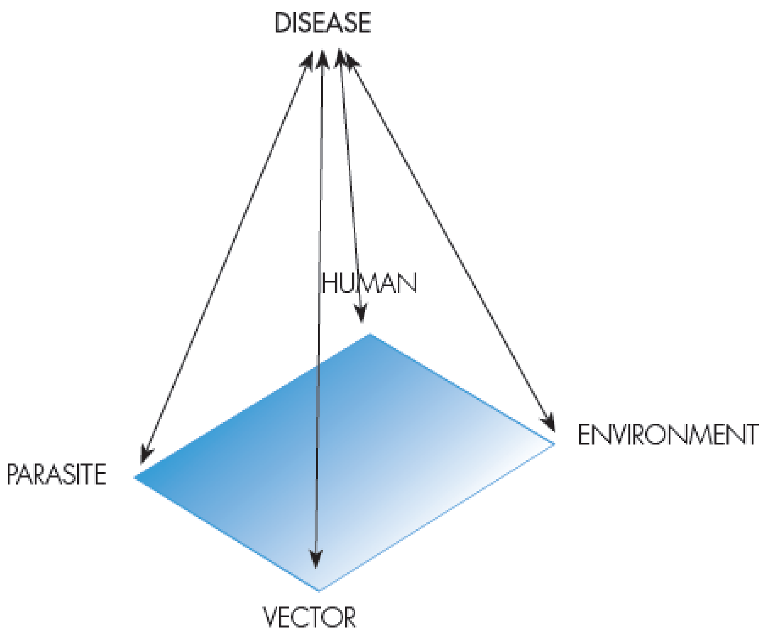



**Figure- 28: Inter-relationship between factors (Source: WHO)**

Aspects such as effectiveness, human and environmental safety, risk of resistance development, affordability, community engagement, policy and logistical support shall be considered as set out in Table- 11.

**Table- 11: Selection criteria of vector control method (Source: WHO)**

| Intervention Category | Types of Intervention measures | Effectiveness | Safety | Risk for resistance | Community participation | Affordability | Logistic & policy support |
|---|---|---|---|---|---|---|---|
| Environmental | • Source reduction | ± | + | | + | | |
| | • Habitat manipulation | ± | + | | ± | ± | |
| | • Irrigation management and design | ± | + | | + | ± | |
| Mechanical | House improvement | + | + | | + | – | |
| Biological | • Natural enemy conservation | ± | + | + | + | + | ± |
| | • Biological larvicides | ± | + | + | + | – | |
| | • Botanicals | | ± | + | + | + | |
| Chemical | • Insecticide-Treated bed Nets | ++ | ± | – | + | – | + |
| | • Indoor Residual Spray | ++ | ± | – | – | – | + |
| | • Insecticidal treatment of habitat | ± | – | – | – | – | |
| | • Chemical repellents | | ± | | | ± | |

Based on selection criteria, vector control methods should be selected from a list of the available methods specified in Table- 12.

**Table- 12: Vector control methods for different diseases (Source: WHO)**

| Intervention Category | Intervention measures | Dengue | JE | Kala Azar | LF | Malaria |
|---|---|---|---|---|---|---|
| Environmental | • Source reduction | + | + | | + | + |
| | • Habitat manipulation | | + | | + | + |
| | • Irrigation management & design | | + | | | + |
| | • Proximity of livestock | | | | + | + |
| | • Waste management | | | | | |
| Mechanical | • House improvement | + | + | + | | + |
| | • Removal trapping | | | + | + | |
| | • Polystyrene beads | | | | | |
| Biological | • Natural enemy conservation | + | + | | | + |
| | • Biological larvicides | + | + | | + | + |
| | • Fungi | + | | | | + |
| | • Botanicals | | | | | |
| Chemical | • Insecticide-Treated bed Nets | + | + | + | + | + |
| | • Indoor Residual Spray | + | | + | | + |
| | • Insecticidal treatment of habitat | | | | + | + |
| | • Insecticide-treated targets | | | | | |
| | • Biorational methods | | | + | + | + |
| | • Chemical repellents | | | | | + |

### 2.6 IVM implementation strategy

- Entomological surveillance in sentinel and random sites at monthly/quarterly/ annual intervals
- Promotion of source-reduction, minor engineering, etc. by the involvement of Panchayati Raj Institutions at the village level
- Scaling up the use of larvivorous fish with the involvement of NGOs under PPP model
- Appropriate use of insecticides for supervised IRS
- Scaling-up use of LLIN
- Insecticide treatment of community-owned bed-nets
- Intensified anti-larval operations in urban and peri-urban areas within the states/ districts
- Supportive interventions including IEC and BCC activities through Village Health and Sanitation Committee meetings on monthly basis, intersectional collaboration meetings in districts and blocks with high disease burden/ parameters and involvement of other sectors for social mobilization towards prevention and control with coordinated efforts of district programme managers.

# 3. Monitoring and evaluation

**Learning Objective**

By the end of training programme, participants should be able to….

- Learn about methods of monitoring and evaluation including design, data collection and result
- Describe about different outcome indicators
- Learn about entomological as well as epidemiological surveillance

Guidance for monitoring and evaluating the implementation of the national IVPM strategy is vital for achieving objectives to make any required improvements. It helps to propose standard monitoring and evaluation methods at regional and national levels.

## 3.1 Introduction

Vector-borne diseases such as malaria, dengue, chikungunya, Japanese encephalitis, leishmaniasis and lymphatic filariasis etc. are responsible for human suffering and their prevention and control by vector control methods have an important role to reduce morbidity and mortality. This training module assists with the IVPM practice, guiding adapting existing VBDs control methods.

Vector control interventions are to be promoted separately or combinational, selected according to local knowledge about the vectors. Monitoring term involves the use of inputs, outcomes and impacts. Evaluation should be formulated and the impacts should be rigorously measured in such a way as to be applied to a programme or strategy. The combination of monitoring and assessment makes it possible to understand the cause-and-effect relationships between implementation and impact. The major challenge in monitoring and evaluation is identifying valid indicators that can be measured objectively and systematically.

## 3.2 Methods of monitoring and evaluation

Methods of monitoring and evaluation are important implications that are designed to improve the existing system of vector control and prevention of VBDs. There are different methods or indicators used to determine the outcomes and impact. Monitoring and evaluation should identify progress made by designing, collection of data, use of results and roles. Monitoring refers to the measurement of a programme performance, which is done by observing and reporting the activities and their immediate outcomes. Evaluation is the assessment of outcomes and impacts that can be attributed to programme activities (Figure- 29). Hence, monitoring addresses the cause and evaluation addresses the effect.

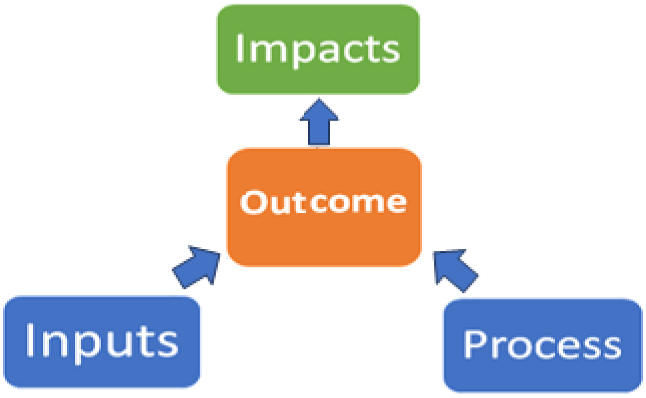



**Figure- 29: Impacts of outcomes (inputs &outputs)**

### 3.2.1 Design

Monitoring and evaluation of disease control are generally conducted longitudinally to record changes over time. Therefore, a baseline is required and information is collected during interventions. Changes in indicators of progress, outcomes and impact are observed relative to the baseline. The limitation of this technique is that other changes occurring throughout the same length of time can affect the indicators so the changes determined might not be attributable solely to the IVM interventions.

IVM strategies can be implemented in a so-called "stepped-wedge" manner, wherein all villages are eventually covered by the interventions, but the timing of the intervention is randomized in a step-wise crossover scheme.

### 3.2.2 Data collection

Under data collection, there are three types of data, which are specified for indicators, which are descriptive, numerical and logical. Data collection will vary depending on the indicators, as some measures will require only descriptive data and qualitative assessment, rather than the other two. Interviews with stakeholders, reviews of documents, field visits and group or house surveys are types of qualitative data. Evaluation plays an important role as they frame questions for interviews and formats for measuring knowledge and skills, testing surveys tools or monitoring forms testing. There are several methods for collecting health data. Routine surveillance with health management information systems has been used in several disease-endemic countries, in which data are produced weekly or monthly at the district level. Such systems could be used to obtain data on the crude death rate, disease-specific death rate, cases of the disease, parasite incidence and other parameters. Similar types of information/data, often of better quality and reliability, are collected in demographic surveillance systems established in certain countries. A more costly but often preferable option is collecting data in a dedicated epidemiological assessment, adapted to the specific requirements of IVM.

### 3.2.3 Use of result

The results should be used effectively for their intended purposes, which might account for the resources used, to learn from the experience and to determine what strategic or operational adjustments are needed. Stakeholders and partners at all levels of administration should learn from experience. The collection of data sources could reveal the reasons and causes for the observed pattern, which requires analytical skills. National decision-makers must know about monitoring and evaluation as it will give an idea about costs and impacts to help understand and interpret results. Monitoring and evaluation could also serve advocacy purposes through indicating policy change.

### 3.2.4 Roles

The evaluation/assessment is performed both internally and externally. Internal evaluation is beneficial due to its availability, low cost, knowledge of the context and operations. The important advantages of external evaluators are their specialist skills and their presumed objectivity, as they are independent and can raise sensitive issues. Pressure on either internal or external evaluators to make a positive evaluation can be a barrier, which might obstruct the efficient identification of a programme’s shortcomings and remedial action.

At the decentralized level of IVM partnership, cross-wise evaluation would be an ideal alternative. Cross-wise evaluation increases all partners' responsibility for their vector management operations, enhances relationships and helps to prevent biased outcomes; however, it needs training and supervision.

### 3.3 Outcome indicators

There are three types of indicators used i.e., process, outcomes and impacts. Process indicators reflect the performance of a programme, and whether the planned activities were adequately conducted promptly. Outcome indicators are used to describe the direct outcomes of the activities, whereas impact indicators are used to describe the indirect effects that can be attributed to the programme (Ahmed T et al., 2017). For example, field implementation begins with analysis and decision-making in districts and villages, resulting in vector control that affects the vector population, which in turn affects disease transmission, disease prevalence and morbidity (Figure- 30).

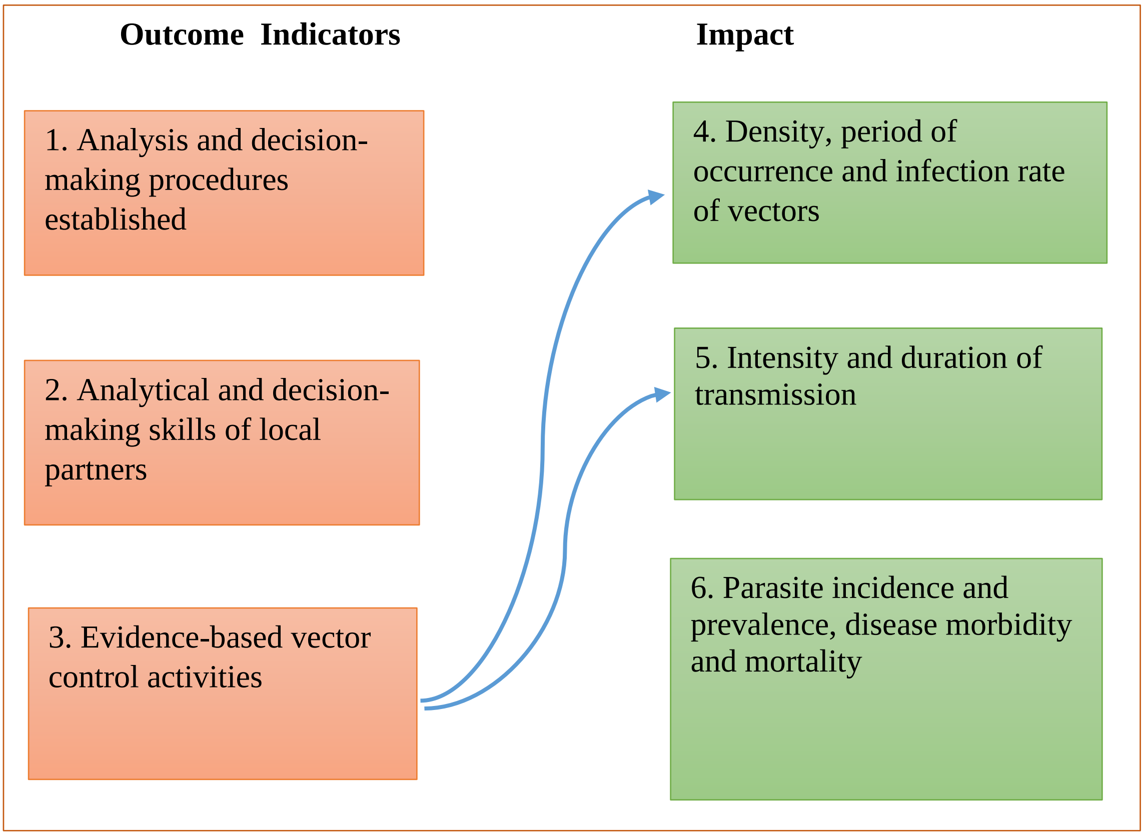



**Figure- 30: Cause-effect relationship between outcome and impact (WHO)**

#### 3.3.1 Planning and implementation

Planning and implementation of maintaining IVM and IVPM must be monitored and evaluated in order to ascertain progress and impacts and to identify areas for further attention. If more than one disease is covered in one programme, for example when evaluation of lymphatic filariasis is added to a malaria control programme, the data collection methods should be revised.

### 3.3.2 Organization and management

Organization and management must be monitored and evaluated to ascertain the progress made and to identify issues for further attention. The indicators that could be used are listed in Table-14. A comprehensive framework for monitoring and evaluation is presented in the previous section. A career structure is an important incentive for people to seek training and is necessary to keep graduates in their profession. This indicator is applicable to staff in the health sector and other sectors. For both groups, the numerator of this indicator is the total number of staff (any unit or department) for whom 'vector control activities' is added to their job description (*i.e.,* the phrase 'vector control' or 'mosquito control' is mentioned). The denominator is the targeted number of health staff for whom vector control is to be added to their job description (Table-14).

#### 3.3.2.1 Within the health sector

**a. At central level**

At the central level, it is usually the health sector and its vector control department that takes the lead in an IVM strategy. However, internal relations determine how vector control is organized, where operational decisions are made and whether vector control is incorporated into single-disease programme or not. In a decentralized system, the central ministry maintains an important role in IVM in terms of preparing policy and guidance, reviewing job descriptions and terms of reference, facilitating planning and implementation IVPM activities, preventing and responding to epidemics and providing supplies and technical support. However, decisions on the implementation and associated management aspects of IVPM are transferred to health systems at the district or village level.

**b. At local level**

IVPM involves the integration of disease-specific vector control programme and surveillance services within a decentralized health system. The embedding of IVPM in local health systems requires new skills and capacities for analysis and decision-making. Public health staff in districts and villages could be trained in the technical, operational and managerial aspects of IVPM giving rise to the local leadership of IVPM. The IVPM could thus contribute to making health offices more capable and less dependent on centralized expertise because it adds analytical and decision-making skills and contributes to partnerships with other sectors and communities.

**c. Inter-sectoral collaboration**

An IVPM strategy calls for collaboration between the health and other sectors and civil society. This implies new links, roles and responsibilities, which may require changes in job descriptions or terms of reference. Sectors such as agriculture, local government, environment, construction, tourism and communities may contribute to vector proliferation and put people at risk of infection. All sectors should be strongly encouraged to conduct a health impact assessment of their activities to identify any risks for VBDs to reduce the risks in each sphere.

- **Management of pesticides**

The management of pesticides requires intersectoral collaboration. Issues involved in sound management of pesticides include legislative control, procurement, storage, transport, distribution, application, management of resistance, quality control and disposal. The use of pesticides in agriculture has important implications for public health, not only in terms of pesticide poisoning but also for vector control, particularly for malaria and JE control. The uncontrolled use of pesticides in the agricultural sector is directed at selection of resistance to insecticides. The use of pyrethroids in agriculture, which was connected to the development of resistance in malaria vectors, is of particular concern. Pyrethroids are the only group of pesticides necessary to treat insecticide-treated nets. For this purpose, cooperation with the agricultural sector is critical to ensure the continued effectiveness of vector control methods.

### 3.3.3 Behaviour Change Communication (BCC)

Awareness campaigns are important for communicating information on behaviour for vector control to communities at risk for vector borne diseases. The number of sites (e.g., villages) at which such campaigns have been conducted indicates the extent to which there has been communication at a community level. The numerator of this indicator is the number of sites (villages or smallest administrative units) in which campaigns or community-wide communication on behaviour change for vector control was conducted during the reporting period. The denominator is the total number of villages targeted for campaigns or community-wide communication.

**Table-13: Indicators to monitor and evaluate progress in planning and implementation of IVPM**

| Process Indicator | Outcome Indicator |
|---|---|
| 1. Required resources for the implementation of IVPM cost and mobilized | National strategic and implementation plan |
| 2. Required staffing levels and competencies for IVPM identified | |
| 3. Epidemiological data disseminated and utilized by programme for decision-making and impact evaluation | Epidemiological surveillance system on VBDs in place |
| 4. Vector data disseminated and utilized by programme for decision-making and impact evaluation | Number (and %) of targeted sentinel sites with functional vector surveillance and insecticide resistance monitoring |
| 5. Institutions to carry out operational research identified | Number (and %) of operational research priorities on vector control that have been addressed |
| 6. Technical assistance provided to the programme to utilize the results of operational research | Number of operational research outcomes on vector control that have been utilized by the implementation programme |

**Table- 14: Indicators to monitor and evaluate progress in organization and management of IVM**

| Process Indicator | Outcome Indicator |
|---|---|
| 1. Task force constituted to revise job descriptions and operating procedures | Number (and percentage) of targeted staff with job descriptions that refer to vector control |
| 2. Task force constituted to develop professional standards on vector control and public health entomology | Standards for professions and a career track in vector control and public health entomology in place |

This indicator is restricted to field campaigns for personal protection and vector control; the use of broadcast media is excluded. Data is obtained through surveys or interviews with the relevant government or private sector units or civil society organizations, supplemented by information from reports. The strength of this indicator is its simplicity, while its limitations are that it does not indicate the number or percentage of people who reached the suitability or quality of the communicated information or the effectiveness of these activities in changing people's behaviour for personal protection and vector control (Table- 15).

**Table-15: Indicators to monitor and evaluate progress in advocacy and communication of IVM**

| Process Indicator | Outcome Indicator |
|---|---|
| 1. Major stakeholders have identified the requirements for vector control | Number of targeted stakeholders that have allocated resources for vector control |
| 2. Targets set for the number of villages to receive campaigns on behavioural change on vector control resources allocated and persons trained | Number of targeted villages that received campaigns on behavioral change on vector control |
| 3. Guidance is given to villages on organizing and planning vector control activities | Number of targeted villages where communities have been mobilized on vector control |

Progress in advocacy and communication must be monitored and evaluated to identify areas for further attention. Indicators that could be used are listed in Table-15. A comprehensive framework for monitoring and evaluation is presented in the previous section.

### 3.4 Entomological surveillance

Entomological surveillance is an important aspect of an IVM strategy. Entomological surveillance serves two purposes: to provide evidence for decision-making in IVM and for evaluating a programme's impact on vector populations. It can be used for monitoring and evaluation if the surveillance of vector sites is located in or near the implementation sites. Vector surveillance involves regular measurement of vector population density with any type of sampling method. Surveillance can also include species composition, vector bionomics, infectivity rate, parous rate and insecticide susceptibility, although these activities may require special expertise and equipment. The information collected serves as an evidence base for decision-making in IVM. Therefore, the links between vector surveillance and vector control must be established (Srivastava et al., 2016).

Monitoring and evaluation of vector breeding habitats in the particular village by trained community members recognized by village and district authorities. Basic training on vector biology, ecology, sampling and mapping training should be conducted for the village surveillance team, consisting of field-based volunteers and a local coordinator.

#### 3.4.1 Adult surveillance

There are several methods available for sampling or surveillance of mosquito vectors such as hand collection, aspirator collection, outdoor collection, bait collection, and trap collection. Routine vector surveillance is advocated under the programme.

#### I. Hand collection method

Adult mosquitoes mostly situated in dark corners of houses, ceilings, amongst thatch and cobwebs, clothing and other hanging articles are collected with the help of torch light. The mosquitoes can be collected by using aspirator (oral or mechanical) in indoor or outdoor. Adult vector density can be calculated after the collection of mosquitoes, which is known as Per Man Hour Density (PMHD).

$$\textbf{Per Man Hour Density} = \frac{\text{No. of mosquitoes (Male and Female) Collected}}{\text{No. of Insect Collector x Time spent in hours}}$$

High vector density indicates a high potential for disease transmission.

**a. Collection by aspirator**

This is the most widely used and convenient method for mosquito collection. Aspirator tube is generally having a length of 30-45 cm (internal diameter, 8-12 mm) and is made up of glass or plastic tubing. The resting mosquitoes seen under torch light are sucked gently and the other end of the tube is closed with a finger or cotton plug before transferring to a cage/test tube. Collection of more than 10 mosquitoes at a time should be avoided. It prevents physical damage to mosquitoes. For outdoor collection, mosquitoes can be searched in bushes, shrubs, in wall cracks, under bridges, culverts and tree holes and for indoor collection mosquitoes can be searched inside of houses like bedrooms and other walls collecting used through the aspirator/ mechanical aspirator. (adopted from "guidelines for entomological surveillance of malaria vectors in Sri Lanka, Abeyasingha et al., 2009).

**Essential equipment for adult mosquito collection:**

- Aspirator/Mechanical aspirator
- A torch (with spare bulb and batteries)
- Paper cups with net covers
- Cotton wool
- A pencil
- A note book
- A bag to put all equipment

**Equipment to transport mosquitoes**

- Insulated picnic box or another suitable container
- Sugar solution (5-8%)
- Paper cups with net covers
- Cotton wool
- Towels
- Newspapers to serve as packing material

**Selection of houses**

- In any village, a minimum of 20 houses should normally be examined per day spending 2-3 hours to provide a representative sample. The houses should be randomly selected and scattered throughout the village.
- It is often advantageous to select poorly constructed and inadequately ventilated houses because they usually contain the largest number of mosquitoes. Houses on the fringe of a village or near known breeding sites will often yield more day-resting mosquitoes.

**Collection of mosquitoes**

- Normally takes place early in the morning between 6:00 to 10:00 hrs. and should be done after obtaining the consent of the occupants.
- Examine the bed room in which people slept the previous night. Try to select rooms with few external openings.
- With the aid of the torch, look for mosquitoes on walls, ceiling, the roof and under furniture.
- Search systematically starting from the door and moving clockwise around the inside of the house or room.
- Look for mosquitoes on wall hangings and curtains, behind and under furniture and inside large pots and jars.
- While collecting observe the resting places normally chosen by mosquitoes. If you record in the note book what you see, including the number of mosquitoes on the upper, middle or lower parts of walls, you can determine the proportion resting in each location.
- Collection can be carried out 15 minutes in each house per person.

**Labelling paper cups**

- During hand collecting, transfer mosquitoes to paper cups. Separate paper cups should be used for each house.

- The cup must be clearly labelled with a pencil with at least the following essential information.
    - Location
    - Date and time of collection
    - Time spent on collection
    - House number or house holder's name
    - Type of structure (house, animal shelter, stores etc.)
    - Parts of the surface (Upper, medium or lower part of wall)
    - Whether sprayed or with insecticide-treated bed nets and if so when
    - Insect Collector's name

For outdoor collection mosquitoes can be searched in bushes, shrubs, wall cracks, under sides of the bridges, culverts and in tree holes, etc.

**II. By test tube**

The test tube is the old methodology for which a test tube without a rim having a length of about 100 mm (20 mm diameter) is used. After locating a mosquito with a torch light, a test tube is held in the middle and its mouth is brought slowly over the insect to dislodge the mosquito. Immediately after the entry of the mosquito into the test tube, the opening is plugged with a finger and later by cotton (Figure- 31). The tubes are wrapped in a wet towel till identification and processing.

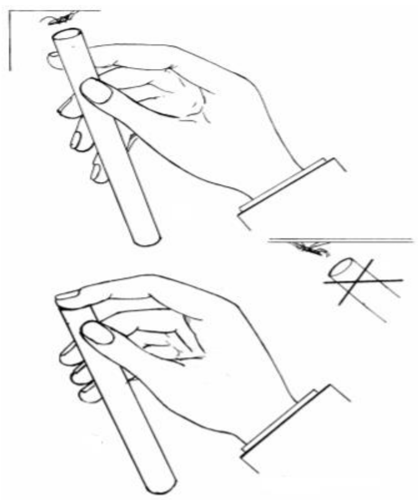


**Figure- 31: Test tube collection method (Source: WHO)**

### III. Bait collection

Mosquitoes are collected directly off the animal baits using a mechanical aspirator while they land on the host to bite or while biting an animal host. This method is one of the most important for understanding the host preference and feeding time. There are two methods of human landing collections-

**a. Direct landing catches of mosquitoes from animal bait**

**b. Collecting mosquitoes in a human-baited net trap (double trap method)**

Female mosquitoes are attracted to humans and/or animals to obtain blood meals.

**a. Direct landing catches of mosquitoes from animal bait**

**Essential equipment:**

- Aspirator or mechanical aspirator
- Test tubes
- A torch (with spare bulb & batteries)
- Paper cups with net covers
- Mosquito cage for a large collection
- Cotton wool
- A plastic basin
- A towel

**General rules**

- Collections should not be carried out during fast winds (when wind speed is more than 10-15km/hour).
- Mosquito-repellent substances should not be used during the work.
- Smokes should not be there in the area.

**Collection of mosquitoes from animal baits**

➢ Suitable locations for the night collections should be selected. It should be closer to the vector breeding sites in the area.

- Direct collection of biting mosquitoes should be performed during the night as malaria vectors are active and take a blood meal at the night.
- In a full night programme, hourly collections should be made during the entire period from 18.00 to 06.00 hours (dusk to dawn). Two teams of insect collectors are recommended and each team shall work half of the night.
- If it is a partial night collection, an hourly collection should be made during the peak biting period, from 18.00 to 22.00.
- Mosquitoes are collected directly off the animals (more easily off the legs and other places where the hair is short) with the aid of mechanical aspirators.
- They are collected while resting in the vicinity of the bait, either before or after feeding.
- Mosquitoes may be easily found resting on vegetation, branches of small trees, etc. generally at a level varying from 15cm - 2 m above the ground.

**b. Landing catches of mosquitoes from human-baited trap nets (Double net trap method)**

**Essential equipment:**

- Mechanical aspirator
- A test tubes
- A torch (with spare bulb & batteries)
- Paper cups with net covers
- A folding bed
- Single square net
- Large outer net
- Five poles/sticks
- Cotton wool
- A plastic basin
- A towel

**Note:** For ethical reasons now health workers can not be exposed to be bitten by mosquitoes. In fact, it is not necessary to permit mosquitoes to bite human bait. They can be collected as soon as they settle on the skin, as it can be assumed that biting would normally follow. Therefore, landing rates are measured instead of biting rates.

As mosquito repellants cannot be used while engaging in biting collections, it is unavoidable to be bitten by mosquitoes. To avoid this in such instances, human-baited trap net collections can be conducted. Because of the protective inner net, the risk to collectors can be minimized.

**Collection sites**

Two trap nets should be set up in positions selected, one (a sleeping room) inside the house and the other one outdoors at a site where people usually sit during the evening (Figure- 32).

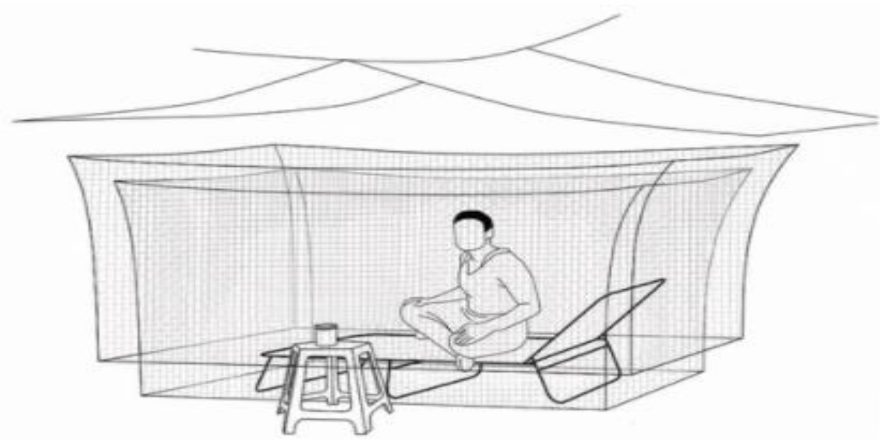


**Figure- 32: Human-baited double net trap**

**Collection of mosquitoes in a human - baited trap net**

- Folding camp beds should be set up to allow the human bait to lie on the bed.
- A square inner net should be put up around the camp bed.
- An outer net should be erected by tying it securely to poles or branches of trees.
- The bottom of the outer net should be stretched and tightly tied to pegs in the ground.
- A space of 15-25 cm height should be left between the ground and the lower edge of the outer net allowing mosquitoes to go inside to reach the bait.
- Bait should be sent into the inner trap and he should be lying down mosquitoes that enter the outer net will be trapped and rest on the inner surface of the outer trap or outer surface of the inner net.
- The alarm clock should be set to ring after one hour and hourly collections are made.

- Hourly collected mosquitoes must be transferred into separate cups, which are labelled as mentioned above.
- The collecting period should not exceed ten minutes.

The same procedure should be repeated throughout the night if it is a full night collection and during the peak biting period if it is a partial night collection.

**Transportation to the laboratory**

Paper cups with mosquitoes collected so are placed in a plastic basin and covered with a wet towel, then carefully transferred to the field laboratory where the mosquitoes will be identified. Necessary dissections should be made (Abeyasingha et al., 2009).

**IV. Spray sheet collection**

The method is applied during the daytime, usually early in the morning between 06:30 and 10:00. The rooms are vacated by removing foodstuff, drinking water, furniture, etc.

**Essential equipment:**

- White floor sheets (size 2m x 2m) can be made of cotton of about 4 numbers
- Hand lenses
- Pyrethrum solution
- Small Petri dishes
- Paper cups with net covers
- Forceps
- A container preferably a picnic box
- Cotton wool
- Filter papers
- A torch
- Hand sprayer- the double action type with an air valve
- Pyrethrum solution concentration in kerosene (1:19)

**Selection of rooms for spray sheet collection**

- It is often advantageous to select poorly constructed and inadequately ventilated houses because they usually contain the largest number of mosquitoes. Houses on the fringe of a village or near known breeding sites will often yield more day-resting mosquitoes.
- Rooms selected should be those in which one or more persons slept the previous night
- Collections are normally carried out in the morning after the occupants of houses have arisen. Permission is required from householders to make a collection in their houses.
- It is normal for the work to be performed by a team of three or four people so that collection can be made in twenty rooms in each locality.

**Preparation of the room**

- All persons, animals and birds or any other pets should be removed from the room
- Remove or cover all food
- Remove all small items of furniture
- Cover all openings and eaves with cloth or netting
- Spread the white sheets to completely cover the floor and all flat surfaces of the remaining furniture. Sheets also should be spread under tables, beds and other places where mosquitoes may hide (Figure- 33).
- Close all windows and doors

**Carrying out space spraying**

- One of the team members should walk around outside of the room and spray in open spaces or holes in the walls and eves.
- Another member of the team should then enter the room close the door and move in a clockwise direction. Apply spray towards the ceiling until the room is filled with a fine mist.

➢ The operator should leave the room quickly and make sure that the door remains closed for at least 10 minutes.

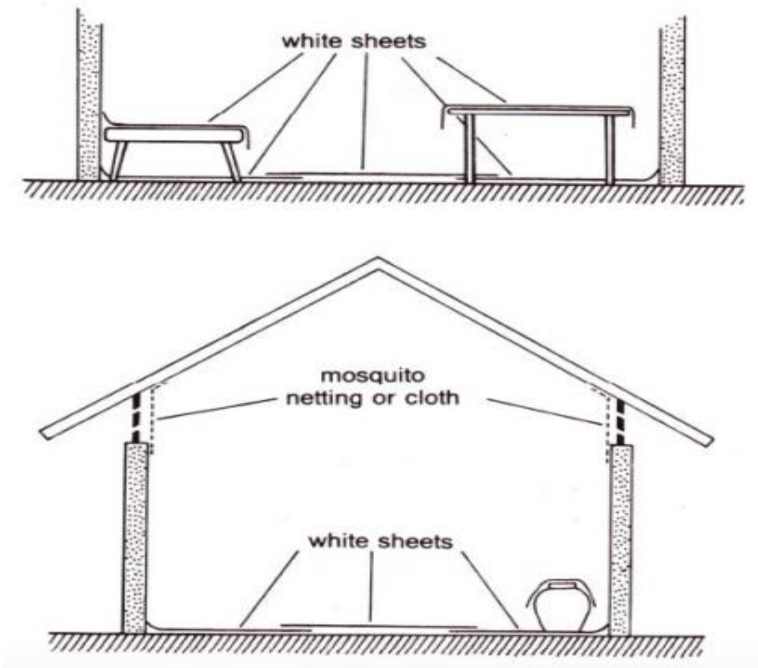



**Figure- 33: Preparation of a room for PSC**

**Collection of mosquitoes from sheets**

- Open the room. Starting from the doorway, pick up the sheets one at a time by their corners. Carry the sheet outside. Collect and examine the mosquitoes outside in daylight.
- If it is windy and rainy; open the room. Move gradually through the room starting from the doorways. With the aid of the torch, collect the mosquitoes from the sheets leaving the sheet in position.

**Labelling containers, keeping the records and transporting them to the laboratory**

- A separate container should be used for mosquito collection in each room.
- The container should be labelled with all relevant data, including:
    - Location
    - Date and time of collection
    - House number or householders name

- Number of people and /or animals in the room during the previous night
- Whether the room has been sprayed previously and if so the date of spraying
- Availability of LLINs in the room, number & type.
- Availability of plain nets or ITNs in the room
- Use mosquito repellants the previous night, specify what coil, mat, vaporizer, etc.
- Name of the collector/supervisor
- This information must be written by pencil directly on paper cups or on a piece of paper, which are placed inside the container
- Keep a separate record in your note book or in a format that can be used to keep the records
- However, if there is a delay before transport a wide-mouthed vacuum flask holding ice cubs should be used to keep the containers cool so that the mosquitoes remain in a suitable condition for dissection. An insulated picnic box with ice packs may be used if one is available. (Abeyasingha R.R et. al., 2009)

**V. Bina Pani Das Hop cage (BPD Hop cage)**

The hop cage is a standard mosquito cage (metal frame), measuring 30 × 30 × 30 cm. Each side of the cage is made up of a thin iron rod of 6 mm in diameter. The metal frame is covered by muslin cloth on its five sides, with a long cotton sleeve on the sixth side and a narrow cotton sleeve outlet on the opposite side. The sleeve of the cage is folded (Figure- 34 a & b) to allow entry of mosquitoes while hopping the cage on land and aquatic vegetation (Das, 2009).

Collection of mosquitoes from vegetation by BPD hop cage method involves up and down hopping movement of the cage with its sleeves completely folded over the vegetation for about one minute. By doing so, resting mosquitoes get disturbed and get trapped inside the cage. The sleeve of the cage was then immediately folded and mosquitoes were retrieved from the opposite side of the cage by an aspirator tube. After several such attempts in different directions in the same vegetation, the density of mosquito species may be estimated as average number of female mosquito species collected per 10 hop cages by the formula:

$$\text{Mosquito density per 10 HC} = \frac{\text{Total number of mosquitoes collected}}{\text{Total number of hops made on vegetation}} x10$$

JE vector *Cx. tritaeniorhynchus* predominantly rests outdoors on agricultural crops and wild vegetation, depending on local situations, where they can also be monitored by BPD Hop Cage method; formerly known as the sweep cage method (NVBDCP, 2014). The density of mosquitoes may be estimated as an average number of mosquitoes collected per 10 Hop Cages. The larger the area covered by hopping, the better representation of the mosquito density.

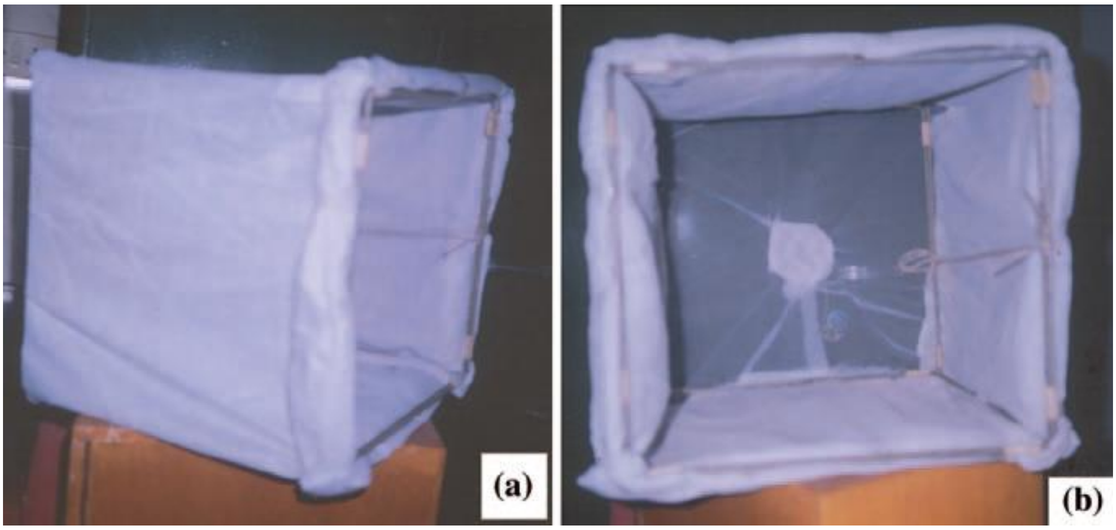



**Figure- 34: Hop cage (a) side view, (b) front view (Das, 2009)**

## VI. Trap collection

Traps are used for collecting mosquitoes and some of the important traps used for the collection of adult mosquitoes are light trap, gravid traps, window traps, magoon traps and BG-Sentinel traps (CDC, 1993).

### a. Light traps

Light traps are most often used in malaria surveillance but have also been used in arboviral vector surveillance. The basic principle of the light trap is that the mosquito attracted at night to the bright electric light enters under the hood of the trap where they are exposed to a strong downward air current produced by a fan operated by an electric motor. The mosquitoes are collected in a holding cage attached to them. Light trap has mostly been used for collecting outdoor flying mosquitoes (Figure- 35). CDC light trap is very common.

**Figure- 35: Light trap**

**Points to be considered**

- The trap should be located 30 feet or more from buildings in open areas near trees and shrubs and away from other lights, areas open to strong winds and industrial plants giving off smoke or gas.
- Moonlight may reduce the effectiveness of the traps.
- The light should be 5.5 to 6 feet above the ground when mounted on a post or hung from a tree.
- Remove the collection each morning for sorting and identification.
- Try to set the traps along the edges of habitats to increase trapping efficiency. A trap located strictly in one ecosystem/habitat may exclude certain species; trapping along the edge of a swamp, for example, will provide a picture of those species found not only in the swamp but also in the nearby upland.
- Consider two traps as the minimum number per site in most situations and compare your data to detect differences that may have been due to outside influences.

**b. Gravid traps**

These traps consist of a black bucket filled with infusion of dead leaves and are designed to collect gravid females that are fed at least once and need to oviposit (Figure- 36). Gravid traps are used in arbovirus transmit vector surveys, as the probability of detecting viral infections in a fed mosquito is higher than in samples obtained by $CO_2$-baited traps, which collect host-seeking females, most of which are unfed. Gravid traps are considered not to be particularly attractive to *Aedes* mosquitoes, but their attractiveness can be improved (for container-inhabiting species only) by using infusions of dead oak leaves or grass. Traps are best set under bushes, under porches, in tall grass, or out of the wind in areas close to where target vector species may be seeking a place to lay eggs. General locations with some shade provided by a tree canopy or other sources are desirable. When trapping any mosquito species, gravid traps are best set sometime between 2 - 4 pm and collected the next day around 8 - 9 am. To reduce viral decomposition and damage to the mosquitoes, gravid traps should only be run for a single day.

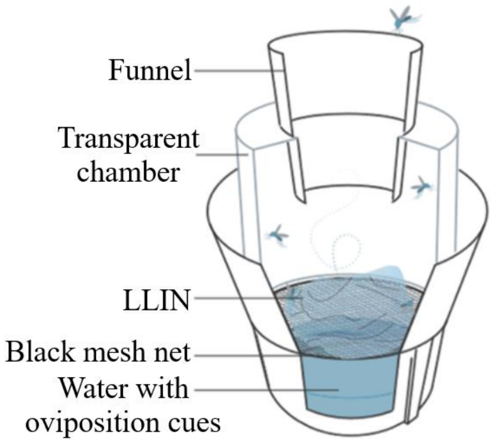



**Figure- 36: Gravid trap for *Aedes* (Erias et al., 2014)**

**Ingredients**

- Large plastic trashcan (40-50 gallons) with a tight-fitting lid
- 30 gallons of water
- 1 pound of straw or hay
- 5 grams of brewer's yeast
- 5 grams of lactalbumin powder

**Mixing directions**

- Place the trashcan in a place where it will get direct sunlight for several hours per day
- Fill the can with 30 gallons of water
- Stir 1 pound of straw into the 30 gallons of water
- Add 5 grams of brewer's yeast
- Add 5 grams of lactalbumin
- Stir the mixture

- Place lid on trashcan and let the mixture brew for five days, stirring at least once each day

**Bait usage directions**

- After about five days, the bait will be ready to use.
- It is convenient to pour the finished bait into a 2.5 gallon wide-mouth container to carry it to the trap sites (an empty 2.5-gallon plastic can litter container works well for this purpose).
- After use, the bait can either be dumped or it can be poured back into the carrying container for repeated use.

**c. Window trap**

The window trap consists of a wooden frame, a cube of six sides of one foot each, five sides of which are closed with mosquito nettings while to the sixth side a deep conical funnel of netting is provided (Figure- 37). The frame of the trap should fit exactly into the window frame of the house so that no space is left to escape from it or the open areas around the window trap should be plugged with cotton or cloth etc.

**Essential equipments:**

- Window traps
- Mouth aspirators
- Paper cups with net covers
- A towel
- An insulated picnic box
- Dark cloth or netting to block openings in rooms

**Fitting exit traps**

- Window (exit) traps are suitable for fitting only to rooms that are well sealed and that have few exit points for mosquitoes.
- If there are any openings other than the windows to which traps are fitting, they must be covered or blocked with dark cloths.

- Normally a sleeping room should be selected and the trap must be fitted to a window. Parts of the window not covered by the trap should be covered with dark cloth or cardboard.
- The trap should be fitted in a manner that the collecting sleeve is pointed outwards.
- It is also important to fix traps in position well before the sun set.

**Collecting mosquitoes from an exit trap**

- Start collection the next morning just after sunrise.
- Collect all mosquitoes through the sleeve of the trap, with the use of a mouth aspirator.
- Use separate containers for the mosquitoes collected from each house and keep dead and live mosquitoes separately.
- When the traps are fitted in houses that have been sprayed with insecticides or in houses using ITNs, keep the mosquitoes caught live for 24 hours.

**Figure- 37: Window trap**

**Labelling paper cups**

The cup must be clearly labelled by pencil with at least the following essential information:

- Location
- Date

- Exit trap number (house number or householder's name)
- Time of collection
- Whether mosquitoes were found dead or live in the trap
- Whether and when the house was last treated with insecticides
- Availability of LLINs in the house/room
- Name of the collector

**d. Magoon trap**

These are essentially portable/detachable wooden huts, in which the upper half of the standing wooden panels fitting with wire gauze netting and an entry slit about 2 cm wide and V-shaped in appearance is provided all around. A convenient size of the trap is 8m x 8m and it should be high enough for the collector to stand up inside. The roof of the trap should be sufficiently slanting to shed water. The trap is baited with a calf, goat or some other animal in the evening. The large number of mosquitoes can be collected the next morning in a single catch.

**e. BG-Sentinel traps or biogents mousquetaire traps**

These traps were designed to attract *Aedes aegypti* and *Aedes albopictus* with a specific chemical lure (BG-Lure). Their effectiveness can be increased by baiting the trap (e.g., a mouse in a cage) or by sweet scent or adding a carbon dioxide source (Biogents devices). Carbon dioxide makes the trap attractive to a wide range of mosquito species (e.g., *Culex pipiens* and *Anopheles plumbeus*). Traps can operate continuously when a power supply is available but can also run on a single 12V battery (which limits operating time). When $CO_2$ is added, these traps have also been reported to catch male mosquitoes, blood-fed females and gravid mosquitoes.

### 3.4.2 Larval collection methods

Larvae are collected with the objectives to establish the breeding habits of different species, and their geographical distribution, study the development of aquatic stages and evaluate the impact of anti-larval measures on larval density. This also helps in rearing adults for taxonomic studies or biological observation (bioassay/susceptibility tests) (Abeyasingha et al., 2009).

### I. Dipping

The dipping method is the most frequently used for the collection of mosquito larvae with a dipper (Figure- 38).

**Essential equipment:**

- Ladle
- Enamel bowl
- Pipette
- Larval vials

**Steps in dipping**

- Estimate the active breeding surface area of the breeding site.
- Dip at the rate of 10 dips per spot of active anopheline breeding.
- During dipping, avoid shadowing (e.g. dipping person, ladle etc.).
- Immerse the ladle in the breeding place (e.g. River bed pools, river margins, streams, edge of swamps, paddy fields, gem pits etc.) at an angle of 45°.
- Let the ladle fill to ¾ of water (with larvae, if any) and withdraw quickly (if the dipper is immersed too slowly, the larvae get disturbed and escape).
- Keep 2-3 minute intervals between two dips to allow larvae to come to the surface again.
- If the surface water is covered with dense floating vegetation or organic debris, the water surface should be agitated to cause the larvae to sink, clear away the vegetation and then wait for 3-5 minutes for larvae to come to the surface and dip.

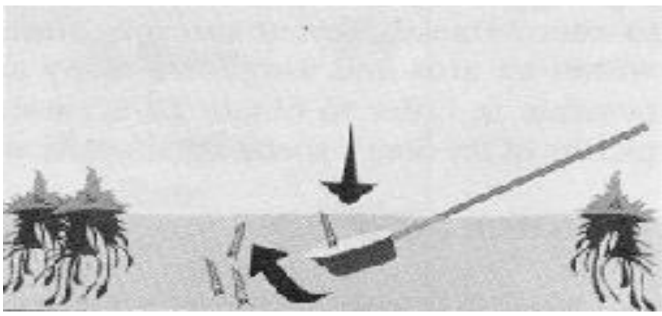


**Figure- 38: Dipping method for larvae**

- Count the 1st and 2nd stage, 3rd and 4th stage larvae and pupae in each dip and record them in the appropriate forms.
- Collect the larvae and pupae of each habitat in separate labelled vials.
- Identify the larvae at 3rd and 4th stage using standard identification guides. Allow the 1st and 2nd stage larvae to develop to 3rd and 4th stages and then identify them. In the case of pupae, allow them to emerge into adults and then identify them.
- Calculate the larval density per 100 dips for each species for each larval breeding habitat separately.

**II. Netting**

Larvae may be collected from large stretches of water along the edge of streams, ponds, wells, and other large water bodies. A larval net consists of a ring of iron frame of 25 cm in diameter with a nylon/muslin cloth net measuring about 10 cm long. A long wooden handle is attached to the ring (Figure- 39).

**Essential equipment:**

- Larval net
- Enamel bowl
- Pipette
- Larval vials

**Steps in netting**

- A larval net consists of a ring of iron frame (diameter 20 – 25cm) to which a nylon/ muslin cloth net (10cm long) is attached. A long wooden handle is attached to the ring.
- For collecting larvae, the net should be held at an angle of 30° and skimmed rapidly through the surface water near emerging or floating vegetation.
- The net should be inverted and washed out in a bowl of water for larvae and pupae collection.
- Larvae and pupae should be identified and recorded as in dipping.
- The larval density should be given as larvae per larval net for each species for each breeding habitat.

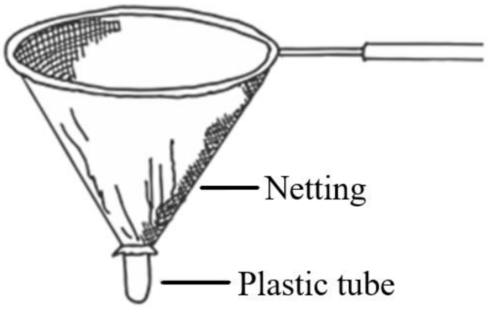



**Figure- 39: Larval dip net**

In the collection of larvae from wells, pond net (well net) can be used. The usual pond net is devoid of a handle and provided with nylon netting attached to four points on the iron ring at equal distances.

**Preparation and collection of larvae using a well net**

Join the four pieces of string in such a way that the ring forms an angle of 30° and attach this to a rope tied with it.

**Steps in collection of larvae**

- While collecting larvae from a well, put a small weight in the net to keep its bottom under the water surface.
- Move the net around the border of the well two or three times and then withdraw.
- Invert the net in a white enamel bowl containing water.
- Identify the larvae and make reports.
- The density is given as larvae per well net for each species.

**III. Pipetting**

Small pipettes or small spoons may be used for collecting larvae from shallow breeding sites like hoof prints, etc. The larvae can be collected from the small, narrow tree holes or the axils of leaves using a wide pipette.

**Essential equipments:**

- Small pipettes
- Larval vials

Small pipettes can be used for the collection of larvae from tree holes or other small breeding sites.

**a. Collection of *Mansonia* aquatic stages**

For a collection of *Mansonia* larvae, a one-foot square bottom tin/wooden tray is kept over floating vegetation and the number of plants is counted. The plants are then removed to an enamel tray with water and the plants are then well shaken to disentangle the *Mansonia* larvae from the roots. Then the number of larvae, pupae and number of plants is counted and the average number of larvae and pupae per plant is estimated.

**b. Collection of immature stages of sandfly**

Sandflies breed in cracks, crevices and other places with soils rich in organic contents. The resemblance in soil and larval coloration makes it difficult to detect larvae visually in their habitat.

**Steps**

- The soil is collected, kept in a petri dish and then examined under a microscope (40 x magnification).
- To facilitate the screening of larger soil samples, a floatation technique is often practised.
- The soil samples are immersed in a saturated sugar solution *i.e.*, 3 parts sugar + 5 parts water.
- Larvae and pupae float in this solution.
- Larvae and pupae are then passed through a series of sieves and finally, the residues are examined under the microscope.

### 3.4.3 Collection of adult sandflies

**I. Hand collection**

This is the most common method wherein sandfly sitting on a surface is caught with the help of an aspirator or test tube and a torch light. This method is particularly useful for the longitudinal monitoring of man hour densities. However, in sandfly collection, the ordinary mosquito barrier netting between the glass tube and rubber tubing of the aspirator must be replaced by a muslin cloth as the smaller size of sand-flies enables them to escape through the ordinary mosquito net.

### II. Trap collection

Usually, four types of traps are used-

#### a. Sticky trap

This is the most extensively used trapping device wherein sand-flies are trapped in a layer of castor oil. Suspended arched sticky papers/foils of standard size (20 x 30 cm) are placed at a height of about 4-5 cm from the ground with a convex sticky side towards the ground. Traps are usually laid in the evening and collected on the following morning. Sand-fly density per trap is calculated for comparisons. Sticky traps are particularly useful in collecting sandflies from hidden shelters like burrows, cracks, tree holes, etc. For some species showing repellence to castor oil, other vegetable oils are required to be used. However, in India, these can be safely used against *Phlebotomus argentipes.*

#### b. Illuminated sticky trap

Illuminated Sticky trap box-shaped batteries are hung on the walls facing sticky traps to make them illuminated in some studies. These traps have provided higher catches as compared to ordinary traps.

#### c. Light traps

CDC miniature light traps are often used for sandfly collections. However, nylon mesh cages suspended in a rigid frame are better than the collapsible cages provided with the traps. Further, for sand-flies they are modified to give UV light or white light.

#### d. Funnel traps

These are particularly useful in collecting flies from rodent burrows. Traps are placed just at the mouth of the burrow to catch the flies emerging out of the burrows. The inner side is provided with sticky paper or foil. Other traps used in mosquito collection like double bed nets, stable nets, malaise traps, magoon trap, etc. can also be used but the effectiveness is not yet well demonstrated.

## 3.4.4 Insecticide resistance monitoring through susceptibility test

### I. Adult susceptibility

The purpose of the susceptibility test is to evaluate the level of susceptibility of adult mosquitoes to an insecticide or measurement of resistance. The results are expressed as

% mortality after 24 hours of holding, and assessment of mortality and knockdown effect (effective KD) are determined. The WHO standard method is used.

**Essential equipment:**

- Holding tubes with "green dot"
- Exposure tubes with "red dot"
- Two metal rings per tube (silver or copper) stages
- One mesh per tube
- One suction tube (mouth aspirator)
- Data sheet "adult susceptibility test"

**Preparation for the test**

**Use "green dot tubes" for the preparation of the control tube**

- Prepare four tubes for the test and one tube for the control
- Insert a control filter paper (without insecticide), held by two silver rings
- Close one end of the tube with mesh and the other end by inserting the stage
- Collect the mosquitoes directly from the cage through a suction tube and release them into the test tubes 25 females/ tube and close the stage of the holding green dot tube
- Label the tube with the number and details about the strain
- Hold the mosquitoes in a tube for one hour in a chamber whose temperature is between 26°C and 28°C and the relative humidity between 80 to 100%
- If possible, replace the dead mosquitoes before keeping them for exposure, or note the number of mosquitoes dead or with a smaller number of legs

**Use "red dot tubes" for the preparation of the test**

- Use disposable gloves
- Insert insecticide-impregnated paper in the red dot tubes
- Note: place impregnated surface inside (inscription readable through the tube)
- Hold the paper with 2 copper rings, and then close the tube with a mesh

**Procedure of the test**

- Prepare a data sheet with the name of the test (adult susceptibility test)
- Screw the exposure tube (control/test) on to the other side of the stage of the holding tube with mosquitoes in green dot tube and label the same number on the holding tube
- Slide the stage plate in a manner that it will open entirely into the exposure tube
- Blow the mosquitoes gently from the holding tube into the exposure tube
- Close the stage by pushing back the plate
- Detach the holding tube from the assembly and place it in such a way that the mesh should be on top
- Hold the mosquitoes in an exposure tube for 1 hour under moderate diffuse lighting
- Note the number of mosquitoes knock-down (KD) at regular intervals in exposures with Pyrethroids
- At the end of the exposure period, transfer the mosquitoes from the exposure tubes into the holding tubes in the same way as previously done
- Hold the mosquitoes in holding tubes for 24 hours in a dark chamber/room with a controlled temperature of 26 to 28°C and RH of 80 to 100%
- Provide 10% glucose/honey solution in a swab while holding
- After 24 hours of holding, count the number of dead mosquitoes

The test is accepted, if the mortality in the control tubes is 20% in control replicates the test should be repeated and the reasons for the same should be explored and rectified.

**II. Larval susceptibility**

**Test principle**

The purpose of the larval test is to determine and follow the level of susceptibility/resistance of larval stages of a given species of mosquitoes to a given insecticide. This test also gives the effectiveness of several insecticides (formulation or active ingredient) with respect to a given species or compares the susceptibility of several mosquito species to a given insecticide.

**Essential equipment:**

- Plastic/Paper cups (volume 200 ml)
- 3 ml Pasteur pipette
- Small strainer to pick the larvae
- Data sheet

**Procedure of the test**

Prepare 5-6 serial dilutions in water in plastic bowls with a range of concentration from the stock solution in ethanol.

- The concentrations used are noted on the data sheet.
- Fill the bowls with 99 ml distilled water and add 1ml of an insecticidal solution to give the desired concentration of insecticide.
- Prepare a series of 5–6 control cups containing 1 ml of ethanol in 99 ml water.
- Collect 20, 3$^{rd}$ instar /early 4$^{th}$ instar larvae of mosquito using a Pasteur pipette on a small strainer.
- Introduce 20 larvae in each bowl.
- The cups are then placed in a controlled climatic chamber having a temperature between 26 and 28°C.
- The reading will be recorded after 24 hrs. of holding.
- Certain insecticides require an additional reading at 48 hrs. In this case one should add food after 24 hrs.

### 3.4.5 Surveillance of dengue vectors

*Aedes aegypti* is the main vector species of dengue in India and common in most of urban areas on account of deficient water management, the presence of non-degradable tyres, long-lasting plastic, overhead tanks and ground water storage tanks are the primary breeding habitats *i.e*., *Ae. aegypti* breeds almost entirely in manmade habitats and around households, construction sites, and factories. *Ae. albopictus* breeds in tree holes, leaf axils and coconut shells, etc. *Aedes* spp. the population fluctuates with rainfall and humidity.

### I. Adult survey

#### Landing collection

Landing collection of humans is a sensitive means of detecting low level infestations of *Aedes* mosquitoes, but very labour-intensive. Because adult males have low dispersal rates, their presence can be a reliable indicator of clear proximity to hidden larvae habitats. It is usually expressed in terms of landing counts per man hour.

#### Resting collection

During periods of inactivity, adult *Ae. aegypti* mosquitoes typically rest indoors, especially in bedrooms and mostly in dark places, such as cloth closets and other sheltered sites. Resting collection requires systematic searching of these sites for adult mosquitoes with the aid of a flashlight. Presence of adult *Aedes* mosquito can be ascertained by resting collection

#### Oviposition traps

Ovitraps are devices used to detect the presence of *Ae. aegypti* where the population density is low and larval surveys are largely unproductive (when the Breteau Index is less than 5) as well as normal conditions. The ovitrap is used for *Ae. aegypti* surveillance in urban areas to evaluate the impact of adulticidal space spraying on the adult female population.

### II. Larval survey

For larval surveys, the basic sampling unit is the house or premise, which is systematically searched for water-holding containers. Containers are examined for the presence of mosquito larvae and pupae. Depending on the objective of the survey, the search may be terminated as soon as *Aedes* larvae are found, or it may be continued until all containers have been examined. The collection of specimens for laboratory examination is necessary to confirm the species. Four indices commonly used to monitor *Ae. aegypti* infestation levels are (NCVBDC: Guidelines for integrated vector management for control of dengue/severe dengue)

- House Index (HI): Percentage of houses infested with larvae and/or pupae.

$$\mathbf{HI} = \frac{\text{Number of Houses infested}}{\text{Number of Houses searched}} \text{ x } 100$$

- Container Index (CI): Percentage of water-holding containers infested with larvae or pupae.

$$\mathbf{CI} = \frac{\text{Number of positive containers}}{\text{Number of containers searched}} \text{ x } 100$$

- Breteau Index (BI): Number of water holding containers positive for larvae and pupae per 100 houses inspected.

$$\mathbf{BI} = \frac{\text{Number of positive containers}}{\text{Number of houses inspected}} \text{ x } 100$$

- Pupae Index (PI): Number of pupae per houses.

$$\mathbf{PI} = \frac{\text{Number of pupae}}{\text{Number of houses inspected}} \text{ x } 100$$

### 3.4.6 Surveillance of malaria vector

A malaria surveillance system consists of the tools, procedures, people and structures that generate information on malaria cases and deaths, which can be used for planning, monitoring and evaluating malaria control programmes (Table-16). An effective malaria surveillance system enables programme managers to:

- Identify the areas or population groups most affected by malaria;
- Identify trends in cases and deaths that require additional intervention, e.g., epidemics; and
- Assess the impact of control measures.

The main entomological indicators can be categorized into five groups:

- Adult vector composition (species occurrence and density);
- Adult vector behaviour (human blood index, human biting rate, biting time, biting location, resting location);
- Adult vector resistance to insecticides (resistance frequency, status, intensity and mechanisms);
- Immature vector aquatic habitats (habitat availability and occupancy, larval density); and
- Proxies for transmission (sporozoite rate, entomological inoculation rate, receptivity) Indicators are usually reported by individual vector species

The selection of surveillance sites becomes increasingly important as transmission decreases, as the key entomological parameters will become more heterogeneous. Surveillance should therefore be targeted on the basis of epidemiological data and local knowledge of malaria risk. Areas in which transmission patterns are changing must be identified, and entomological spot checks conducted to assess receptivity and to implement vector control accordingly.

**Table- 16: Surveillance tools and indicators for malaria**

| Sl. No. | Indicator | Definition | Formula |
|---|---|---|---|
| 1 | **Resting collections (aspirator or handheld net)** | Man Hour Density (MHD) | $\frac{\text{Number of mosquitoes collected}}{\text{Actual man hours spent i.e. number of persons collecting x time spent in hrs}}$ |
| 2 | **Indoor resting density** | Number of adult female mosquitoes per house per night | $= \frac{\left\{\frac{\text{Number of females}}{\text{Number of houses}}\right\}}{\text{Number of nights}}$ |
| 3 | **Human-biting rate (ethical clearance required)** | Number of bites a person receives from a specific vector species per night | $= \frac{\text{Number of mosquitoes collected}}{\text{No. of collectors}}$ |
| 4 | **Human Blood Index (HBI)** | Proportion of blood-fed mosquitoes that fed on humans | $= \frac{\text{No. of mosquitoes positive for human blood}}{\text{Total no. of blood fed mosquitoes tested}} \times 100$ |
| 5 | **Sporozoite rate** | Proportion of mosquitoes of a given species with sporozoites in salivary glands | $= \frac{\text{No. of positive mosquito}}{\text{No. of mosquitoes dissected}} \times 100$ |
| 6 | **Insecticide susceptibility** | % Mortality of insect against insecticide | $\frac{\text{Number killed}}{\text{Number exposed}} \times 100$<br>Use Abbott's formula if mortality in control is between5-20%<br>$\frac{\text{\% test mortality} - \text{\% control mortality}}{100 - \text{\% control mortality}} \times 100$ |
| 7 | **Density of immatures** | Measure of larval + Pupal density | $= \frac{\textit{Total no. of larvae and pupae collected}}{\text{Total no. of dips taken}}$ |
| 8 | **Larval density** | Measure of larval density | $= \frac{\text{Total no. of larvae collecetd}}{\text{Total no. of dips taken}}$ |
| 9 | **Pupal density** | Measure of Pupal density | $= \frac{\text{Total no. of pupae collecetd}}{\text{Total no. of dips taken}}$ |

**Source:** NVBDCP, 2016

### 3.4.7 Surveillance of JE vector

Outdoor resting mosquito vectors of JE can be collected from vegetation by BPD Hop (Bina Pani Das Hop) cage. In order to collect resting mosquitoes from land vegetation, folded mosquito cage was allowed to hop through the shady vegetation near the ground and also low-level ground vegetation by a series of quick forward, backward, up and down movements through a distance of 5 ft (lengthwise) for about 2 min (Das, 2009). This led to the trapping of mosquitoes in the cage. One side open sleeve of the cage is then immediately folded in order to prevent the trapped mosquitoes from escaping. The mosquitoes were retrieved from the narrow cotton sleeve outlet of the cage by a mouth aspirator tube. Such attempts are made at least ten times in one type of vegetation. For collecting mosquitoes from aquatic vegetation like hyacinth marshes same procedure was followed along the side of the water body.

Hop cage has to be used 10 times while collecting day-resting mosquitoes from land as well as aquatic vegetation and the mosquito density was measured as an average number of female mosquitoes collected per ten hop cages (PTHC) by the following formula:

$$\text{Mosquito density (PTHC)} = \frac{\text{Total numbers of female mosquitoes collected}}{\text{Total numbers of hopping attempts made on vegetation}} \text{x10}$$

Each hop on vegetation covers an area of 1 sq. foot. The larger the area of the vegetation covered by hopping, the better representation of the mosquito density.

### 3.4.8 Entomological survey of Lymphatic filariasis

From each sentinel and spot check site, entomological data collection should be made from10 catching stations spending 15 minutes in each catching station using a flash light and aspirator tube in the early morning between 06:00 and 10:00. All the female *Culex quinquefasciatus* shall be dissected to find out the filarial infection. The following entomological parameters are to be calculated for each selected village/ward. From each site, minimum of three collections at an interval of 10 days shall be carried out before each round of MDA.

$$\textbf{Ten Man} - \textbf{hour Vector Density} = \frac{\text{No. of male \& female } Cx.\, quinquefasciatus \text{ collected}}{\text{No. of man} - \text{hour spent for mosquito collection}}\ x\ 10$$

$$\textbf{Infection rate (\%)} = \frac{\text{No. of mosquitoes positive for any or all stage (L1/L2/L3 stages) of the parasite}}{\text{No. of female vector mosquitoes dissected}} \times 100$$

$$\textbf{Infectivity rate (\%)} = \frac{\text{No. of mosquitoes positive for infective larvae (L3)}}{\text{No. of female vector mosquitoes dissected}} \times 100$$

$$\textbf{Mean number of L3/ infective mosquito} = \frac{\text{No. of infective larvae (L3) found}}{\text{No. of infective mosquitoes}}$$

L1: Stage 1 larva or sausage stage larva

L2: Stage 2 larva or pre-infective stage larva

L3: Stage 3 larva or infective stage larva

### 3.5 Epidemiological surveillance

Epidemiological surveillance is an assessment to determine the incidence and prevalence of all vector borne diseases, it includes vector assessment and analysis of a vector borne disease situation. Vector assessment is to determine the main vector species and their characteristics, stratification to classify geographical areas according to the burden of vector-borne disease.

Epidemiology has been defined by John M. in 1988 as “the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to the control of health problems”. The first step of epidemiological assessment for a decision-making is to determine:

a. Burden of vector borne diseases

b. Measuring the burden of disease, which requires current data on disease incidence prevalence and mortality

c. Information on-
    - Different days
    - Seasonal variations
    - Variations in population and other data, is needed for each VBD

The data available in active and passive surveillance are collected for the target population. This surveillance system is needed for evidence-based decision-making in planning control activities for monitoring and evaluation of IVPM. It can be verified by consulting reports on national surveillance from vector-borne disease control programme.

### 3.5.1 Incidence

It is defined as "the number of new cases occurring in a defined population during a specified period of time". Incidence measures the rate at which new cases are occurring in a population. It is not influenced by the duration of the disease.

$$\textbf{Incidence} = \frac{\text{No. of new cases of specific disease during a given time period}}{\text{Estimated population at risk during that period}} \times 1000$$

The use of incidence is generally restricted to acute conditions. The incidence rate, as a health status indicator, is useful for taking action to control disease, and for research into aetiology and pathogenesis, distribution of diseases, and efficacy of preventive and therapeutic measures (Park, 2015).

### 3.5.2 Prevalence

The term prevalence refers specifically to all current old and new cases existing at a given point in time or over a period of time in a given population. The total number of all individuals who have an attribute or disease at a particular time or particular period divided by the population at risk of having the attribute or disease at this point in time or midway through the period.

- **Point prevalence**

Point prevalence of diseases is defined as the number of all old and new cases of a disease at one point of time in relation to a defined population. The prevalence rate is used without any further qualification it is taken to mean point prevalence. It can be made specific for age, sex and other relevant factors or attributes.

$$\textbf{Point prevalence} = \frac{\text{No. of all current cases of a specified disease existing at a given point in time}}{\text{Estimated population at risk at the same point in time}} \times 100$$

- **Period prevalence**

  A less commonly used measure of prevalence is period prevalence. It measures the frequency of all current cases (old and new) existing during a defined period of time (e.g., annual prevalence) expressed in relation to a defined population. It includes cases arising before but extending into or through the year as well as those cases arising during the year.

$$\textbf{Period prevalence} = \frac{\text{No. of existing cases of a specified disease during a given period of time interval}}{\text{Estimated mid interval population at risk}} \times 100$$

### 3.5.3 Epidemiological parameters of malaria

The parameters used for the measurement of malaria were mostly parasitological, commonly used parameters were API, ABER, SPR, and SFR. Those parameters are unlikely to reveal the true epidemiological picture unless the case detection machinery is fully supervised and very efficient.

#### 3.5.3.1 Annual Parasite Incidence (API)

API is an advanced measure of malaria incidence in a community. It is based on intensive active and passive surveillance. Areas with API is more than 2 ($API \geq 2$) or 2 malaria cases per 1000 population per year have been classified as high-risk areas in India.

$$\textbf{API} = \frac{\text{Confirmed cases during one year}}{\text{Population under surveillance}} \times 1000$$

#### 3.5.3.2 Annual Blood Examination Rate (ABER)

The annual parasite incidence depends upon the annual blood collection and examination rates. A sufficient number of blood slides must be systematically obtained and examined for the malaria parasite to work out accurately API.

$$\textbf{ABER} = \frac{\text{Number of blood slides examined during the year}}{\text{Population under surveillance}} \times 100$$

#### 3.5.3.3 Annual *falciparum* Incidence (A*f*I)

Since the emergence of *P. falciparum* problem in India, data is collected separately for total malaria cases and *P. falciparum* cases. A*f*I denotes the number of *P.falciparum* cases during one year period per 1000 population under surveillance. The percentage of slides positive for *P. falciparum* parasite is known as the Slide *falciparum* rate (S*f*R).

$$\textbf{A}f\textbf{I} = \frac{\text{Total no. of } P.\ falciparum \text{ positive during one year}}{\text{Population under the surveillance}} \times 1000$$

$$\textbf{S}f\textbf{R} = \frac{\text{Total no. of positive } P.\ falciparum \text{ slides}}{\text{Total no. of slides examined}} \times 100$$

#### 3.5.3.4 Slide Positivity Rate (SPR)

Slide Positivity Rate is the percentage of slides found positive for the malarial parasite, irrespective of the type of species.

$$\textbf{SPR} = \frac{\text{Total no. of the positive slide for malaria parasite}}{\text{Total no. of slides examined}} \times 100$$

### 3.5.4 Epidemiological parameters of filariasis

This parameter measured is the incidence and prevalence of microfilariae can also be used to measure the impact of MDA. The Standard method of night blood surveys of the sentinel site population aged ≥5 years is used to determine the prevalence and density of microfilariae.

#### 3.5.4.1 Microfilaria rate

It is the percentage of persons showing mf in their peripheral blood (20 cu. mm) in the sample population, with one slide being taken from each person. The microfilaria prevalence (mf %) is calculated as the proportion of blood slides found positive for microfilariae.

$$\textbf{Microfilaria rate (\%)} = \frac{\text{No. of slides positive for mf}}{\text{Total no. of slides examined}} \times 100$$

### 3.5.4.2 Microfilaria density

It is the number of mf per unit volume (20 cu. mm) of blood in samples from individual persons. It indicates the intensity of infection. Microfilariae density (mfd) is total number of microfilariae found positive in the slides per ml of blood (presuming 60 µl per slide) to the total number of slides found positive. mfd can be calculated as:

$$\textbf{Microfilaria density} = \frac{\text{Total count of microfilariae}}{\text{Total no. of slides found positive}}$$

### 3.5.4.3 Filarial endemicity rate

It is the percentage of number of persons found positive for a disease *i.e.*, showing microfilariae in their blood to total number of persons examined for disease.

$$\textbf{Filarial endemicity rate (\%)} = \frac{\text{No. of persons positive for } mf \text{ or disease or both}}{\text{Total number of persons examined}} \times 100$$

## 4. Glossary

**Active ingredient**

An active ingredient is the element in insecticide that gives repelling or killing power.

**Adult susceptibility test**

Adult susceptibility bioassay is a direct response-to-exposure test; it measures mosquito mortality to a known standard dose of a given insecticide (*i.e.,* the diagnostic or discriminating concentration).

**Adulticide**

Adulticide is the type of chemical insecticide that targets adult vectors. It is intended to impact vector densities, longevity and other transmission parameters.

**Advocacy**

Advocacy is a process by an individual or group, which aims to influence public policy and resource allocation decisions within political, economic, and social systems and institutions. Advocacy can include many activities that a person or organization undertakes including media campaigns, public speaking etc.

**Aerosol**

An aerosol is a suspension of small particles in air or another gas.

**A*f*I**

Annual *falciparum* Incidence is calculated as total positive *Plasmodium falciparum* in a year x 1000 divided by total population.

**Anganwadi**

It is a rural child care center in India, providing care for mothers and young children in a rural area.

**API**

The Annual Parasite Incidence (API) is a malariometric index to express malaria cases per thousand population. API refers to high and moderate malaria transmission risk areas.

**ASHA**

Accredited Social Health Activist (ASHA) is one of the key components of the national health mission (earlier national rural health Mission), which provides every village in the country with a trained female community health activist.

**Aspirator**

It is a device to collect small insects and other invertebrates. The aspirator is having one tube through which they are sucked into the bottle, and another, protected by muslin or gauze, which sucks insects.

**Bait**

Bait is the active placement or manipulation of edible or inedible items, to attract or distract potential prey, facilitating prey capture.

**Behaviour Change Communication**

The changes that the intended audiences are expected to make in their behaviour and the expected changes in the factors that influence behaviour such as knowledge, attitudes and perceptions.

**BG-sentinel trap**

The BG-Sentinel mosquito trap is essentially a collapsible, fabric container with a white lid with holes covering its opening. In the middle of the gauze cover, the air is sucked into the trap through a black catch pipe by an electrical fan, drawing approaching mosquitoes into a catch bag.

**Bioassay**

Bioassays are methods that utilize living materials to detect substances or determine the potential toxicity of chemicals or contaminated matrices. They are widely used to screen for potentially hazardous chemicals in contaminated soils, potable and wastewater, foods, and other materials.

**Biological control**

Deliberate introduction of biological agents such as pathogens, parasites and predators (especially fish) to control arthropod population.

**Capsule suspension**

Capsule suspensions are water-based slow-release formulations containing active ingredients encapsulated inside polymer microcapsules. The CS formulations are very useful to provide a prolonged effect for controlling target pests.

**Chemical control**

The use of chemicals to disrupt the life cycle of vectors at different stages of their life cycle is known as chemical control.

**Climate**

Climate is the average weather condition of the earth's surface over a long period of time, taking into account temperature, precipitation, humidity, wind, barometric pressure, and other phenomena.

**Cold fogs**

With cold fogs the droplets are formed by the mechanical breaking up of the spray mixture, either by passing it through high-pressure nozzles or by passing a slow stream of the mixture through a high-velocity vortex of air.

**Collaboration**

It is a process in which entities share information, resources, and responsibilities to jointly plan, implement and evaluate a program of activities to achieve a common goal.

**Community**

Community is a group of people with diverse characteristics who are linked by social ties, share common perspectives, and engage in joint action in geographical locations or settings.

**Concentration**

The amount of solute dissolved in a unit amount of solvent.

**Crystal protein**

Crystal proteins made by the bacterium *Bacillus thuringiensis* (*Bt*) are pore-forming toxins that specifically target invertebrates (insects and nematodes) and are generally innocuous to mammals.

**Death rate**

Death rate or mortality rate is a measure of the frequency of occurrence of death in a defined population during a specified interval.

**Demography**

Demography is the study of human populations with respect to their size, structure and dynamics.

**Disease morbidity**

Morbidity is the state of being symptomatic or unhealthy for a disease or condition. It is usually represented or estimated using prevalence or incidence.

**Distribution**

In epidemiology, distribution means the frequency and pattern of health-related characteristics and events in a population.

**Dose**

Dose is a quantity of an insecticide, medicine or drug taken or recommended to be taken or used at a particular time.

**Ecological interrelationships**

Ecological interrelationships describe the interactions between and among the organisms within their environment.

**Ecosystem**

An ecosystem can be visualized as a functional unit of nature, where living organisms interact among themselves and also with the surrounding physical environment.

**Ecosystem integrity**

Ecosystem integrity is defined as the system's capacity to maintain structure and ecosystem functions using processes and elements characteristic of its eco region.

**Electric vaporizer**

Electric vaporizers enable harmful flies and mosquitoes to be removed from indoor spaces owing to the vaporization of the natural and herbal volatile oils in liquid form by means of electricity.

**Emulsifiable concentration**

Emulsifiable concentrates are typically optically transparent oily liquid formulations that are prepared by dissolving a certain amount of pesticide in organic solvents (such as benzene, toluene, xylene, and solvent oil), which may also contain surfactants and other additives.

**Endemic**

Endemic refers to the constant presence or usual prevalence of a disease or infectious agent in a population within a geographic area.

**Entomology**

Entomology is the science dealing with the scientific study of insects.

**Entomological surveillance**

Periodic collection of data related to knowledge of local vector species and their susceptibility to insecticides, as well as on vector and human behaviors that may allow mosquitoes to avoid contact with interventions and thereby maintain residual transmission, which is essential to inform vector control strategies and track their impact on disease.

**Environmental management**

Environmental management consists of actual decisions and action concerning policy and practice regarding how resources and the environment is appraised, protected, allocated, developed, used, rehabilitated, remediated and restored.

**Epidemic**

An epidemic is the occurrence of more cases of the disease, injury, or other health condition than expected in a given area or among a specific group of persons during a particular period. Usually, the cases are presumed to have a common cause or to be related to one another in some way.

**Epidemiology**

Epidemiology is the study of the distribution and determinants of health-related states or events in specified populations and the application of this study to the control of health problems.

**Epithelium**

Epithelium represents an interface between the internal and the external environment.

**Eradication**

It is the permanent reduction to zero of the worldwide incidences of infection caused by a specific agent as a result of deliberate efforts.

**Evaluation**

Evaluation is a systematic determination of a subject's merit, worth and significance, using criteria governed by a set of standards. It can assist an organization, programme, design, project or any other intervention or initiative to assess any aim, realizable concept/proposal, or any alternative, to help in decision-making.

**Exotic species**

Exotic species often referred to as alien, non-native, non-indigenous, or introduced species, are those that occur in areas outside of their natural geographic range.

**Fogging**

Fogging is defined as space spraying of insecticide against mosquitoes to prevent an outbreak of mosquito-borne infection.

**Formulation**

Formulation could be defined as the set of operations that aim to create a physical system, which contains the drug, in order to meet the quality requirements, set in advance (specifications) and ensure the maintenance of efficacy and safety characteristics of the active substance.

**GIS**

A Geographic Information System (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.

**Homeostasis**

Homeostasis is the body's automatic tendency to maintain a relatively constant internal environment in terms of temperature, cardiac output, ion concentrations, blood pH, hydration, dissolved $CO_2$ concentration in blood, blood glucose concentration, concentrations of wastes, etc.

**Host**

An animal or plant, which is infected with or is fed upon by parasitic or pathogenic organism (e.g. nematodes, fungi, viruses etc.).

**HBI**

The Human Blood Index (HBI) represents the proportion of blood meals derived from humans by mosquito vectors. It may be used to estimate the human biting habit, an important component of vectorial capacity, as a proxy measure of malaria transmission.

**Humidity**

Humidity is defined as the measure of the water vapour content of air (or other gas).

**Incidence**

It is defined as the number of new cases occurring in a defined population during a specified period of time.

**Indicators**

A quantitative or qualitative factor or variable that provides a simple and reliable means to measure achievement, to reflect the changes connected to an intervention.

**Indoor Residual Spray**

IRS involves coating the walls and other surfaces of a house with a residual insecticide. For several months, the insecticide kills mosquitoes and other insects that come in contact with these surfaces.

**Infection**

It means the entry and development or multiplication of a pathogenic agent in the body of humans or animals.

**Infectivity rate**

It is typically used to measure the frequency at which disease spreads within a defined population during a specified time frame.

**Infestation**

It means the external invasion or colonization of animals or their immediate surroundings by arthropods, which may cause clinical signs or are potential vectors of pathogenic agents.

**Ingredients**

An ingredient is a substance that forms part of a mixture.

**Insect Growth Regulators (IGRs)**

Several compounds that adversely interfere with the growth and development of insects have been synthesized, and have been collectively referred to as IGRs.

**Insecticide**

Insecticides are toxic substance that is used to kill insects. Such substances are used primarily to control pests that infest cultivated plants or to eliminate disease-carrying insects in specific areas.

**Insecticide resistance**

It is defined as the ability of an insect to withstand the effects of an insecticide by becoming resistant to its toxic effects by means of natural selection and mutations.

**Insecticide-Treated Nets**

Insecticide-Treated Nets (ITNs) are a form of personal protection, which are simple mosquito nets that have been treated with an insecticide. These nets require 're-dipping' to restore the insecticide element every 6-12 months.

**Integrated Pest Management**

Integrated Pest Management (IPM) is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties.

**Integrated Vector Management**

Integrate Vector Management (IVM) is a rational decision-making process for the optimal use of resources for vector control. The approach seeks to improve the efficacy, cost-effectiveness, ecological soundness and sustainability of disease-vector control. The ultimate goal is to prevent the transmission of vector-borne diseases such as malaria, dengue, Japanese encephalitis etc.

**Intensity**

Intensity refers to the rate at which the activity is being performed or the magnitude of the effort required to perform an activity or exercise.

**Invertebrates**

Invertebrates belong to the animal kingdom. They lack a backbone and have soft bodies because they don't have an internal skeleton (endoskeleton) for support although, some of them possess an exoskeleton that encompasses the entire body. Invertebrates do not possess lungs since they respire through their skin and are heterotrophic.

**Irrigation**

The process of supplying water to land by artificial means. Its basic objective is to supplement the natural supply of water, for raising crops with an economic and efficient system. Controlling and harnessing various natural resources. To achieve it, irrigation systems are required.

**Larval density**

Larval density is the number of larvae collected to the number of dips made.

**Larval habitat**

These are the places where eggs are laid, larvae hatch, instars moult, pupate, and adults emerge. They may be natural or man-made, permanent or temporary, large or small.

**Larvicide**

A larvicide is an insecticide that specifically targets the larval life stage of an insect. Larvicides may be contact poisons, stomach poisons, growth regulators, or (increasingly) biological control agents and are most commonly used against mosquitoes.

**Light trap**

Light trapping is the most common and regular sampling technique. Nocturnal arthropods particularly insects are attracted by artificial light sources therefore light traps have been widely used to collect nocturnal insects.

**LLINs**

LLIN is a mosquito net impregnated with insecticide. The insecticide is cleverly bounded within the fibres that make up the netting and is 'slow released' over a 4-5 years period.

**Longevity**

How long an organism lives, is often expressed as the mean expectancy of life. Vector longevity is one of the most important factors in disease transmission dynamics and vector control.

**Man Hour Density**

Man Hour Density (MHD) is an important index to determine relative densities of mosquitoes to compare the prevalence of vectors in the same areas of seasons, months or years or to compare different places also.

**Management**

Management is the organizational process that includes strategic planning, setting objectives, managing resources, deploying the human and financial assets needed to achieve objectives, and measuring results.

**MDA**

Mass Drug Administration (MDA) is the administration of anti-malarial treatment to every member of a defined population or every person living in a defined geographical area at approximately the same time and often at repeated intervals.

**Mechanical control method**

Mechanical control methods involve the complete or partial removal of plants by mechanical means, including harvesting, shredding, mowing, rototilling, rotovating and chaining.

**Microfilariae**

Microfilaria is an organism, which is serpentine in shape and is filled with nuclei of many cells. It is an early stage in the life cycle of parasitic nematodes in the family onchocercidae. Adult releases microfilariae into the bloodstream of the vertebrate host.

**Mists**

Mists are dispersions of liquids in gases. They are formed during the nebulization of liquids, during condensation from the vapour phase and during chemical processes (for example oil mist, and hydrogen chloride in damp air).

**Mortality**

A mortality rate is a measure of the frequency of occurrence of death in a defined population during a specified interval.

**Nematodes**

A nematode is one of a phylum of elongated cylindrical worms parasitic in animals or plants or free-living in soil or water.

**Nozzles**

A nozzle is a simple device used to break apart a fluid flow into a spray pattern. It atomizes liquid into droplets, disperses the droplets in a specific pattern, metres liquid at a certain flow rate and provides hydraulic momentum.

**Oil in water emulsion**

Oil-in-water emulsions are conventionally defined as thermodynamically unstable systems, which include two immiscible liquids (generally water and oil), in which oil is distributed into the water.

**Organization**

A social unit of people, systematically structured and managed to meet a need or to pursue collective goals continuingly.

**Outbreak**

Outbreak is an occurrence of significantly more cases of disease than expected in a given area among a specific group of people over a particular period of time.

**Parasite**

Parasites are organisms, which live in or on another organism, drawing nutrition from the host and causing it harm.

**Pathogenesis**

The parasite or pathogen can interfere with one or more of the essential functions of the plant or animal.

**Pathogens**

A pathogen is defined as an organism causing the disease to its host. Pathogens are taxonomically widely diverse and comprise viruses and bacteria as well as unicellular and multicellular eukaryotes.

**Pests**

Pest is an insect (or organism) that causes harm to humans, their livestock, crops or possessions. Pest includes nematodes, weeds, bacteria, insects, fungi, molluscs, phytoplasma, viruses and viroids.

**Pesticides**

Pesticides are chemical compounds that are used to kill pests.

**Population density**

Population density is defined as the number of persons per square kilometre. It is an important index of population, which shows the concentration of the population in a particular area.

**Predator**

An animal that feeds upon other animals (prey) that are either smaller or weaker than itself.

**Prevalence**

Prevalence measures the amount of disease in a population at a given time and can be expressed as a percentage. The point prevalence is a single assessment at a fixed point in time, whereas the period prevalence is the percentage of a population who has the disease at any time within a stated period.

**Proliferation**

To proliferate normally means to increase rapidly in number or quantity, or to grow or reproduce by rapid production of new parts (biological).

**Protozoa**

Protozoa are single-celled, animal-like organisms.

**Public health entomology**

Public health entomology focuses on the population biology of vector-borne infections, seeking to understand how such pathogens perpetuate over time and attempting to devise methods for reducing the burden that they impose on human health.

**Remote sensing**

Remote sensing is science of obtaining information about an object or feature without physically coming in contact with that object or feature. The process infers surface parameters from measurements of electromagnetic radiation (EMR) from the earth’s surface. This EMR can either be reflected or emitted from the Earth’s surface. It is a useful tool for vectorborne diseases.

**Sanitation**

Sanitation refers to the provision of facilities and services for the safe management of human excreta from the toilet to containment and storage and treatment onsite or conveyance, treatment and eventual safe end use or disposal.

**Social mobilization**

Social mobilization is the process of bringing together all societal and personal influences to raise awareness of and demand for health care, assist in the delivery of resources and services, and cultivate sustainable individual and community involvement.

**Species**

A group of individuals in natural populations that can inter-breed by mating within the group and producing fertile progeny; individuals are usually similar in appearance and behavior.

**Spinosad**

Spinosad is a naturally derived fermentation product, which has demonstrated insect control activity against a large number of pests. The product is isolated from actinomycetes *Saccharopolyspora spinosa*.

**Sporozoite rate**

Sporozoite rate is the number of mosquitoes infected with sporozoites divided by the total number of mosquitoes examined using each respective method of mosquito collection, expressed as a percentage.

**Susceptibility**

Susceptibility means “the state of being susceptible” or “easily affected.”

**Thermal fogging**

Thermal fogging is the generation of ultra-fine droplets in a range of 1-50 µm using thermo- pneumatic energy. The fluid to be fogged is first vaporized by an increase in temperature and the vapour is then condensed upon introduction to the cooler atmospheric air.

**Toxicity**

Toxicity can be defined as the relative ability of a substance to cause adverse effects in living organisms.

**Vector**

Vectors are living organisms that can transmit infectious pathogens between humans, or from animals to humans. A distinction is made between ‘mechanical vectors’, which are only carriers of infectious agents, and ‘biological vectors’, within which the agent lives for a part of its life cycle.

**Vector incrimination**

The vector capable to transmit the pathogen to an uninfected host is called vector incrimination.

**Vertebrates**

Vertebrates are members of the larger phylum chordata. The distinct feature is presence of the vertebral column, or backbone, which surrounds and protects the main nerve cord. Other major chordate features at some point in their life cycles includes notochord, dorsal hollow nerve cord, pharyngeal slits, and a post-anal tail.

**Vertebrate Animals**

An animal with a skull, which surrounds the brain and a skeleton of bone or cartilage, including the spine of vertebral bones surrounding a spinal cord of nerves; includes mammals, aves, fishes, reptiles and amphibians.

**Vertical transmission**

Transmission of an infection from a mother to her offspring during the perinatal period (the period immediately before and after birth). Transmission might occur across the placenta, in the breast milk, or through direct contact during or after birth. eg., HIV, hepatitis B and hepatitis C.

**Veterinary**

Relating to the diseases, injuries, and treatment of farm and domestic animals.

**Vicinity**

The area or region near or about a place; surrounding district; neighbourhood.

**Virology**

Virology is the study of viruses, complexes of nucleic acids and proteins that have the capacity for replication in animal, plant and bacterial cells.

**Virulence factors**

It determines the degree to which the pathogen causes damage, invasion, and infectivity.

**Volume Median Diameter (VMD)**

The volume median diameter is the diameter half the volume of the aerosol particles contained in particles with larger diameters and half is contained in particles with a smaller diameter.

**Waterholes**

Wildlife water holes are an important habitat component for a variety of wildlife. They provide drinking water for many wild animal species including bats, wild boars, elephants turkeys and deers and these also serve as breeding habitat for many amphibians.

**Wetlands**

Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.

**Wettable powder**

Water dispersible powder technical grade insecticide diluted with an inert carrier (dust) and to which a wetting agent or surfactant has been added. The resultant wettable powder is then mixed with water for spraying onto the surface.

**Zoonotic disease**

A disease that can be transmitted from animals to people or, more specifically, a disease that normally exists in animals but that can infect humans. There are multitudes of zoonotic diseases.

**Zoophagic**

Zoophagic is defined as feeding on animals or animal matter; specifically (of a mosquito) feeding on animals other than humans.

**Zoophilic**

Zoophilic mosquitoes are mosquitoes that prefer animals for blood.

**Zygote**

Cell that forms by the union of a male and female gametes.

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