Extension Guidelines for Pest / Vector Management in Human Habitations

~~National~~ Institute of Agricultural Extension Management (MANAGE)
(An Organization of Ministry of Agriculture and Farmers Welfare, Govt. of India)
Rajendranagar, Hyderabad-500 030, Telangana, India
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Concept and Edited
by
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(An Organization of Ministry of Agriculture and Farmers Welfare, Govt. of India)
Rajendranagar, Hyderabad - 500 030, Telangana

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About the Publication: This publication is printed and published by the Director General, MANAGE, Hyderabad. It provides basic information of pests and vectors, their surveillance techniques and procedures to use available tools and most appropriate methods at local level to manage them in a time framework with systematic actions.

Disclaimer: The information in this book has been authored by expert scientists drawn from agriculture, public health and pest management sectors. The authors are solely responsible for the accuracy of the information.

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FOREWORD

With the advent of global warming, deforestation, industrialization, the pests with their normal niche of agricultural and forest areas are able to invade into human habitations and dwellings causing physical losses to commodities and structures in ever expanding villages and also transmitting diseases to humans in these neo-ecosystems. In order to address this threat, MANAGE organized an Orientation Workshop in November, 2018 for Public Health functionaries in Local bodies. As an offshoot of one of its recommendations, a booklet entitled "Extension Guidelines for Pest/Vector Management in Human Habitations" is brought out by MANAGE. The objective of this publication is to provide guidance on pest and vector management in human habitations to the designated Pest/Vector management professionals and Pest Management Professionals including NGOs, Civil society etc.

The target group is the grass-root level functionaries in rural and urbanizing human habitations. It provides basic information of pests and vectors, their surveillance techniques and procedures to use available tools and most appropriate methods at local level to manage them in a time framework with systematic actions. This would also facilitate up-skilling the capacity in pest/vector management among extension professionals in local bodies as well as commercial pest management professionals in industrial and urban areas. This can also be used as guidance document which can cater the needs of students pursuing Pest Management as their career.

Eminent Scientists and Extension personnel having about 30 years of field experience contributed the articles/chapters on major pests/vectors, viz., mosquitoes, rodents, cockroaches, termites etc., with step-wise operational procedures for their management in ever increasing vector borne diseases era. The authors are drawn from Agriculture, Public Health and Structural Pest Management sectors

It is hoped that the targeted objectives will be fulfilled by Extension Functionaries in effective management of pests and vectors. I compliment Dr. A.M.K. Mohan Rao, Member, Vector Control Working Group for Asia and the Pacific, Geneva for taking responsibility of organizing the workshop and editing this publication. I also appreciate Resource Persons who contributed important chapters in this publication and Dr. Srinivasacharyulu Attaluri, Program Officer of MANAGE for his efforts in bringing out this publication.

V. Usha Rani, I.A.S
Director General
MANAGE

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August 19, 2019

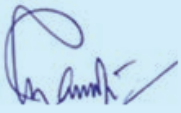
PREFACE

It is quite heartening to know that the National Institute of Agricultural Management (MANAGE), an organization of Ministry of Agriculture and Farmers Welfare, Government of India, has come forward to bring a publication entitled "Extension Guidelines on Pest and Vector Management in Human Habitations" at a time when entire country is reeling with increased prevalence of vector borne diseases, especially Dengue and Malaria. Urban agriculture, a part of urban ecological system, plays important role in urban environmental management system and may show ways to solves problems by turning urban wastes in to productive resource. On the advent of Global warming, increased travel facilities, climatic variability often with floods and famines, a favourable environment is created in the country to flourish pest and vector related problems impacting the economy and health of humans. The industrialization in the country through expansion of vast stretches of agrarian ecosystems to industrial areas with unsupported infrastructure lead to flare up of the pest and vector problems. The structural losses are caused by pests like termites, rats etc in the ever expanding human habitations, while mosquitoes, flies, cockroaches, etc have led to flare up of social related respiratory and infectious diseases, especially in poorer and high urban density localities. This is mainly due to increased wastes and lack of its disposal.

The MANAGE, an autonomous unit of Union Agriculture Ministry has focused its attention on urban related agriculture problems as well as ever increasing public health diseases in the neo-urban areas organized a Workshop in November, 2018 inviting the Public Health

functionaries of major Municipal Corporations for interaction on various urban pest and vector related problems faced in the country. During the discussions, it emanated that documentation on comprehensive pest and vector problems and their management in human habitations is lacking, although time to time guidelines are extended by National Vector Borne Disease Control Program (NVBDCP), Ministry of Health and Family Welfare to local bodies. I understand that this has lead MANAGE to bring out present book involving highly experienced professionals in pest and vector management.

I feel happy that the book will serve as a guidance document to the extension professionals, whether sanitation or public health departments in local bodies to undertake management of pests and vectors to reduce the structural damages as well as to prevent zoonotic/infectious diseases ruling the roost now in different parts of the country. I compliment and congratulate Ms. Usha Rani, IAS, Director General, MANAGE for taking this long vision initiative for a prosperous and healthy society. I congratulate Dr. A.M.K. Mohan Rao, a renowned scientist having roots in ICAR as well as in Dept of Agriculture and Cooperation (Ministry of Agriculture and Farmers Welfare) for last 35 years and all Subject Matter Experts drawn from Public Health, Agriculture and Pest Management Sectors, who have contributed the technical chapters on each major pest/vector group. Particularly, I feel happy that guidelines on safer and judicious usage of household pesticides are given focused attention. Bringing such a publication may also be one of the major steps to implement ONE HEALTH concept of Government of India successfully to reduce urban disease burden.



P.K. Chakrabarty

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PREFACE

Every nation including India makes sure of the food security of its population through implementation of policies and programmes for the production of food components such as cereals, pulses, oilseeds, vegetables and fruits. The onus of securing these commodities from destruction and spoilage due to various noxious pests is a joint effort of farmers, trade sector and industries. The government can offer technical knowledge support in addition to offer technologies for pest-proofing concepts along with capacity and skill expansion. India produces about 283.37 MT of food grains (cereals and pulses) and 314.41 MT of oilseeds as per 3rd Advance Estimates of Government of India. Food is the basis for sustaining the health and energy requirements.

Health is the next major concern of nations and the state of health in both rural and urban population in communities can be managed only by containing the diseases and their vectors. Debilitating vector-borne diseases due to viruses, bacteria and protozoans have increased in this millennium in India. The country's need to attain the United Nations Sustainable Development Goals in food and health sector by 2030 could be met by enhancing the capacity to counter and contain all threats due to vector-borne ailments in humans and animals. India has to gear up its technical and operational capacity and upscale the routine interventions in all families by empowering them with due knowledge and skills along with requisite tools and materials. For perfection in containing pests and vector populations, careful planning and implementation by relevant agencies and institutions is desirable.

I am extremely happy to find the National Institute of Extension Management (MANAGE), Hyderabad to take up the skill-enhancement and enforcement in states through this publication - "**Extension Guidelines for Pest/Vector Management in Human Habitations**. It was an offshoot of a Technical Workshop – "Extension Approaches in urban pest/ vector Management" held at MANAGE on 22-24 November, 2018 and this publication would bring in a sea-change in empowering the pest and vector managers/personnel of the country. Dr A.M.K. Mohan Rao, an international expert on pests and vector biology and management has steered the entire national pool of talents and expertise in the field to crystallize this useful publication. The MANAGE may spread this knowledge reservoir

through its vast national network to reach out to all those agencies and personnel who are involved and responsible for pest and vector management and reduce the burden of pests as well as vectors in rural and urban human/animal communities. India can hope to attain its SDGs for food security and health by 2030 through such yeomen effort of MANAGE and all institutions of relevance in the country.

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EDITOR'S NOTE

In recent past, an increasing number of people have been attracted to move from rural to urban areas for better employment opportunities due to wider variety of social benefits and services which do not exist in rural areas. As a result people are migrating towards the cities and the cities attained rapid growth. At present about 34% of India's population lives in urban areas and an increase of about 3% is recorded since 2011 census indicating a remarkable increase in the pace of urbanization in the country. On the other hand, human population is on rise even in rural areas due to rural industrialization, which brought human settlements into agriculture land areas. These demographic changes coupled with climate variability lead to poor sanitation and hygiene in these areas. At the same time, improper waste management measures made rural habitats conducive for the habitation of a variety of pests and vectors like mosquitoes, rodents, termites, flies, cockroaches, bedbugs, ants etc. resulting in (i) structural and commodity losses, (ii) Nuisance value and (iii) diseases to humans due to their vector role. In the neo-urban areas, poor people often live in old, run-down buildings that provide ready access to these ever increasing pests impacting often the ill, debilitated, aged, or otherwise helpless poor.

It is often observed that the corporate industries engage facility management services to prevent pests in their facilities. Often, they engage the services of personnel who have no much technical background. This is due to lack of awareness of facility management units about pest management and simple guidelines on pest and vector management.

The threat of malaria, dengue, chikungunya and entry of Zika in the country made Government to be vigilant on mosquito control, which is managed by personnel from sanitation or public health units with inadequate knowledge levels. These personnel need training in pest and vector management in local bodies to prevent vector borne diseases.

There is deficiency of training facilities in the country for pest and vector management so far and need exists for developing training facilities under 'Skill India' program of Government of India. Efforts are in progress in this direction to develop and align the Integrated Pest and Vector Management courses. At the same time, need exists to develop training material with simple extension guidelines to tackle both pests and vectors.

There is no comprehensive extension based publication so far on pest and vector control in human habitations covering public areas, industrial corridors, commercial establishments and residential complexes. In order to fullfil this lacunae, attempt is made to bring this publication with brief on each pest and vector giving simple operation procedures (SOPs) for their effective management for the professionals of urban bodies, as well as in-house staff of Industrial parks or buildings involved in household pest control. It can also be used as a valuable reference and guidance document for sanitation and building managers and even researchers.

This book brings together the multiple skills and activities required of pest/vector control personnel with a primary emphasis on pest and vector organisms. It provides information and tips on biology of each pest in addition to information on control and management, monitoring and follow-up methodologies. It focuses information particularly on globally significant pests in urban environs with nationally applicable methods and provides practical and hands-on solutions. This would also facilitate up-skilling the capacity in pest/ vector management among extension professionals in local bodies as well as commercial pest management professionals.

The authors of each chapter are highly experienced (+30 years of technical experience) in their respective fields of specialization and hoped that the purpose of the publication will be fulfilled. The particulars of them are given elsewhere.

I am grateful to the Director General, Ms. Usha Rani, IAS, National Institute of Agricultural Extension Management (MANAGE), Rajendranagar, Hyderabad for encouraging and guiding to bring this publication. Thanks are due to Dr. Srinivasacharyulu, Program Officer, Mr. P. Sharath Kumar, Research Fellow for all cooperation during the preparation and printing of the publication. I am indebted to my parents for inculcating the habit of technical contributions for the welfare of the society.

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Chapter - 1

Identification and Surveillance Methods of Mosquito Vectors in Human Habitations

Dr. Ujwala Oturkar

CHAPTER CONTENTS

Dr. Ujjwala Oturkar

Dr. Ujjwala Oturkar is the Programme Officer for Vector Borne Diseases working at Navi Mumbai Municipal Corporation. She possesses a medical degree with Public Health background. She possesses vast field experience of about 19 years for mapping of malaria breeding areas, planning and implementation of anti-larval activities against malaria, Dengue and Chikungunya. National Vector Borne Disease Control Programme at Ministry of Health & Family Welfare, Govt. of India has recognized her as Champion at NMMC, Navi Mumbai as role model towards malaria elimination in the country and got awarded by National Health Mission, Govt. of India during 2016.

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Identification and Surveillance Methods of Mosquito Vectors in Human Habitations

A. Purpose & Applicability

The purpose of this Simple Operational Procedure (SOP) is to present knowledge on the role of vector transmitting diseases like malaria, dengue, filaria etc., Vector identification and surveillance tools. The procedure outlines broadly about the life-cycle of vector mosquito, identification of all stages of life-cycle and the surveillance methods for entomological monitoring control

B. Major Vector Borne Diseases

1. Malaria

Malaria is a life-threatening disease caused by parasites that are transmitted to people through the bites of infected anopheles mosquitoes. *Plasmodium vivax* and *Plasmodium falciparum* are two main parasitic species detected in different parts of the country.

Malaria is an acute febrile illness. In a non-immune individual, symptoms appear seven days or more (usually 10–15 days) after the infective mosquito bite. The first symptoms – fever, headache, chills and vomiting – may be mild and difficult to recognize as malaria.

Early diagnosis and treatment of malaria reduces disease and prevents deaths. It also contributes in reducing malaria transmission. Microscopy and rapid diagnostic test are used as diagnostic tools to detect and confirm malaria parasite. The best available treatment, particularly for *P. falciparum* malaria, is artemisinin-based combination therapy (ACT).

2. Lymphatic Filariasis

LF is caused by infection with nematodes of the family Filarioidea: 99.4% of infections are caused by *Wuchereria bancrofti* and rest by *Brugia malayi*. The former is widely distributed while the latter is restricted to Kerala. The transmission of Lymphatic filariasis is through mosquitoes namely *Culex quinquefasciatus and Mansonia species.*


LF is a seriously debilitating and incapacitating disease. During the early phase, the infected person remains apparently healthy but serves as a source of infection for transmission. When lymphatic filariasis develops into chronic conditions, it leads to lymphedema (tissue swelling) or elephantiasis (skin/tissue thickening) of limbs and hydrocele (fluid accumulation).

The recommended treatment is DEC 6 mg per kg body weight for 12 days. Mass Drug Administration with DEC+Albendazole single dose annually for five or more years is recommended to liquidate parasite load and interrupt transmission. The program recommends mass administration of a combination of medicines (diethylcarbazaine +albendazole) to all eligible individuals in the states.

3. Dengue

Dengue is a mosquito-borne viral infection. The infection causes flu-like illness, and occasionally develops into a potentially lethal complication called dengue haemorrhagic fever (DHF) and dengue shock syndrome (DSS). In India, *Aedes aegypti* is the main vector in most urban areas; however, *Ae albopictus* is also found as vector in few areas of southern and eastern India.


The *Ae. aegypti* mosquito lives in urban habitats and breeds mostly in man-made containers. Unlike other mosquitoes it is a daytime feeder; its peak biting periods are in the morning and in the evening before dusk.

Diagnosis of the dengue virus is done by using NS1 or Elisa IgM Tests. There is no specific treatment for dengue fever. Antipyretics and cold sponging may be used to lower the body temperature.

4. Chikungunya

- The virus is transmitted from human to human by the bites of infected female mosquitoes. Most commonly, the mosquitoes involved are *Aedes aegypti* and *Aedes albopictus*, two species which can also transmit other mosquito-borne viruses, including dengue. These mosquitoes can be found biting throughout daylight hours, though there may be peaks of activity in the early morning and late afternoon. Both species are found biting outdoors.
- *Ae. aegypti* is more closely associated with human habitation and uses indoor breeding sites, including flower vases, water storage vessels and concrete water tanks in bathrooms, as well as the same artificial outdoor habitats as *Ae. albopictus*.
- Chikungunya is a viral disease transmitted to humans by infected *Aedes* mosquitoes. It causes fever and severe joint pain. Other symptoms include muscle pain, headache, nausea, fatigue and rash.
- Chikungunya is characterized by an abrupt onset of fever frequently accompanied by joint pain. Other common signs and symptoms include muscle pain, headache, nausea, fatigue and rash. The disease shares some clinical signs with dengue, and can be misdiagnosed in areas where dengue is common.
- There is no cure for the disease. Treatment is focused on relieving the symptoms.

5. Japanese Encephalitis (JE)

- JE virus is transmitted to humans through the bite of an infected mosquito, primarily *Culex* species. The virus is maintained in an enzootic cycle between mosquitoes and amplifying vertebrate hosts, primarily pigs and wading birds. Humans are incidental or dead-end hosts, because they usually do not develop a level or duration of viremia sufficient to infect mosquitoes.
- Most human infections with JE virus are asymptomatic; <1% of people infected with JE virus develop clinical disease. Acute encephalitis is the most commonly recognized clinical manifestation of JE virus infection.
- Milder forms of disease, such as aseptic meningitis or undifferentiated febrile illness, can also occur.
- The incubation period is 5 – 15 days.
- Illness usually begins with sudden onset of fever, headache, and vomiting. Mental status changes, focal neurologic deficits, generalized weakness, and movement disorders may develop over the next few days.
- Laboratory diagnosis of JE virus infection should be performed by using a JE virus–specific IgM-capture ELISA on CSF or serum. JE virus–specific IgM can be measured in the CSF of most patients by 4 days after onset of symptoms and in serum by 7 days after onset.

- There is no specific antiviral treatment for JE; therapy consists of supportive care and management of complications.

6. Kala-azar

- Kala-azar is one of the complex public health diseases, caused by the parasite *Leishmania donovani* and transmitted by vector named as *Phlebotomine argentipes* sandfly.
- Sandflies remain inactive during daytime and rest in cracks and crevices in the dark corners of house and cattle sheds.
- Sandfly breeds in loose soil with moisture rich in organic matters. Garbage/cow dung disposal site around houses are the excellent breeding conditions for sandflies.
- The disease presents as a fever of long duration with splenomegaly, anaemia, progressive weight loss and darkening of the skin.
- The diagnosis is done by using RDK for Kala-azar and Bone marrow aspiration. Treatment regimen included use of oral drug miltefosine and amphotericine.

C. Vector Mosquito

The main vectors species with regard to these diseases are as follows:

- **Malaria**
  An. culicifacies, An. fluviatilis, An. minimus
  An. sundaicus, An. stephensi, An. dirus
- **Dengue**
  Ae. Aegypti, Ae. Albopictus
- **Filariasis**
  Cx. quinquefasciatus, Ma. annulifera and uniformis
- **Japanese Encephalistis**
  Cx. vishnui, Cx. tritaeniorhyncus etc.
- **Kala azar**
  Phlebotamus argentipus

D. Characteristics of a Mosquito Vector

Mosquitoes belong to the phylum of Arthropoda and class of Insecta, order Diptera. Arthropods include (among many others) spiders, beetles, ticks, butterflies, houseflies and mosquitoes. Mosquitoes can be recognized by the characteristics listed below:

The body:

- is composed of several parts or segments, some of which may be jointed,
- is covered with a tough skin called an exoskeleton,

- normally has paired, jointed legs and antennae.
- Within the Arthropoda, there are several classes, including the class Insecta – mosquitoes are members of this group. Insects have the following characteristics:
- the body is divided into three sections – head, thorax and abdomen,
- the head has one pair of antenna, and a pair of compound eyes,
- the thorax has three pairs of legs.
- Class Insecta includes several orders; mosquitoes belong to the order Diptera. Insects in this order have the following characteristics:
- the thorax has one pair of visible wings,
- the hind wings, which are vestigial, are small movable filaments known as halters, which are mainly used for balance.

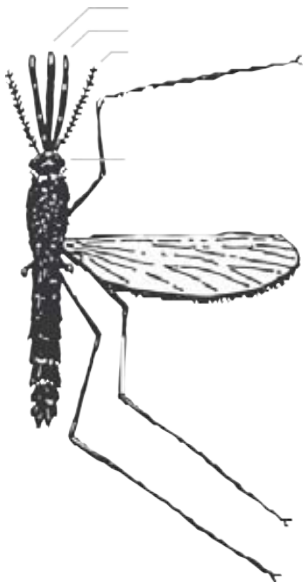


Figure 1 Main parts of the adult mosquito

Figure 1 shows the main parts of the adult mosquito. The body, as in all insects , is divided into head, thorax and abdomen. Four characteristics can be used to identify adult mosquitoes: one pair of wings; a long proboscis; maxillary palps; the body covered with scales; and wings with veins that show a defined pattern.

Species complexes (sibling species) - Many insect vectors are members of species complexes composed of sibling species which are often morphologically identical, but differ in their behaviour and ecology. At least half of the important vectors of malaria belong to sibling (or cryptic) species complexes whose members are isomorphic or similar. The recognition that members of cryptic species complexes often differ in their capacity to transmit malaria

has been, and continues to be, a driving force in the development of identification methods other than morphological criteria. An ideal method should be rapid, cost-effective, easy to implement, and applicable to both sexes and to all developmental stages.

E. Life-cycle of anopheline mosquitoes

The life-cycle of mosquitoes has four distinct stages: the egg, larva, pupa and adult (Fig. 2).

The time taken for the various stages to develop depends on temperature and nutritional factors, with development more rapid at higher temperatures.

There are about 490 species of *Anopheles* mosquitoes including sibling species.

Approximately 60–70 species worldwide can transmit malaria and of these, about 30 are vectors of major importance (Fig. 2).

Some anophelines prefer to bite animals and rarely transmit malaria

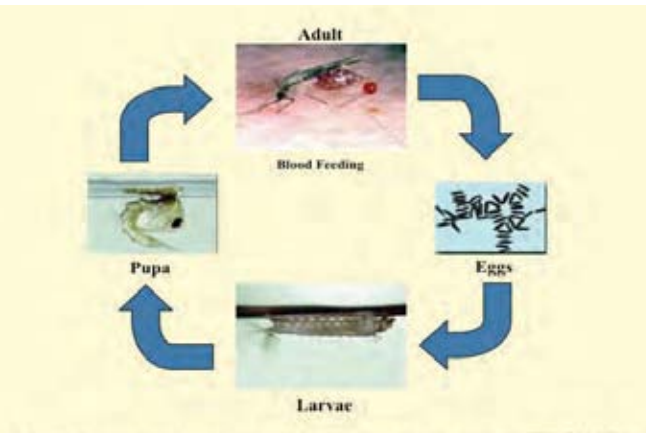


Fig. 2

Others do not live long enough to permit development of the parasite,

Eggs

- A female anopheline mosquito normally mates only once in the lifetime and usually requires a blood-meal after mating before the eggs can develop.
- Blood-meals are generally taken every 2–3 days, before the next batch of eggs is laid. About 100–150 eggs are laid on the water surface during oviposition.
- Oviposition sites vary from small hoof-prints and rain pools to streams, swamps, canals, rivers, ponds, lakes, rice fields, and sometimes even dirty water.
- Each species of mosquito prefers a particular type of habitat for oviposition.
- Under the most favourable conditions in the tropics, the average lifespan of female anopheline mosquitoes is 3–4 weeks.

- A female mosquito continues to lay eggs throughout life and most will lay 1–3 batches of eggs, though some may lay as many as 7 batches.

Larva

- A larva hatches from the egg after 1–2 days and generally floats below and parallel to the water surface, where it breathes air.
- It feeds by filtering food particles from the water. When disturbed, the larva quickly swims downwards but soon needs to return to the surface to breathe.
- There are four larval stages or instars.
- The small larva emerging from the egg is called the first instar. After 1–2 days it sheds its skin and becomes the second instar, followed by the third and fourth instars at further intervals of about two days each.
- The larva remains in the fourth instar stage for 3–4 more days before changing to become a pupa.
- The total time spent in the larval stage is generally 8–10 days at normal tropical water temperatures.
- At lower temperatures, the aquatic stages take longer time to develop.
- Depending on the species, larvae may be found in small pools, fresh water, rice-land, drains, ditches, running water with shade, brackish water, salt water, streams, ponds, lakes, marshes, wells, water containers, discarded tin cans, discarded tyres and hoof-prints.

Pupa

- The pupa undergoes a major transformation, from living in water to becoming a flying adult mosquito.
- The pupa is shaped like a comma.
- It stays under the surface and swims down when disturbed.
- The pupae do not feed.
- The pupal stage lasts for 2–3 days after which the skin splits.
- The adult mosquito then emerges and rests temporarily on the water's surface until it flies.

Adult

- Mating takes place soon after the adult emerges from the pupa.
- The female usually mates only once because sufficient sperm are received from a single mating for all subsequent egg batches.
- Normally the female takes the first blood-meal only after mating, but sometimes the first blood- meal is taken by young virgin females.

- The first batch of eggs develops after one or two blood- meals (depending on the species) while successive batches usually require only one blood-meal.

Feeding and Resting habits

- The feeding and resting habits of mosquitoes are of great importance in vector control programmes and they must be well understood.
- Most anopheline mosquitoes bite at night. Some bite shortly after sunset while others bite later, around midnight or the early morning. Some mosquitoes enter houses to bite and are described as being endophagic; others bite mostly outdoors and are called exophagic.
- After taking a blood-meal the mosquito usually rests for a short period. Mosquitoes that enter a house usually rest on a wall, under furniture or on clothes hanging in the house and are said to be endophilic.
- Mosquitoes that bite outdoors usually rest on plants, in holes, in trees or on the ground or in other cool dark places and are termed exophilic.
- Host preferences are different for different species of mosquitoes. Some mosquitoes prefer to take blood from humans rather than animals and are described as being anthropophagic while others take only animal blood and are known as zoophagic.
- Those which prefer to take human blood are the most dangerous as they are able to transmit infection in human populations.
- The adults can be found on vegetation, on solid surfaces in sheltered places, in the banks of streams and in ditches, holes in rocks, culverts, cracks, caves, animal burrows, on the trunk of trees and termite mounds.

F. Distinguishing anophelines from culicines

Eggs

Culicine eggs clump together in a "raft" *(Culex)* or float separately *(Aedes)*; anopheline eggs float separately and each of them has "floats".

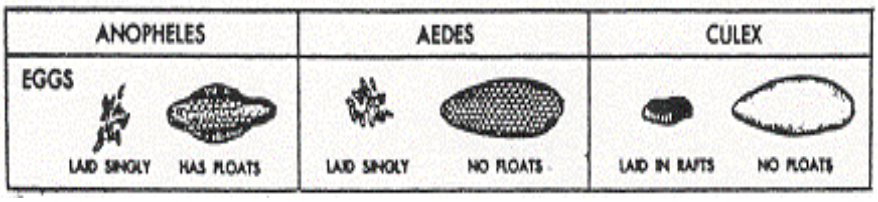


Fig. 3

Larvae

- The culicine larva hasabreathing tube (siphon) whichit also uses tohang down fromthewater surface, whereas the anopheline larva has no siphon and rests parallel to and immediately below the surface.

- In *Culex* larvae the siphon is longer than in *Aedes* larvae.

Pupae

- Pupae of both anophelines and culicines are comma-shaped and hang just below the water surface.
- They swim when disturbed.
- The breathing trumpet of the anopheline pupa is short and has a wide opening, whereas that of the culicine pupa is long and slender with a narrow opening.
- However, as it is difficult to distinguish anopheline from culicine pupae in the field, it is preferable to rear them in an insectary so that the emerging adult mosquitoes can be identified.

Adults

- With live mosquitoes, adult anopheline and culicine mosquitoes can be distinguished by observing their resting postures.
- Anophelines rest at an angle between 50º and 90º to the surface whereas culicines rest more or less parallel to the surface.

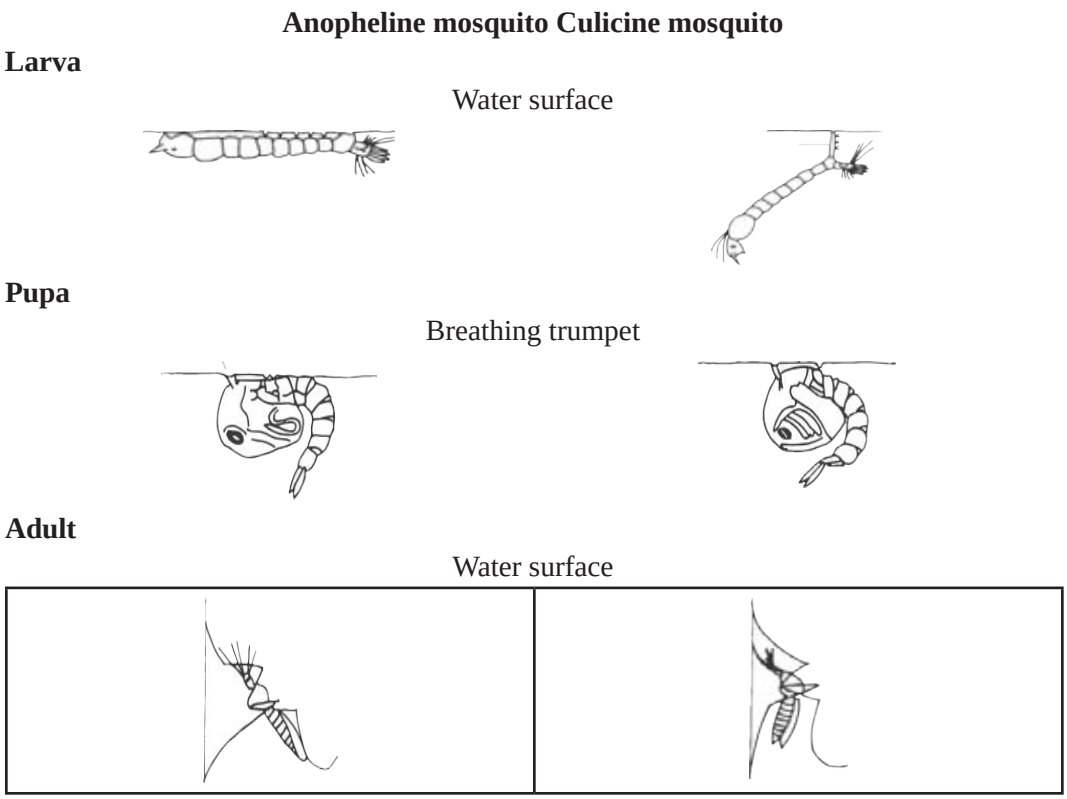


Fig. 4

G. Surveillance Methods

G.1 Audult collection

- Surveillance for vector mosquito 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.
- These data will enable the selection and use of the most appropriate vector control tools, and can be used to monitor their effectiveness.
- There are several methods available for the detection and monitoring of larval and adult populations.
- The selection of appropriate sampling methods depends on surveillance objectives, levels of infestation, and availability of resources.

G.1.1. Collection of adult mosquitoes

The collection of adult mosquitoes is made for:

(i) Qualitative studies – To study the prevalence, distribution, behaviour of different mosquito species in different macro and micro environmental conditions.

(ii) Qualitative studies – To study the vector relative density and abundance, longevity, infectivity, impact of anti –vector measures on the vector population, impact on the transmission.

Several methods for sampling of mosquitoes are available which are undertaken alone or in combination with others depending on objective of survey.

Hand collection of mosquitoes

G.1.2. Principles and objective of the method

- Mosquitoes feeding on host Species or resting on different surfaces (indoor and outdoor) can be collected by a test tube or sucking tube.

G.1.3. Collection of mosquitoes

- Adult mosquitoes in indoor situations should be searched in dark corners of houses, ceilings, amongst thatch and cobwebs, on the underside of shelves, amongst clothing and other hanging articles with the help of torch light.
- Large number of mosquitoes may be collected from sheds used for cattle, horses and pigsties, etc.

i. By Aspirator tube or Sucking tube:

- A widely used and convenient method for mosquito collection.
- Aspirator tube is generally having a length of 30-45 cms (internal diameter, 8-12 mm) and is made up of glass or plastic tubing.
- A piece of mosquito netting fixed over a short piece of smaller diameter rubber tuning, which is inserted into the end of larger tubing.

- 50 cm long rubber tubing is slipped over the end of glass tubing provided with mosquito netting.
- The resting or feeding mosquito on being detected with torch light can be sucked in gently, unless to worker keeps sucking or closes the end of tube with a finger or cotton plug, the captured mosquitoes are liable to fly out.

Mosquito Collection by sucking tube

Equipment for mosquito surveys.

ii. By test tube:

- Test tube without rim and having a length of about 100 mm (20 mm diameter) are used for the collection of mosquitoes.
- After locating a mosquito with torch light, hold a test tube in the middle and brings its mouth slowly over the insect; then move the tube slightly to dislodge the mosquito, slide the hand up the tube and quickly place a finger over the open end and plug it with cotton.

iii. Catches off baits:

- Mosquitoes are collected directly off the human or animal baits using sucking tube while they land on the host to bite or while in the process of biting a human or an animal host.
- This method is one of the most important for collecting partially or entirely exophilic mosquitoes.
- Mosquitoes may also be collected while resting in the vicinity of the bait, either before or after feeding.

Fig.7: Animal Bait Collection

iv. Hand net catches:

- **Use s**mall hand net about 15 cms in diameter, made of fine mosquito netting with long handle to catch adult mosquitoes resting in human and animal habitations in large number.
- The usual procedure is to gently spray the hut with a non-toxic oil (Risella or citronella oil) paying attention to cracks and crevices. The disturbed mosquitoes are collected by sweeping the net.

vi. Spray sheet collection:

- Apply this method in morning hours between 06.30 and 10.00 am.
- Remove all occupants, animals and easily removable objects like foodstuff, drinking water, furniture, etc. from the structures.
- Close all doors and windows and cover the floor of the hut with white sheet. Spray 0.1 per cent pyrethrum in kerosene oil @ 15-30 m1/1000 cu.ft in the hut space with ordinary hand-pump.
- Close the door after filling the room with insecticides mist.

- Open the door after ten minutes after the spray and lift the sheets with four corners and bring outside in daylight.
- Collect the mosquitoes with entomological forceps and transport to the laboratory for detection of malaria / filarial parasites, ovarian age grading and precipitin test, etc.

vii. Trap collection

- Traps are used extensively for collecting mosquitoes which are flying in search of food, shelter or egg laying sites or due to external influences like environmental viz., wind, change of humidity, temperature and light or produced by humans.
- Some of the important traps used for the collection of adult mosquitoes are window trap, magoon trap, malaise, light trap, etc.

viii. Window trap

- Window traps are the most widely used for mosquito collection.
- Place them in the path of incoming or outgoing flying mosquitoes.
- 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 whiles to the sixth side a deep conical funnel of netting or provided.
- Fit the frame of the trap into the window frame of the house so that no space is left to escape from it.
- Window trap collections give information on the circulation of mosquito in different physiological conditions form outside to inside and vice versa.

G.2 Larval collection

Collection of larval samples is essential

(i) to establish the breeding habits of different species,

(ii) to establish the active breeding places,

(iii) to study the development of aquatic stages

(iv) to evaluate the impact of anti-larval measures on the larval density and

(v) to collect samples of larvae for rearing adults for taxonomic studies or biological observation (bioassay/susceptibility tests.)

Larval collection methods

a) Dipping:

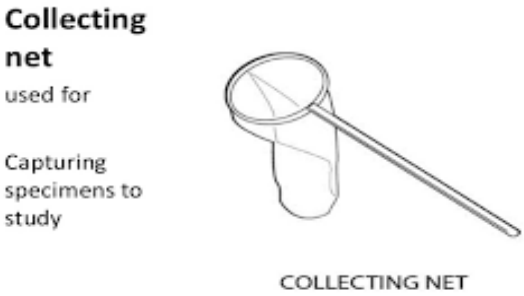
- The dipping method is frequently used method for the collection of mosquito larvae.
- Immerse the collecting equipments viz. Enamel bowl or flying pan or ladle in the breeding places (edges of swamps, ditches, streams, rice fields other bodies of waters) at an angle of 450.

- Maintain an interval of 2-3 minutes between each dip to allow stage III, IV larvae and pupae to come to the surface again. In case surface should be agitated to cause the larvae to sink, clear away the vegetation and then wait for 3-4 minutes for larva to come to the surface and collect them with dipper.
- Assess the larval density terms of average larval density per dip.

Fig. 8: Dipping Method

b) 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 about 25 cm in diameter, to which a nylon / muslin cloth net is attached, measuring about 10 cm long. A long wooden handle is attached to the ring.
- Collect the larvae holding the net at an angle of 300.
- Skim it rapidly through the surface water near emerging or floating vegetation.
- Invert the net and wash out in a bowl of water and collect the larvae with a pipette.
- Measure the density in terms of density per larval net.
- While using square nets in water bodies, the density is measured in terms of larvae per well net.



Netting Method

c) Pipetting: Small pipettes or small spoons may be used for collecting larvae from the shallow breeding sites like hoof prints, etc.

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9. Guidelines of Larvivorous Fish for Vector Control http://www.nvbdcp.gov.in/Doc/Guidelines-larvivorous-fish.pdf
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I. Checklist

Chapter - 2

Management of Mosquitoes and Integrated Approaches in the Urban Areas and Residential Premises

Dr. S.N. Sharma

CHAPTER CONTENTS

Dr. S.N. Sharma

Dr. S.N. Sharma is renowned vector control expert in the country with more than 37 years of experience in the field of medical entomology and vector control. He is former Joint Director, National Vector Borne Disease Control Program, Govt. of India and presently re-employed as Advisor at National Centre for Disease Control, Ministry of Health, Govt. of India. He has authored several documents and guidelines on Integrated Vector Management, Indoor residual spray, use of larvivorous fishes, environmental management, urban malaria scheme, insecticide resistance and medical entomology. He is the member Vector Control Working Group Roll Back Malaria, Geneva, Expert Member of Technical Committee of Govt. of India on the use of Insecticides. He has visited several countries representing the country from Ministry of Health and Family Welfare. He is also, presently, the Managing Editor of Journal of Communicable Diseases.

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Management of Mosquitoes and Integrated Approaches in the Urban Areas and Residential Premises

A. Purpose and Adaptability

The purpose of the document is to understand the concept of Integrated Vector Management and adopt them for optimal mosquito management and reducing possible hazards to humans.

- To map the type of breeding potentials areas for Anopheline, Culex and Aedes.
- Identify Integrated approaches for Vector Control.

B. Operational Definitions

Integrated Pest/Vector Management

Managing vectors/pests using various methods to keep them below the threshold levels

Vector control

Controlling human disease causing organisms

Source reduction

Reducing/removal of carrying capacity or source of infestation eg. Garbage removal

Repellants

Substances which repels the vectors/pests

Larvicides

Substances/organisms which kill the larvae of pests/vectors

Adulticides

Substances which kill the adult pests/vectors

C. Integrated Vector Management

This includes a combination of strategic tools available to be appropriately and judiciously applied in different habitats for the control of vector species to achieve cost-effectiveness and synergy

D. Methods of Mosquito Management

Under the concept of IVM, there are many tools / options available and recommended appropriately for vector control. Before planning any measure, mapping the areas of their infestation, especially larval habitats need to be undertaken. Follow the below mentioned steps

- Conduct geographical reconnaissance through GIS for mapping of mosquito breeding areas in rural areas, which helps to calculate the requirements of particular larvicide.
- Mapping of breeding potential areas through GIS is being taken for early warning system in an rural settings for understanding the land scape of that geographical area on wide scale. Make the mapping to cover their habitats as below:

- Anopheline species of mosquitoes breed in fresh water larger water bodies.
- Culicine breed in polluted water bodies.
- Aedes mosquito is a small container breeder and breed in and around human populations.

Based on the breeding areas comprehensive planning of IVM may be done. The following methods for Integrated vector management can be used.

1. Source reduction & Environmental management
2. Personal Protection
3. Biological (fish)
4. Chemical – Larvicides and Adulticides

D1. Source reduction and Environmental management

- any change that prevents or minimizes vector breeding thereby reducing human-vector contact.
- Major measures for the control of the immature stages of dengue vectors, are :

i. ***Improved water supply:***

Deficient and irregular piped water supply or storage of water in varied types of containers leads to increased *Aedes* breeding. Majority of such containers are large and heavy (e.g. storage jars) and can neither be easily disposed of nor cleaned, but afford habitat for mosquito larvae

ii. ***Mosquito-proofing of overhead tanks/ cisterns/ underground reservoir/wells:***

These structures should be mosquito-proofed either with tight lid or with proper mesh.

iii. ***Flower pots/vases and ant traps***

- Flower pots, flower vases and ant traps are common sources of *Ae. aegypti* breeding. They should be punctured to produce a drain hole.
- Flowers can be placed in a mixture of sand and water.
- Flowers should be removed and discarded weekly and vases scrubbed and cleaned before reuse.
- Ant traps to protect food storage cabinets can be treated with common salt or oil.

iv. Desert water coolers, condensation collection pans under refrigerators, and air conditioners should be regularly inspected, drained and cleaned.

v. The design of buildings

Inspect the drainage pipes of rooftops sunshades/porticos periodically to remove any blocks, which often becomes breeding sites for mosquitoes. There is a need for periodic inspection of buildings during the rainy season to locate potential breeding sites.

vi. Mandatory water storage for firefighting:

Fire prevention regulations may require mandatory water storage. Such storage tanks need to be kept mosquito-proofed.

vii. Solid waste disposal

- Solid wastes, namely tins, bottles, buckets or any other waste material scattered around houses, should be removed and buried in landfills.
- Scrap material in factories and warehouses should be stored appropriately until disposal.
- Household and garden utensils (buckets, bowls and watering devices) should be turned upside down to prevent the accumulation of rain water.
- Plant waste (coconut shells, cocoa husks) should be disposed of properly and without delay.

viii. Tyre management

- Used automobile tyres are major source for *Aedes* mosquito breeding and are therefore a significant public health problem.
- Tyre depots should always be kept under cover to prevent the collection of rain water.

ix. 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, crushed glass, or concrete to eliminate potential *Aedes* larval habitats.

D2. Personal Protection

i. **Protective clothing**

- Clothing reduces the risk of mosquito biting if the cloth is sufficiently thick or loosely fitting.
- Long sleeves and trousers with stockings protect the arms and legs, the preferred sites for mosquito bites.
- Schoolchildren should adhere to these practices whenever possible.

ii. Mats, coils and aerosols

- Use household insecticidal products, namely mosquito coils, electric vaporizer mats and liquid vaporizers, pyrethrum space spray and aerosols for personal protection against mosquitoes.

iii. Repellents

- Use repellants against mosquitoes and other biting insects.
- These are broadly classified into two categories
- Natural repellents - Essential oils from plant extracts viz., citronella oil, lemongrass oil and neem oil
- Chemical repellents - DEET (N, N-Diethyl-m-Toluamide) for several hours.

iv. Insecticide-treated mosquito nets and curtains

- Insecticide-treated mosquito nets (ITMN)/LLINs are used under programme since many years in high malarious areas.
- Though LLINs have limited utility in dengue control due to day biter vector, it can be effectively utilized to protect infants and night workers who sleep during day.
- Impregnated curtains can be used as mosquito nets are not used by all in every area due to weather conditions.

D3. Biological Control

The application of biological control agents against the larval stages of mosquitoes used under programme are mainly fish or bacteria.

i. Fish: Larvivorus fish (*Gambusia affinis* and *Poecilia reticulata*) have been extensively used for the control of *An. Stephensi* and/or *Ae. aegypti* in large water bodies or large water containers in many parts of countries.


Gambusia affinis Poecillia reticulata

ii. Bacteria

- Two species of endotoxin-producing bacteria are recommended under programme which are *Bacillus thuringiensis* serotype H-14 and *Bacillus sphaericus.*
- These are effective mosquito control agents and do not affect nontarget species.
- *Bt.H-14* has been found to be most effective against *An. Stephensi* and *Ae. aegypti*, while *Bs* is the most effective against *Culex quinquefasciatus* which breeds in polluted waters.

D4. Chemical Control

Chemicals have been used to control vector borne diseases by attacking both larvae and adult of vector species.

D4.1. Larviciding

- Larviciding has to be done at weekly/fortnightly interval to avoid emergence of adults.
- Chemical larvicides are best to be used in situations where the disease and vector surveillance indicate the existence of certain periods of high risk and in localities where outbreaks might occur.
- Control personnel engaged in anti-larval programme should always encourage house occupants to control larvae by environmental sanitation.



The larvicides used under programme are described below:

Larvicide Formulations and Dosage

S.No.	Name of Larvicide	Commercial formulation	Preparation of ready to spray formulation	1 square meter	50 linear meter	Per Hectare	Frequency of application	Equipment required	Remarks
1	MLO	100% petroleum project product	As it is	20 CC	1 Litre	200 Litres	Weekly	Knapsack / Hand compression sprayer	To be applied along the shore of the water body
2	Temephos (Abate)* (OP)	50% EC	2.5 cc ten Litres of potable water	20 CC	1 Litre	200 Litres	Weekly	-do-	Can be applied in clean water
3	Bacillus Thuringenesis Israrlensis (164, serotype H14) WP Bio larvicide	Wettable powder	5 kg in 200 Litres of water	20 CC	1 Litre	200 Litres containing 5 kg of powder 164 strain	Fortnightly	-do-	For both clean and non-potable polluted water
4	Bacillus Thuringenesis Israrlensis (12, Aqueous Suspension (AS) Bio larvicide	Aqueous Suspension 12 (AS)	1 Litre in 200 Litres of water	20 CC	1 Litre	200 Litres containing 1 Litre of 12 AS	Weekly	-do-	Clean water
			2 Litre in 200 Litres of water	20 CC	1 Litre		Weekly	-do-	Polluted water
5	Diflubenzuron 25% WP Insect growth regulator	25% WP	100 g in 100 Litres in clean water 200 g in 100 Litres of polluted water			25 g a.i (100 Litres)	Weekly	-do-	Clean water Clean water
6	Pyriproxifen (GR) Insect growth regulator	0.5% granular	Ready to use			2 kg clean water 4 kg polluted water	Weekly	Granular applicator / Hand broadcast	Clean water Clean water

• The dose of Temephos may be doubled or tripled in case of water bodies having more than 50 metres depth.

Insect growth regulators:

- Insect growth regulators (IGRs) interfere with the development of the immature stages of the mosquito by interference of chitin synthesis during the molting process in larvae or disruption of pupal and adult transformation processes.
- Most IGRs have extremely low mammalian toxicity.
- Two such compounds have been recommended in the programme i.e.
    - pyriproxifen and
    - diflubenzuron.

D4.2. Adulticiding

Insecticidal Residual Spray (IRS)

- Interrupt the transmission by reducing numbers of infective vectors by ensuring safe and correct application of the insecticide to indoor surfaces of houses and animal shelters.
- Insecticidal Residual Spray is one of the most cost-effective control measures for Malaria and Kala-azar in India.
- Synchronize it with case detection to maximize the impact of IRS.
- The success of IRS operations depends on the planning and implementation.
- IRS plans should be developed before hand.
- IRS planning should be made, based on the capacity for achieving complete and uniform coverage.
- When there is resource constraints it is preferable to limit the size of the operation and achieve quality coverage.

Insecticide Formulations

- At present, different formulations of synthetic chemical insecticides are in the use for vector control –
- Wettable powder (WP) formulations are used for indoor residual sprays
- Emulsion concentrate (EC) formulations are used for larval control.
- For Indoor Residual spray (IRS) insecticides in use are DDT 50% WP, malathion 25% WP and synthetic Pyrethroid (WP).
- Synthetic Pyrethroids include deltamethrin 2.5% WP, Cyfluthrin 10% WP, lambdacyhalothrin 10% WP, alphacypermethrin 5% WP, Etofenprox 10% WP and Bifenthrin 10% WP.
- Synthetic pyrethroid insecticides are also being used for impregnation of bed nets.

ADULTICIDE FORMULATIONS AND DOSAGES

S.No.	Name of insecticide	Amount of insecticide to prepare 10 litres of suspension	Dosage per sq. metre of active ingredient	Residual effect in weeks	Area (in sq. m) to be covered by 10 litres of suspension	Requirement of insecticide per million population (in MT)
1	DDT 50% WP	1.000 kg	1 gm	10-12	500	150.00
2	Malathion 25% WP*	2.000 kg	2 gm	6-8	500	900.00
3	Deltamethrin 2.5 % WP	0.400 kg	20 mg	10-12	500	60.00
4	Cyfluthrin 10% WP	0.125 kg	25 mg	10-12	500	18.75
5	Lambdacyhalothrin 10% WP	0.125 kg	25 mg	10-12	500	18.75
6	Alphacypermethrin 5% WP	0.250 kg	25 mg	10-12	500	37.50
7	Bifethrin 10% WP	0.125 kg	25 mg	10-12	500	18.75

*In the case of Malathion, the requirement shown above, is for the three rounds

Indoor Residual spray (IRS)

1. Most of the insecticides having residual effect are sprayed indoors, so that mosquitoes after having bite on an infective person will rest in the house and will pick up sufficient insecticide particles sprayed on the walls and other indoor surfaces of the house and its longevity will be reduced so much so that it does not survive to become infective.
2. In areas where the vectors are strongly endophilic, i.e. they tend to rest indoors, indoor residual spraying of human dwellings can give very effective control.
3. Vectors that are exophillic i.e. they tend to rest outdoor but tend to feed or rest indoors briefly, can be effectively controlled by indoor residual spraying with insecticides that have good airborne effect.
4. In areas where vectors are strongly exophilic and/or exophagic, i.e. they rest and bite outdoors, use insecticide treated mosquito nets or exterior space spraying for emergency control.

- The effectiveness of house spraying depends on adherence to the specified criteria of the insecticide and application procedure, public acceptance of spraying, the availability of well maintained equipment, adequately trained spraying personnel, efficient supervision and strong financial support.
- The size of the area depends on local circumstances and is influenced by the distribution of malaria and malaria vectors; distance from important breeding sites, the flight range of the vectors and demographic features.
- The target areas could be all the interior walls and ceilings in human dwellings, field huts where people sleep during the planting or harvesting season.
- Treat also the underside of furnitures, back of the doors, outside caves and porch.

Selection of Insecticides

- Several factors need to be considered in the selection of an insecticide spraying, including availability, cost, residual effectiveness, safety, vector susceptibility and excito-repellency.
- There are large number of insecticides, which are used as aduliticides for indoor residual spray. These are DDT, Malathion and different formulations of synthetic pyrethroids.

D4.3. Space Spray

1. Space spray is usually used to knock down the infected population of vector mosquitoes resting indoor situations.
2. Pyrethrum extract 2% EC and Cyphenothrin 5% EC are being used for space spray.
3. The pyrethrum 2% extract is used in 1:19 ratio with kerosene oil or diesel.

INDOOR SPACE SPARY

S.No.	Name of insecticide	Commercial formulation	Preparation of Formulation	Equipments required	Remarks
1	Pyrethrum extract	2.0% extract (Plant extract)	1:19 i.e. 1 part of 2% Pyrethrum extract in 19 part of Kerosine (50 ml in 1 litre K. oil)	Pressurized spray machine or fogging machine	Used for indoor spray
2	Cyphenothrin	5% EC (Synthetic pyrethroid)	0.5 gm a.i. Per sq metre (20 ml in 1 litre of K.oil)	- do	-do-

D4.4. Thermal or ULV Fogging

i. During the outbreak situations, Thermal fogging or ULV is used in the indoor and outdoor situations.

ii. Manually operated machines are used inside the premised, while the vehicle mounted machines are used for outdoor situations.

iii. The following insecticides are used for thermal fogging/

OUTDOOR FOGGING

S.No.	Name of insecticide	Commercial formulation	Preparation of Formulation	Equipments required	Remarks
1	Malathion	Technical Malathion (organo - phosphate)	1:19 i.e. 1 part of Malathion in 19 part of Disel (50 ml in 1 litre Disel)	Shoulder mounted fogging machine Or Vehicle mounted thermal fogging machine	Used for outdoor thermal fogging
2	Cyphenothrin	5% EC (Synthetic pyrethroid)	3.5 gm a.i. per hectare (7 ml in 1 litre Disel)	- do	-do-

iv. These are additional interventions being implemented such as indoor space spraying, fogging or ultra-low volume (ULV) spray.

v. However, the evidence base for aerial or truck mounted ULV is limited since this intervention has no sustained impact on mosquito populations, is not cost effective for routine delivery.

vi. Vector control interventions are similar whether the disease is in urban or rural areas. In case of JE affected areas, coverage of the village reporting cases should be 100% with ULV. Malathion technical is recommended for outdoor fogging.

E. General safety precautions while handling insecticides

- Exposure to insecticides may occur when handling and spraying insecticides.
- The exposures to insecticides may occur in following situations:

When handling the insecticide product during opening of the package, mixing and preparation of the spray.

When spraying the insecticide.

When disposing the insecticide solution and containers General precautions:

i. The operator should also wear a protective hat and face shield or goggles.

ii. Do not eat, drink or smoke while working.

iii. Wash hands and face with soap and water after spraying and before eating, smoking or drinking.

iv. Shower or bath at the end of every day ís work and wear new clean clothes.

v. Wash overalls and other protective clothing at the end of every working day in soap and water and keep them separate from the rest of the family ís clothes.

vi. If the insecticide touches the skin, wash off immediately with soap and water.

vii. Change clothes immediately if they become contaminated with insecticides.

viii. Inform the supervisor immediately if one feels unwell.

Specific protective clothing and equipment given below must be worn in accordance with the safety instructions on the product label.

- Broad-rimmed hat (protects head, face and neck from spray droplets).
- Face-shield or goggles (protects face and eyes against spray fall-out).
- Face mask (protects nose and mouth from airborne particles).
- Long-sleeved overalls (worn outside of boots).
- Rubber gloves.
- Boots

Storage

a. Insecticide storehouses must be located away from areas where people or animals are housed and away from water sources, wells, and canals.

b. They should be located on high ground and fenced, with access only for authorized persons. However, there should be easy access for insecticide delivery vehicles and, ideally access on at least three sides of the building for fire-fighting vehicles and equipment in case of emergency.

c. Insecticides must NOT be kept where they would be exposed to sunlight, water, or moisture which could affect their stability.

d. Storehouses should be secure and well ventilated.

e. Containers, bags or boxes should be well stacked to avoid possibility of spillage. The principle of ëfirst expiry first outí should be followed.

f. Stock and issue registers should be kept upto date. Access to the insecticides should be limited to authorized personnel only.

g. The store room should have a prominently displayed mark of caution used for Stock and issue registers should be kept upto date. Access to the insecticides should be limited to authorized personnel only. The store room should have a prominently displayed mark of caution used for poisonous or hazardous substances. It should be kept locked.

h. Containers should be arranged to minimize handling and thus avoid mechanical damage which could give rise to leaks. Containers and cartons should be stacked safely, with the height of stacks limited to ensure stability.

Transportation

a. Insecticides should be transported in well sealed and labeled containers, boxes or bags.

b. Insecticides should be transported separately. It should NOT be transported in the same vehicle as items such as agricultural produce, food, clothing, drugs, toys, and cosmetics that could become hazardous if contaminated.

c. Pesticide containers should be loaded in such a way that they will not be damaged during transport, their labels will not be rubbed off and they will not shift and fall off the transport vehicle onto rough road surfaces.

d. Vehicles transporting pesticides should carry prominently displayed warning notices.

e. The pesticide load should be checked at intervals during transportation, and any leaks, spills, or other contamination should be cleaned up immediately using accepted standard procedures. In the event of leakage while the transport vehicle is moving, the vehicle should be brought to a halt immediately so that the leak can be stopped and the leaked product cleaned up. Containers should be inspected upon arrival at the receiving station.

There should be official reports to the national level and follow-up enquiries in the event of fires, spills, poisonings, and other hazardous events. Disposal of leftover/remains of insecticides and empty packaging.

a. At the end of the day after work during IRS activities, the inside of the spray pump should be washed and any residual insecticide should be flushed from the lance and nozzle.

b. The rinsing water should be collected and carefully contained in clearly marked drums with a tightly fitted lid. This should be used to dilute the next day during tank loads or disposed properly by the supervisor at disposal sites like pits or digs.

c. Never pour the remaining insecticide into rivers, pools or drinking-water sources.

d. Decontaminate containers where possible. For glass, plastic or metal containers this can be achieved by triple rinsing, i.e. part-filling the empty container with water three times and emptying into a bucket or sprayer for the next application.

e. All empty packaging should be returned to the supervisor for safe disposal according to national guidelines.

f. Never re-use empty insecticide containers.

g. It shall be the duty of manufacturers, formulators of insecticides and operators to dispose packages or surplus materials and washing in a safe manner so as to prevent environmental or water pollution.

h. The used packages shall not be left outside to prevent their re-use.

i. The packages shall be broken and buried away from habitation.

Disposal of Expired Insecticides

i. Adequate measures should be undertaken to avoid expiry of stocks in storehouses.

ii. First Expiry First Out principle should be strictly followed during stock movements.

iii. Information about near expiry stock, should be provided well in time so that the stock can be re-allocated to other locations.

iv. The expired stock should be returned to manufacturer for disposal as per guidelines preferably through incineration process.

v. The chemical efficacy should be tested before disposal of expired insecticide to find out possibility of usage. The efficacy and active ingredient percentage of insecticide is tested and certified by the authorized testing laboratory.

Health Monitoring

a. In case of accidental exposures or appearances of symptoms of poisoning, medical advice must be sought immediately.

b. In case of organophosphorus (Malathion), regular monitoring of cholinesterase (CHE) level should be carried out and spraymen showing decline in CHE to 50% should be withdrawn and given rest and if needed medical aid.

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G. Checklist

Chapter - 3

Application Equipment for Mosquito Control: their Safe handling and Maintenance

Dr. S.N. Sharma

CHAPTER CONTENTS

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Dr. S.N. Sharma is renowned vector control expert in the country with more than 37 years of experience in the field of medical entomology and vector control. He is former Joint Director, National Vector Borne Disease Control Program, Govt. of India and presently re-employed as Advisor at National Centre for Disease Control, Ministry of Health, Govt. of India. He possesses. He has authored several documents and guidelines on Integrated Vector Management, Indoor residual spray, use of larvivorous fishes, environmental management, urban malaria scheme, insecticide resistance and medical entomology. He is the member Vector Control Working Group Roll Back Malaria, Geneva, Expert Member of Technical Committee of Govt. of India on the use of Insecticides. He has visited several countries representing the country from Ministry of Health and Family Welfare. He is also, presently, the Managing Editor of Journal of Communicable Diseases.

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Application Equipment for Mosquito Control: their Safe handling and Maintenance

A. Purpose and Applicability

Application equipments are used depending on the type of application to be used in different situations and can be mainly divided into three components.

1. Larviciding
2. Adulticiding
3. Space Spray or Fogging

B. Operational definitiions

Vectors
Animals which carry and transmit diseases to humans and farm animals

Vector borne diseases
The diseases viz., Malaria, Filaria, Dengue, Leptospirosis, Salmonellosis etc transmitted by vector animals

Vector surveillance
Periodic sampling of vector species to monitor the vector bionomics

Aspirator
An instrument used to collect the mosquitos

C. Methods of Chemical Control for Mosquito Vectors

The mosquito vectors need to be targeted primarily at the aquatic / larval stage. In the Urban situations, all the breeding potential areas / spots are mapped and area is calculated for selection of appropriate larvicide.

The water bodies / habitats with polluted water i.e. drains, seepage tanks, pits, ponds contribute for the *Culex* breeding.

The water bodies / habitats with clean water i.e. over head tanks, cemented tanks, hodies, construction sites, wells, underground tanks, coolers, fountains and water pools are favourable breeding places for Anopheles mosquito.

Aedes mosquito is a small container breeder and found in earthen pots, cemented tanks, unused wells, tyres, coconut shells, flower pots, waste plastic cups and glasses.

D. Application Equipments

There are different types of equipments to be used for the control of mosquito vectors, which are as follows.

- Equipments for anti-larval treatment
- Equipments for adulticide treatment
- Equipments for space spray or Thermal Fogging or ULV

D1. Equipments for anti-larval treatment

(i) Knapsack sprayer

This is used for larvicide applicationand carried on the back. A shield is provided so that it doesnot come into actual contact with the back. A skirt isusually fitted to the bottom of the container to prevent the direct contact with the ground. Knapsack sprayer is acontinuous type of Sprayer and the discharge rate is fairlyconstants.

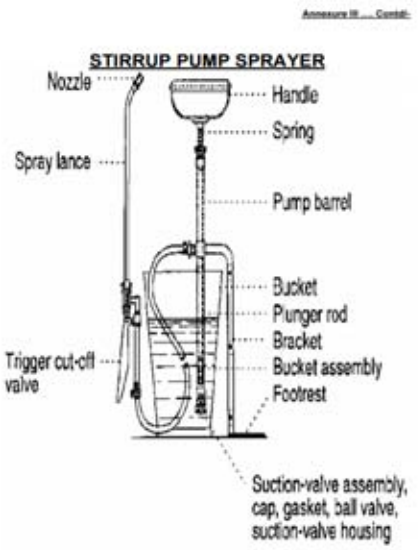
(ii) Bucket & Mopping : The use of Malarial Larvicidal oil is being used with bucket and mopping method. The larvicide is spilled over the breeding side with a mop after dipping into the larvicidal oil frequently.

D2. Equipments for adulticide treatment

a. **Stirrup pump**

- These pumps are bucket sprayers as the container for spray is bucket.
- The stirrup pump is traditional one being used in vector control and consists of a pump, attached discharge hose, spray lance with a bracket and foot-rest or stirrup.
- The spray discharge is continuous because an air chamber is incorporated in the pump system to maintain spraying pressure during suction stroke.
- Two persons are required during operation i.e. one for pumping and other for holding spray lance.

- Relatively little skill is required for operating and maintaining this pump as it works even with rough handling in field.
- However, great care is required to avoid spillage of insecticide suspension from open buckets.



Advatages

i. Stirrup pumps for IRS are used under Programme since inception

ii. Insecticide spray suspension is thick and requires continuous stirring to avoid settling of insecticide. Stirring is easy in bucket & insecticide is not allowed to settle.

iii. Spray team and workers are tuned to use stirrup pumps during IRS.

iv. Pressure is maintain with continuous strokes

v. The length of the hose of stirrup pump is usually 5 meter which helps in reaching the long corners of the room.

vi. Two persons are needed, one to pump and one to direct the spray. The persons directing spray can move freely even in smaller rooms while the pump man is outside the house.

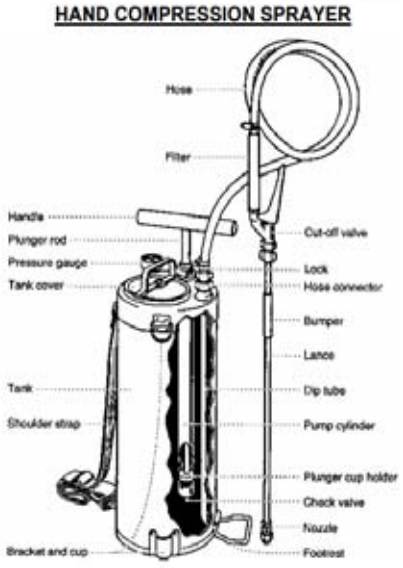
vii. Washing of pump is easy.

Issues

- Two persons are needed per pump hence more Human resource required.

b. Hand Compression pump

- The container of this pump acts as a pressurized air chamber and the air pressure impels the liquid.
- These pumps are fitted with pressure gauze and safety device to release excess pressure.
- Compression pumps used for vector control are usually of 10 litre capacity.
- These are simple to use and save human resource as one person is required per pump.
- The only disadvantage of this pump is that pressure falls with discharge of liquid.
- Control flow valve has been designed as remedial measure but it can be fitted in few branded pumps only.
- The most important thing to care is to ensure that material of pump will withstand the pressure otherwise it may burst and harm the spray worker.



Advatages

- One person is needed per pump hence less Human resource

Issues

i. Carrying pump with 10 ltrs of suspension becomes an issue due to its weight.

ii. Insecticide spray suspension is thick and requires continuous stirring to avoid settling of insecticide. Stirring in pump is difficult & insecticide settles in pumps.

iii. Nozzle tips gets choaked & hamper the spray

iv. Pressure gets diluted which effects the spray dose

v. Washing /cleaning of pumps is required during spray which is difficult

D3. Equipments for space spray or Thermal Fogging or ULV

a) Automizer –

- These are operated on principle of compression pump.
- The three-quarter of container is filled with spray liquid and then air in remaining space is compressed through built-in air pump of plunger type.
- The trigger valve is used to release the spray.
- These are useful or small scale larviciding or aerial spray of liquid like pyrethrum extract etc.

b) Fogging Machine – Hand Operated

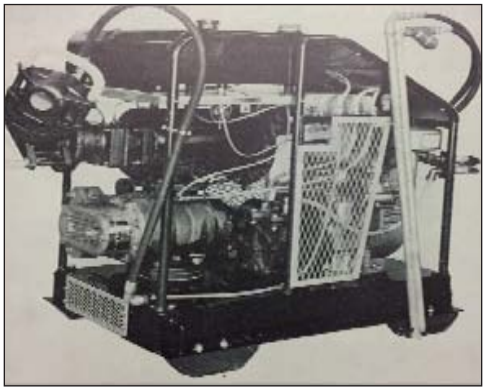
- In such devices, insecticide is dissolved in an oil of suitably high flashpoint which is vaporized into a high-velocity stream of hot gas.
- When discharged into atmosphere, the mixture containing insecticide condenses in the form of fog.
- Two basic methods are employed for production of fog.

- In one type, mixture is injected into the exhaust gas of a pulse-jet internal combustion engine at a point it will be completely vapourised and then immediately discharged. This is used generally for hand operated ones.
- In the second method, petrol is burnt in a specially designed that is constantly supplied with large volume of heated air at low pressure. The formulation is injected into a discharge tube through which air is passing and is emitted as densefog. This is used in vehicle mounted ones.

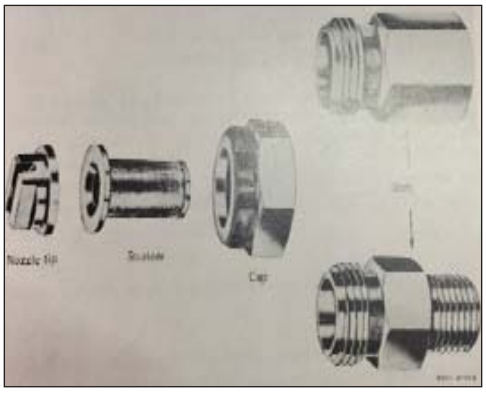
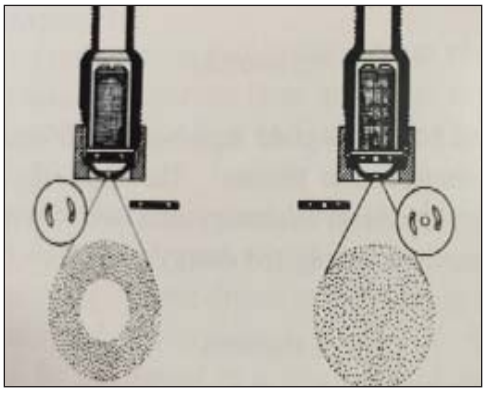
c) Fogging Machine – Vehicle mounted

Nozzles- There are different type of nozzles but for vector control under programme, two types are used- Flat Fan for IRS and cone nozzle for larviciding.

i. Fan nozzle produces a spray in the form of flat sheet and its orifice governs the discharge rate. Ordinary nozzles spoil the spray if the discharge rate is notgoverned properly.




ii. Cone nozzles are used mainly for anti-larval work. Liquid is discharged from orifice either as a hollow cone or as a solid cone of spray drops. This nozzle contains aswirl plate with helical slots and a small whole in centre.

E. Care and maintenance of spray equipments

i. Care

All applicator equipments require diligent care if they are to be kept operating properly. Several basic rules should be followed in the care of a sprayer.

1. Handle it carefully.
2. Keep it clean.
3. Strain the formulations through proper filters.
4. Rinse it out thoroughly with water after use and pump 1 litre of water through it.
5. Every 3 months, disassemble it completely, put small metal parts into kerosene, allow to set clean with a small bottle brush, soak nozzles, spray lance and tank with trisodium phosphate solution (washing soda), and clean with a scrubbing brush, then rinse thoroughly. Replace worn gaskets, broken parts etc. Reassemble it. Pump clean water through it.

While all attempts must be made to select most effective equipment available in the country, safety should be the prime consideration to eliminate health hazard to the operators as well as to general public. A defective non-standard equipment shall result in safety hazard and environmental pollution

ii. Maintenance of the Equipment

Having selected spray equipment, the maintenance of the equipment both during spray and after spray are also important. For proper maintenance the following aspects are to be looked for, to tide over the operational difficulties in field.

1. One pair of pliers, screw driver (of different sizes) one small adjustable wrench, a knife and a string or greased string
2. In the case of power sprayers, a spare spark plug, a plug spanner, suitable tachometer
3. A toolbox
4. Spare equipments (one or two for each team if available)

F. Precautions / Safety Measures

1. Handle the spray equipment carefully
2. Keep the equipments clean
3. Strain the formulation through proper filters
4. Revise the equipment thoroughly with water after use and pump water through it
5. Keep (a) Extra nozzles, washers and spare parts
6. Keep the equipments under lock and key when not needed for use with due care to the various parts during storage.

(i) **Before Spraying**

1. Choose only recommended insecticide, which is the least toxic
2. Read the instructions issued by the Authorities concerned now and then on the insecticides under use and on the spray equipment supplied.
3. Check the spraying equipment
4. Ascertain that all components are clean
5. Replace worn-out parts
6. Check the nozzle spray pattern and discharge rate
7. Make sure that appropriate protective clothing available for use
8. Train all concerned with the application method
9. Check that the pesticide/insecticide are kept in dry, locked store
10. Do not transfer insecticide into other containers especially into containers used to hold soft drinks
11. Notify the area about your spray programme
12. Use the pesticide/insecticide only when really needed

(ii) **During spraying**

1. Take only sufficient insecticide for the days' application from the store to the site.
2. Recheck the insecticide under use and the equipment
3. Make sure correct formulations are made
4. Wear appropriate clothing
5. Avoid contamination of the skin (avoid splashing)
6. Avoid drifting of the insecticide while spraying
7. Never eat, drink or some when mixing or applying the insecticide

8. Never below out clogged nozzles with your mouth
9. Follow correct spray technique
10. Never allow children or unauthorized persons to be nearby during mixing.

(iii) **After spraying**

1. The left out insecticide in tank should be emptied and disposed off in pits dug on the wasteland.
2. Never leave unused insecticide in sprayers
3. Never empty the tank into irrigation canals or ponds
4. Always clean equipments properly
5. After use, oil it and then keep away in storeroom
6. Do not use empty containers for any purpose. Crush and bury the containers preferably in a land filled dump.
7. Clean buckets, sticks, etc. used in preparing the spray solution
8. Remove and wash protective clothing and footwear
9. Wash yourself well and put on clean clothing
10 Keep an accurate record of insecticide usage.

G. Personal Protection measures

Products available for personal protection- These are generally used to avoidbites from mosquitoes and other insects.

1. Protective clothing: Clothing reduces the risk of mosquito biting if the clothis sufficiently thick or loosely fitting. Long sleeves and trousers with stockings protect the arms and legs, the preferred sites for mosquito bites. Schoolchildren should adhere to these practices whenever possible.

2. Mats, coils and aerosols: Household insecticidal products, namely mosquito coils, electric vaporizer mats and liquid vaporizers, pyrethrum space spray and aerosols have been used extensively for personal protection against mosquitoes.

3. Repellents are a common means of personal protection against mosquitoes and other biting insects. These are broadly classified into twocategories, natural repellents and chemical repellents. Essential oils fromplant extracts are the main **natural repellent** ingredients, i.e. citronella oil,lemongrass oil and neem oil. **Chemical r**epellents such as DEET (N, NDiethyl-m-Toluamide) can provide protection against *Ae. albopictus, Ae.aegypti and anophel*ine species for several hours.

4. Insecticide-treated mosquito nets and curtains: Insecticide-treated mosquito nets (ITMN)/LLINs are used under programme since many years inhigh malarious areas. ThoughLLINs have limited utility in dengue control due to day bitervector, it can be effectively utilized to protect infants and night workers who sleep during day. Impregnated curtains can be used as mosquito nets are not used by all in every area due to weather conditions.

5. Mosquito repellents, attractants and insect killing devices like rackets, traps etc.

H. References

1. Manual on Integrated Vector Management. Dte. of NVBDCP
2. Guidelines for Indoor Residual Spraying (IRS). Dte. of NVBDCP
3. Urban Malaria Scheme – Guidelines. Dte. of NVBDCP
4. Manual on Lymphatic Filariasis. Dte. of NVBDCP

I. Checklist

Chapter - 4

Termite Management Techniques in Pre and Post-Construction Areas

Dr. Sarang Savalekar

CHAPTER CONTENTS

Dr. Sarang Savalekar

Dr. Sarang Savalekar has rich experience in pest management in structures and in human habitations for over 28 years. He has good and successful research based contributions for termite management in new and old structures and also on integrated management of termite pests in both pre and post building construction scenario. He is involved in developing training programs and curricula in structural pest management for Technicians and organized several In-House training programs. He is presently President of Pest Management Association, Pune and actively engaged in betterment of pest management industry.

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Termite Management Techniques in Pre and Post-Construction Areas

A. Purpose and Applicability

The purpose of this SOP is to give an account of Termites, their habits, habitats, polymorphy and their management both before and after the construction of a building. The basic philosophy is to form a protective layer preventing their entry inside the buildings in order to arrest their damage to wood, cloth or other fabrics, hides, leather, rubber, insulation materials, linoleum wool and other commodities. Considering the population strength and the destructive power of termites, total control of termite is not possible for any professional and hence this comprehensive guidance document.

B. Operational Definitions

1. Indian Standards (I.S. Code)

The 'Bureau of Indian Standards' (BIS) adopted the draft standard finalized by the Building Construction Practices Sectional Committee and published in 1971 in the name '*Code of Practice for Anti Termite Measures in Buildings*'. It was re-revised and published again in 2013 by adding new termticides and by adding one new section of building i.e. Basement.

2. Pre-Construction anti termite treatment: (I.S. Code 6313 part II): This standard provides recommendations for different treatments for different foundations, building sections and the extension of new structures with the Termiticides to prevent attack and damage by subterranean termites. Specifically this standard is more applicable for under construction buildings.

3. Post Construction anti termite treatment: (I.S. Code 6313 part III): This standard provides recommendations for different treatments for various existing structures with the Termiticides approved and recommended as well as registered with Central Insecticide Board (CIB) for the existing infestation and to restrict the new entry termite attack.

C. Cautions, Health and Safety Warnings

Safety aspect is divided into following categories –

- **Clients point of view**

Safety of Site staff, Workers, Children's, Pet Animals etc.

- **Environment point of view**

Safety of environment i.e. treatment area, nearby trees, underground water, bore well i.e. ground water and the soil.

- **Operators point of view**

The operator who is actually engaged in termite management he shall be more careful about the safety. He is the person who is in contact with concentrated termiticides while doing the dilution or mixing. He shall wear all the personal protection equipments (PPE) during mixing and during operations.

Personal Protective Equipment (PPE)

i) Suit Wear


Figure 1: Personal protective equipment

- Some pesticide labeling requires "coverall worn over short-sleeved shirt and short pants".
- The phrase "short-sleeved shirt and shorts" does not refer to undergarments.

ii) Coveralls and chemical resistant suit

- The worker safety regulations contain two quite different standards for employer-provided body protection.
- Use coveralls with body covering of tightly woven cloth, or equivalent, extending from the neck to wrists to ankles.
- Use disposable or limited use specialty fabrics clothing with stringent chemical resistance.

iii) Eyewear and closed systems

- Use eye protection glasses while preparing to use closed systems, such as loading pesticides from a rig to the application equipment (the aircraft), when opening containers and inserting probes.
- Use protective eyewear also while using closed systems that operate under positive pressure.
- When using a closed system, protective eyewear must be available on site.

iv) Gloves

The use of glove liners is allowed only when the following conditions are met:

- Pesticide product labeling does not prohibit the use of glove liners.
- Glove liners must be separable from the chemical-resistant glove.
- Liners may not extend outside of the chemical-resistant gloves.
- Liners must be replaced immediately if directly contacted by a pesticide.
- Liners must be discarded at the end of each workday.
- Contaminated liners must be disposed of in accordance with federal, state or local regulations.

v) Respirators

- The employer shall provide approved respiratory protection equipment to the employees to maintain employee exposure below an applicable exposure standard.
- Use respiratory protection appliance for employees required to wear it by labeling or regulation.
- Keep Material Safety Data Sheet (M.S.D.S.) at storage area.
- The M.S.D.S. of Termiticide includes the active ingredients, group of termiticide, mode of action, contents with its percentage, dose, anti-dote, precautions etc.

D. Necessary Equipment And Supplies

1. Equipment related to pre-construction anti termite treatment:

a. Iron rod/ drill machine to take holes in the soil for vertical treatment

b. Hand operative pressure pump for spraying the chemical

c. Water can also may use to spread and cover the recommended consumption of chemical

d. Measuring glass to measure the concentrated chemical

e. 200 Ltrs/ big capacity of drum for the preparation of solution

f. (chemical with water)

g. PPE

h. Adequate concentrated chemical

2. Necessary equipment related to post-construction anti termite treatment:

a. Torch for the inspection

b. Screw driver or any kind of sharp rod for easy identification of damage wooden part and investigation

c. Sprayer i.e. indoor pressure pump

d. Measuring glass

e. PPE

f. Adequate concentrated chemical

E. PROCEDURAL STEPS

E1. Pre-Constructional measures

i. Identify the building section:

Before the treatment, identify the soil contact with the building for creating effective termiticide.

Various Foundation Sections and Its Soil Contact with Entry of Termite

✓ *Masonry Foundation:*

The soil contact is at the bottom and sides of the foundation through the backfill in excavation around masonry wall.

✓ *R.C.C. Foundation:*

Termite cannot penetrate the 1:2: 4 rich concrete so it is not necessary to create a chemical barrier at excavation.

The treatment is required at backfill around column considering immediate soil contact.

✓ *Basement with individual footing pits inside the excavation:*

All the backfill soil around each footing in basement excavation is the soil contact for this section.

✓ *Basement without footing pits inside the excavation:*

In this section there is no backfill inside the excavation around footing and after excavation of basement the bottom surface of basement is the immediate soil contact.

✓ *Pile Foundation:*

All the backfill around pile cap it the soil contact for termite barrier.

✓ *Combine Pile Cap:*

There is no independent pile cap in this section and for a specific structure requirement the pile cap is combine and the filling around combine pile cap is the immediate soil contact.

✓ *Crawl Space:*

In this case, the structure raised above with the space below the structure and except footing there is no contact with the soil. The soil around footing is the only soil contact for this structure.

✓ *Earthquake Resistant inter connected footings:*

For the strengthening of building structure, all the foundations i.e. footings are interconnected. Entire surrounding filling soil area is the immediate soil contact for chemical barrier.

✓ *Wooden Structure:*

In the case of wood structure raised on the Masonry/ R.C.C./Steel Structure Foundation, all the filled soil around the respective foundation as well as the soil contact with wooden structure is the immediate contact for termite barrier.

ii. Site preparation:

Site inspection:

- ✓ Before the application, professional pest control operator shall visit the site first to understand the termite infestation as well as soil condition i.e. moisture etc.
- ✓ During site inspection he shall confirm the storage place for Termiticides, note all the entry points of pests and should plan the physical control measures before planning for chemical control

Training to the operators:

- ✓ Training to the operators i.e. actual pest control workers is very much necessary.
- ✓ Untrained operators may misuse the pesticides i.e. use of wrong pesticide, over dose, mixing of two different group of pesticides.
- ✓ Trained operator ONLY shall be given the responsibility of structural pest control.

iii. Selection of suitable termiticide for effective Termite Management:

- ✓ As per the site requirement he shall select the repellent or non-repellent termiticide first.

Documentations:

- ✓ To keep control to avoid misuse of termiticides he shall maintain the documents of day to day chemical consumption as well as the stock at stores.

Training to the customers:

- ✓ He shall guide and educate the customer about the toxicity of termiticide, its residual effects, dose and anti-dote.

iv. Recommended Treatments for different building sections: (I.S. 6313 part II 2013 latest and revised)

Ist Treatment:

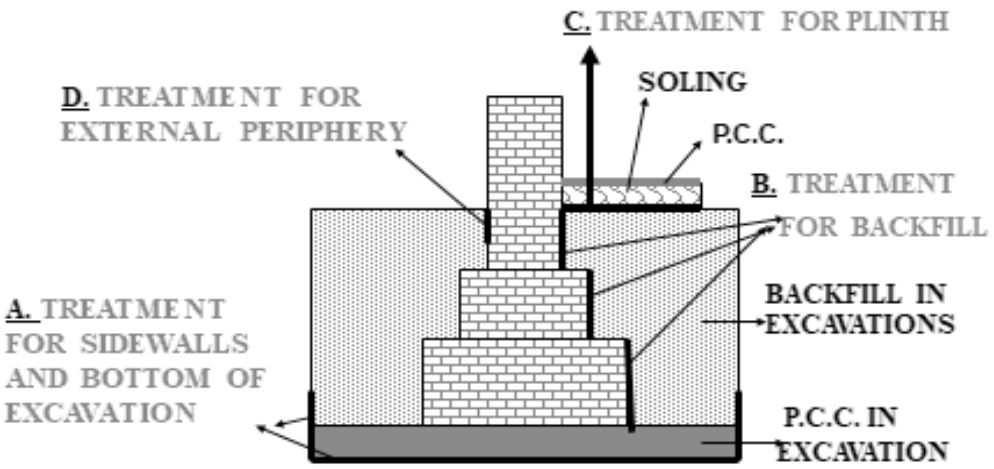
a. Treatment For Masonry Foundations

i. After Excavation in foundation pits:

- ✓ Provide and apply chemical emulsion and create a chemical barrier under and around the column pits, wall trenches, basement excavation etc.
- ✓ In foundation pits, treat the bottom and the sides to a height of about 30 cm at a rate of 5 Lt. Per Sq.Mtr.

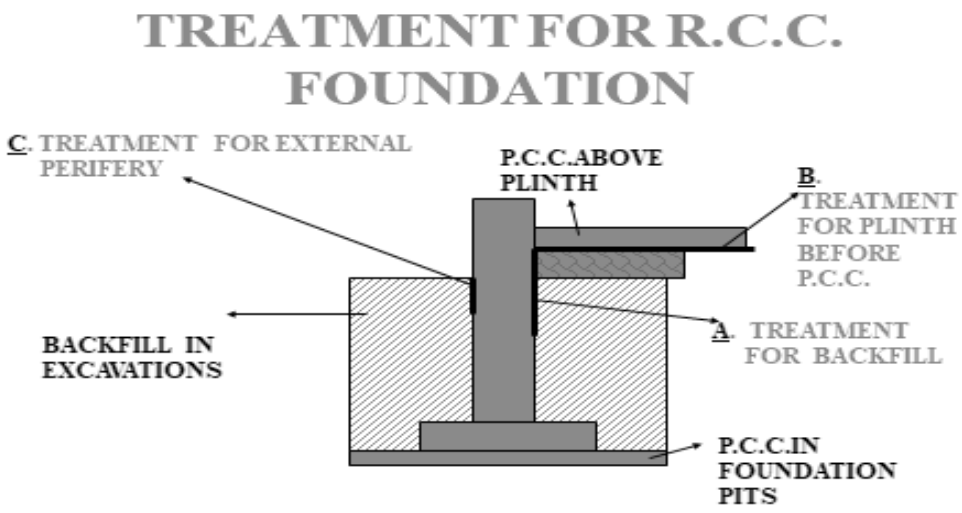
i. After the masonry foundations and the retaining wall of the basement come up:

- ✓ Backfill in immediate contact with the foundation structure shall be treated at the rate of 7.5 L. Per Sq.Mtr.



b. Treatment for R.C.C. Foundation

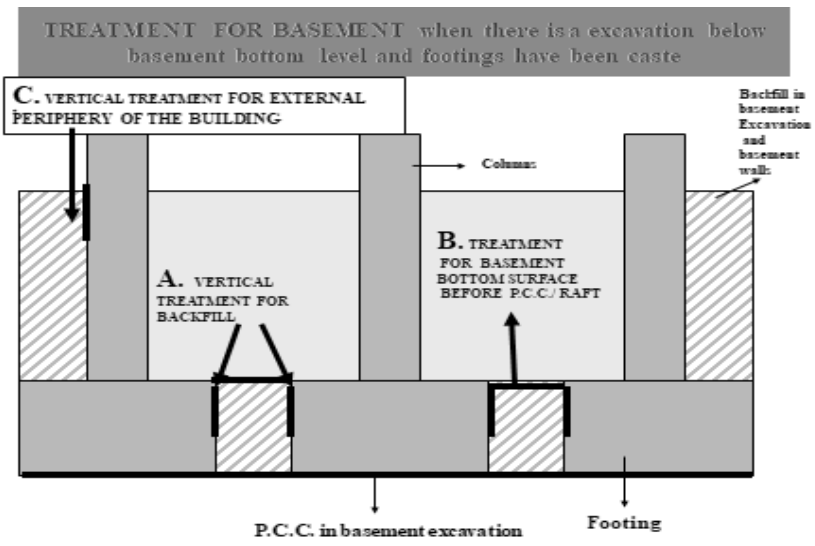
In the case of R.C.C. Foundations, the concrete is dence being minimum1:2:4 mix or richer, the termites are unable to penetrate it. It is therefore, unnecessary to start the treatment from the bottom of excavation. Treat the surrounding filled soil of RCC foundations (columns) 500 mm below earth level i.e. vertical surface of the RCC. foundations shall be treated with the chemical at the rate of 7.5 L per Sqm.



c. Treatment for Basement

- ✓ In case of basement, entire basement bottom surface after compaction shall be treated with the chemical by spraying treatment @ 5 Lt. per Seq .Mtr.
- ✓ If there is excavation in basement for footings, treat the entire backfill area around R.C.C foundation @ 7.5 lt per Sq.M. by following treatment for RCC foundation mentioned above.

Treatment for Basement



II Treatment: Treatment for Plinth

- ✓ Treat the top surface of plinth filling between plinth walls shall be treated with the chemical at the rate of 5 lt. Per Sq.M. by injecting and spraying method.

III Treatment: **Treatment For External Periphery**

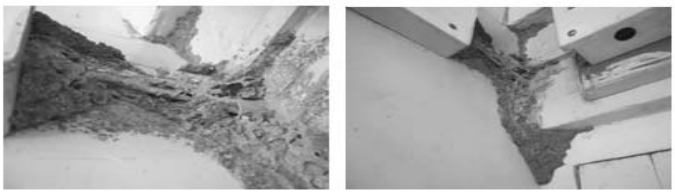
- ✓ After the building is complete, the earth along the external perimeter of the building should be rodded at intervals of 150mm and to a depth of 300mm.
- ✓ And treat the chemical at the rate of 7.5 lt. Per Sqm of vertical surface.

E2. Post Construction anti termite treatment for existing structures

i. Site Inspection:

- ✓ Supervisor shall visit the site for thorough inspection to identify whether it is subterranean termite or wood termite.
- ✓ He shall prepare the detailed inspection report of infestation.

Actual Termite Damage Images at site



ii. Treatment Procedure:

1. Treatment for Building:

Internal peripheral aea of all the rooms of all floors (By drilling the holes and flooding with chemical)

- ✓ Drill vertically 6 to 8 mm holes at the intervals of 300 mm to reach the chemical inside properly and to create a chemical barrier.
- ✓ Chemical emulsion shall be poured inside the holes by hand operative pressure pumps until refusal the holes shall then be sealed.

2. External Peripheral Area:

- ✓ Treat the soil in contact with the external wall of the building with chemical emulsion at the rate of 7.5 Lt. per Sq. M of the vertical surface of the sub-structure to a depth of 300 mm.
- ✓ To facilitate this treatment adopt rodding with 12mm diameter mild steel rods at 150 mm apart in the soil adjacent to the building to a depth of 300 mm from ground level.

3. Treatment For Basement:

- ✓ It is not advisable to drill the holes in any basement and should not disturb the waterproofing at basement floor level and therefore we shall apply spray treatment to entire basement floor area and all the wall surfaces by the chemical to protect entry from flooring.

4. Treatment for wooden door frames and wooden affected furniture:

- ✓ Treatment for the entire affected wooden material and wooden door frames shall be treated with injecting and spraying
- ✓ Spraying treatment for the entire floor surface area before tiling at each floor level.
- ✓ In the case of ground floor, the holes can be taken vertically in the floor if infestation is sever.
- ✓ In the case of new flooring for old structure, after removing the old flooring /tiles, the entire floor surface area shall be treated with the chemical.
- ✓ Spraying treatment for all the wall surfaces especially for the wall cracks and joints with the junctions with the floor to create a chemical barrier.

Post Anti Termite Treatment

iii. Monitoring and check-up treatment

- ✓ Post treatment monitoring is very important for effective Post Construction anti termite treatment.
- ✓ The expert technician shall visit the site and shall monitor the treated areas and if required shall repeat the treatment within a period of 8 to 15 days.

F. Recommended Chemicals for Anti Termite Treatment:

- ✓ Till the year 1992 Aldine/ Heptachlor/ Chlordane were the chemicals which was recommended by Indian Standards 6313 part II 1971 publication
- ✓ In the year 1992-93, the termiticides Aldine/ Heptachlor/ Chlordane were banned due to the health hazard.
- ✓ In the year 1992-93 Chloropyrifos 20%, Indosulfan and Linden were recommended by the revised I.S. Code.
- ✓ Recently Indosulfan and Linden is also banned due to the reason of health hazard.
- ✓ Almost ten years before Imidachloprid is recommended for effective termite management.
- ✓ These termiticides have proved its effectivity too.
- ✓ This molecule may be used for indoor purposes also as a safe termiticide.
- ✓ The Dose of both the termiticdies are also less in compare to the dose of Chloropyrifos 20%.

1. Imidacloprid 30.5% SC:

- ✓ Imidacloprid 30.5% SC is safe and harmless for the environment and soil (ultmiately safe for ground water).
- ✓ Due to its Odorless as well as No-Vapors action it will be safe for the implementation and execution of ATT Scope at site for chemical applicator, supervisor, staff and the site labours too.
- ✓ Dose: 2.1 ml per 1 lt. of water.

  (10.5 ml per 5 lt of water recommended dose in IS code 6313 part II 2013)

2. Bifenthrin 2.5% EC:

- ✓ Bifenthrin 2.5 % EC is also recommended for effective termite management i.e. for Pre-Post construction anti termite treatment with Wood Preservations treatment.
- ✓ Dose: 1 part of Bifentrin 49 part of water

3. Chloropyrifos 20% E.C.

- ✓ Chloropyrifos 20% E.C is recommended by I.S. Code 6313 part II & II 2013
- ✓ Dose: 1 part of Chloropyrifos with 19 part of water.

G. References

IS Code 2001 Code of Practice for anti termite measures in buildings

IS Code 2001 6313 Part II

IS Code 2001 6313 Part III

Krishna, K and Weesner, F.M., 1970. Biology of Termites. Academic Press.

H. Checklist

Chapter - 5

Diagnosis of Major Wood Damaging Pests

Dr. Anil Mazagaonkar

CHAPTER CONTENTS

Dr. Anil Mazgoankar

Dr. Anil Mazgoankar is a researcher and expert in pest management in human habitations. Worked at various teaching and research positions with the Konkan Krishi Vidyapeeth for a decade. Working in the Pest Management Industry from 1993, first as an employee and later as an entrepreneur. Specialized in termite ecology, studied on species diversity of Termites and utilization of termites for soil improvement in the coastal zone of Maharashtra. Continues taking up various teaching assignments in colleges and with the Pest Management Association programs. Serving as Vice President for Pest Management Association and taking part in organizing various In-House training programs to Technicians and Supervisors.

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Diagnosis of Major Wood Damaging Pests

A. Purpose and Applicability

The purpose of this Simple Operating Procedure (SOP) is to inspect various premises and establishments for the presence of various wood damaging organisms and diagnose the species and monitor their presence.

B. Operational Definitions

Termites
Soft-bodied insects that lives in large colonies with several different castes, typically within a mound of cemented earth

Subterranean Termites
Termites living or operating beneath the earth's surface; underground

Dry Wood Termites
Termites that live and feed in dry wood without a soil connection

Wood Borers
Invertebrates that bore into wood

Wood Decaying Fungi
Any species of fungus that digests moist wood, causing it to rot and parasitic and colonize living trees

C. Cautions and Safety Warnings

- ✓ Termites may bite, but these wounds are not toxic.
- ✓ Some persons may be allergic and suffer asthmatic attacks due to fine dust particles from termite and wood borer galleries and wood damaging fungi.
- ✓ Quiet often chemicals used for termite control may lead to heath problems by allowing little time to elapse before reentering a treated premise.
- ✓ Termites often cause severe damage to the wooden members and may lead to floor and roof collapses hence due caution has to be taken during inspection of old and damaged structures.

D. Equipment and Supplies

The equipment required to conduct an inspection include flash light, a mechanic mirror, a screwdriver, hand Magnifying lens and plastic or glass vials.

Torch *Mechanic Mirror* *Screw Driver* *Magnifying Lens* *Vial* *Ice Pick*

> Apart from these, carry a plastic sheet and a dark coloured paper.
> A smart phone with a camera is a useful device during inspections.
> A rough plan of the layout of the area to be inspected is also required to mark out the affected areas.

E. Procedural steps

1. Inspection of surrounding area

The procedural steps include locating the damaged wood and checking all the likely places of termite presence.

i. Initiate the inspection for the presence of termite and wood borer activity from the surrounding area
   - o the garden,
   - o surrounding trees both live and dead tree stumps,
   - o wooden material on the ground or
   - o paper material stored near the houses.

ii. Identify termites by the presence of mud tubes or shelter tubes on living trees or, tree stumps, fence posts, or old packing boxes which are stored near houses.

iii. Look for the presence of termite mounds or termite nests which may vary in size from the very small ones to prominent nests.

Trees and Wooden stumps damaged by termites

Termite Nests or Termitoria of various sizes.

iv. Collect the insects in a vial and check with a magnifying lens to make sure whether the insects in the soil nests are termites or ants

v. Look for the presence of wood powder around base of the trees or other wood, which indicate presence of wood borer damage. Damage to the wood below the bark is also caused by the presence of wood borers.

vi. Note the presence and intensity of the termites and wood borers on a map or layout of the structure being inspected.

2. Inspection of the perimeter structure

The next step is the inspection of the perimeter of the structure.

i. Inspect thoroughly the plinth protection and the foundation of the building for the presence of termite shelter tubes.

ii. The termites quiet often take advantage of the cracks that develop between the. Hence check all cracks in the plaster thoroughly.

iii. Any hollow sounding plaster should also be checked.

iv. Thoroughly check the areas around the drain and water supply pipes and electric cables entering the structure. Check the wall behind these pipes and cables as the termite shelter tubes may be behind these pipes or cables and not easily visible.

v. Check the electric meter rooms also since these are the most likely entry points of termites into the structure.




vi. All door frames window frames and all porch and verandas also should be thoroughly inspected for the presence of termite shelter tubes.

vii. Pay special attention to areas where water is likely to collect. Check if any trees are in contact with the structure.

viii. Check the external walls for the presence of any trees growing on the walls near plumbing pipes or leaves collected on the roofs and around houses.

ix. Also check the terraces of the houses for the presence of discarded wood or paper trash.



3. Inspection of the interior of the structure

Next, inspect inside the structure.

i. Check entire structure for the presence of termite shelter tubes.

ii. Check all areas that are dark, poorly ventilated and may have higher moisture content.

iii. Check areas around all bathrooms especially the lofts.

iv. Check the electrical conduits inside the structure.

v. Check all the furniture particularly furniture that is fixed to the walls needs to be thoroughly investigated.

vi. While doing so, check the wood for any swelling or blistering and peeling paint by removing the surface paint, which is a sign of termite damage. Check such wooden members.

Bubbling or blisterling of wood and portion after removal of the surface veneer

vii. Even check all undamaged wooden members for the presence of termites. Use the handle of the screw driver or ice pick to knock all the wooden members. Any hollow sounding portion should be checked more thoroughly and it should be pried open with the ice pick or screw driver to expose the inner portion and check for damage.



Check the wood for hollowness Pry open Expose the damage

viii. Check the areas below the hollow sounding wooden members thoroughly for the presence of wood powder or frass indicating the presence of dry wood termites or wood borers.



Dry Wood Termite Wood Borer damage Wood borer damage

4. Identification of the pest species

4.1. Subterranean Termites

Termites belonging to Order Isoptera in Arthropoda with equal front set of wings can be found in a wide range of terrestrial environments and are distributed throughout the tropical, subtropical and temperate regions of the world and India is not an exception.

i. Their infestation is less in areas that have very heavy soils that crack deeply and easily in the rain and heavy soils that are subject to frequent flooding.

ii. They are white or tan coloured social insects that can cause severe destruction to crops, constructions and wooden structures.

iii. Termite castes, viz. workers, soldiers and reproductives, live in small to large colonies, sometimes single colony containing a million or more individuals.

iv. The life cycle of termites begins with a mating flight wherein winged reproductive females and males leave an established colony to procreate.

v. After the nuptial flight the winged termites land and form tandem pairs, after a short courtship they shed their wings along a basal suture and become dealates. These dealates burrow into the soil adjacent to wood and a moisture source mate and form a new family.

vi. The founding reproductive pair is now called the Royal Couple, the King and Queen of the new colony.

vii. The growth of the colony from the original primary reproductive pair is slow.

viii. They lay few eggs the first year with these requiring over 50 days to hatch.

ix. The first and second instars of the nymph each require 14 - 18 days.

x. The third instar of the nymph requires one month, while the fourth instar of the nymph requires two months. The fifth instar of the nymph is the longest and may last up to two years.

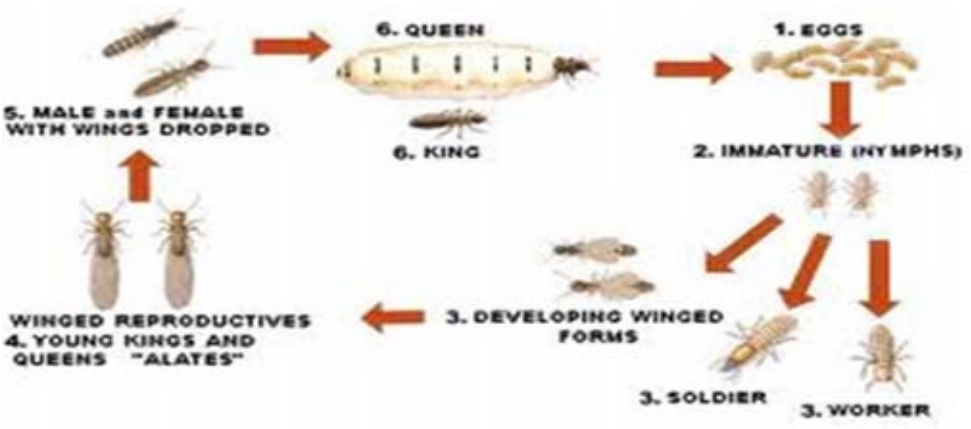
xi. In colonies where there is a large amount of fraternal feeding, well-matured workers and reproductive nymphs may develop.

xii. In the seventh instar, the perfect reproductive stage is attained in the reproductive caste and male and female alates are formed.

xiii. Under ideal conditions, it is three or four years before swarms of alates are present. This development is aided by the supplementary reproductives which lay eggs and therefore add to the growth of the colony.

Reproductive Sterile

Primary Reproductives Secondary Reproductives Workers Soldiers



a. In a mature colony there are two basic forms –

- ✓ the fertile reproductive forms which consist of the Primary reproductive (the King and the Queen) and the Secondary reproductives, which develop on the death of the primary reproductives and
- ✓ the sterile forms are the Workers and the Soldiers

b. The queen normally lives much longer than the worker which only lives for three to five years.

c. Soldiers protect the colony from invaders such as ants will have large heads equipped with large mandibles ("jaws").

d. The bulk of the termite colony consists of thousands of whitish workers who serve various roles. Some workers maintain the nesting site and take care of the queen and the newly hatching immature or nymphs. Other workers go out and actively forage (search) for food.



Odontotermes mound; *Odontotermes* spp soldiers & workers; *Coptotermes* soldier & worker

e. Termites from a single colony can forage across an area of one-third acre and travel over 200 feet from their nest.

f. As the foraging area expands the colony actually splits to form several smaller nesting sites or satellite colonies.

g. Colonies use self-organized systems of activity guided by swarm intelligence which exploit food sources and environments unavailable to any single insect acting alone.

h. "Shelter tubes" or "mud tubes" are one of the characteristic signs of subterranean termites commonly built in the gap between the soil and the structure, and are made from sand or soil, or small particles of wood, or both. The particles are coated with a glue-like substance that is secreted by the termites. In addition, fecal matter is used as cement.


Coptotermes Queen, King Soldier and Worker Odontotermes Queen, King and Worker

i. The major function of shelter tubes is to protect against natural enemies, primarily ants and the minor function is to protect against air movement which desiccates the termites.

j. Termites often rebuild damaged tubes, which is another indication of current activity. Without knowing the inspection history of the house, it is impossible to tell or guess at the age of tunnels or etching.

k. Tubes that are found on ceilings or on upper levels of a building indicate that the termite colony actually lives in the building and the termites are travelling up from the soil.

l. Mud tubes built by an aboveground colony usually contain materials other than soil, e.g., wood and Plaster of Paris from wall finishing or false roofs or whatever the termites are feeding on.

m. These secondary infestations occur when there is a serious moisture problem or leak somewhere within the structure. In such situations, a thorough inspection is required.

n. These aboveground infestations cannot be controlled only with the usual soil treatment. In these situations, finding and correcting the moisture problem should be the first step to eliminating the termites.

4.2. Dry wood termites

i. Dry wood termites live, feed and nest in undecayed or sound wood which has low moisture content and do not require any contact with the soil leading to serious damage to movable wooden objects such as furniture.

ii. They are restricted usually to coastal areas.

iii. A typical dry wood termite colony contains about 10,000, while subterranean termite colony can contain more than 500,000 termites.

iv. A male and female pair work their way into the wood chosen for the nest. The opening through which they enter the wood is sealed with a plug of brown cement-like material about 1/8-inch in diameter. Behind this plug they excavate a chamber where the queen lays the first eggs.

v. The nymphs which hatch from these eggs perform the work of the colony. Soldiers and reproductives develop from these nymphs.

vi. There is no distinct worker caste as in subterranean termites.

vii. During the swarming season, nymphs make round holes 1/16- to 1/8-inch in diameter through which the reproductive forms leave the wood. When swarming is completed, these holes are plugged in the same way as the entrance holes.

viii. Damage done by dry wood termites is entirely different from that caused by subterranean termites.

ix. These termites cut across the grain of the wood, excavating large chambers which are connected by small tunnels.

x. The chambers and tunnels being used by the colony are kept clean. Excreta and other debris are stored in unused chambers or cast out through small openings in the wood called kickout holes.

Dry Wood Termites Frass or pellets

xi. The excretal pellets have six distinct concave surfaces on the sides; only the ends are rounded. The pellets of certain anobiid beetles can easily be distinguished from those of dry wood termites because they have rounded, convex surfaces.

xii. Entrance into wood is usually made from a crack or crevice which the termites can enter before boring into the wood. This may be a crack in the wood itself or may be the joint between two pieces of wood.

xiii. Because of their ability to live in wood without soil contact, dry wood termites are frequently carried in infested furniture and other wooden objects into geographical areas where they are not normally found.

xiv. Dry wood termites may attack wood products of all kinds. Structural timbers and woodwork in buildings, as well as furniture and other wooden objects, may be damaged.

xv. Dry wood termites are not always a widespread structural problem. Sometimes the infestations are very small and localized and can be treated with spot or localized wood treatments and dusts.

xvi. In order to effectively use a liquid, aerosol or dust formulation, holes are drilled into the infested timbers through the termite galleries or kickout holes, using a 3/16 inch drill bit. Insecticide is then forced through these holes to be dispersed through the galleries

4.3. Wood borers

Wood Borers or Powder post beetle is a term used to describe several species of small (1/8-3/4 inch long) insects that reduce wood to a flour-like powder.

i. The developing grub-like larvae inflict damage as they create narrow, meandering tunnels in wood as they feed.

ii. Tunneling and larval development takes place entirely below the wood surface. Infestations typically are discovered after noticing powder, accompanied by small, round "shot holes" or 'exit holes' in the wood surface after adult beetles chew out of the wood after completing their development.

iii. Newly emerged adults mate and lay eggs on or below the surface of bare, unfinished wood.

iv. The eggs hatch into tiny larvae that bore into the wood, emerging as adults one to five years later depending upon species. Usually the damage is seen rather than the beetles, because the adults are cryptic and active mainly at night.

v. The three most destructive groups of beetles are the *lyctids, anobiids,* and *bostrichids*. Each group contains several species capable of damaging wood materials.

Lycitid beetle Bostrichid Beetle Anobiid Beetle

Damage caused by Wood Borer/ Powder Post Beetles

4.4. Wood Decaying Fungi

Wood is also damaged by Wood Decaying Fungi. The damage mainly occurs when wood is above fibre saturation point (27-30%) but below wetness. This decay is accompanied by discolouration.

- ✓ These fungi utilize sound unaltered wood as an energy source through enzymatic degradation of the wood cell walls.
- ✓ They can be seen as fan-shaped patches, strands, root-like structures, fruit bodies as toadstools, brackets or crusts.
- ✓ The mycelium permeates the wood and uses lignin-cellulose as food
- ✓ Certain decay fungi attack heartwood in living trees causing heart rot.
- ✓ Others grow on logs, sawed timber, structural timber, poles, etc. Some decay fungi continue from trees to products

Symptoms of Wood Decay

- ✓ Change of colour-dark brown spots, flecks of lighter colour
- ✓ Change in density -weight loss
- ✓ Change in odour-mushroomy smell
- ✓ Change in strength -toughness, shock resistance, bending strength, hardness, elasticity reduced
- ✓ Change in heat conductivity -increased
- ✓ Change in water holding capacity -increased
- ✓ Presence of zone lines -narrow dark zone lines
- ✓ Physical presence of fungi on wood -mycelium, fruit bodies

Two major Types of Fungal damage are seen –

i. **Brown rot** In this only cellulose is extensively removed while lignin remains unaltered or slightly modified resulting in cuboidal cracking

ii. **White rot** In **this** both lignin and cellulose are removed and the wood becomes leached or white hence the name.

Brown Rot White Rot

5. Wood Protection

Various methods of wood preservation are used to increase the life of the wood.

a. Oil Type: Creosote Coal Tar and Fuel Oil in equal proportions is applied to the surface

b. Organic Solvents : Copperised Cashewnut Shell Oil, Copper Naphanate and Zinc Naphanate

c. Water based : Ammonical Copper Arsenate, Borax and Sodium Penta Chlorophenate, Copper Sulphate

These chemicals may be applied either by flood brushing or allowing it to steep into the over a period of a week. Pressure impregnation is used in wood industries.

F. Data and Records

Inspection Report for the Surrounding area

Sr. No.	Infestation Source	Location and No.	Action to be recommended and Pesticide to be used
1	Trees Live		
2	Tree Stumps		
3	Termite Mounds/Nests		
4	Accumulated Waste		

Inspection Report for the Perimeter of the Structure

Sl. No.	Infestation Source	Location and No.	Action to be recommended and Pesticide to be used
1	Trees on walls Live/dead		
2	Plumbing - Pipes		
3	Electrical Cables Meter Rooms		
4	Damaged Door and Window frames		
5	Accumulated Waste		

Inspection Report for the Interior of the Structure

Sl. No.	Infestation Source	Location and No.	Action to be recommended and Pesticide to be used
1	Bathrooms and Damp Walls		
2	Damaged Electrical Boards		
3	Damaged Furniture and Wooden Paneling		
4	Shelter Tubes		

The same report format can be used to note the observations after the treatment for the follow up and monitoring visits

G. References

Anonymus (2001) Code for Practice for Anti termite Measures in Buildings Part 1, II & III BIS 6313

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H. Checklist

Date of visit	Observations	Actions taken	Actions planned

Chapter - 6

Fly Problems in Human Habitations and their Management with Special Reference to Housefly

Dr. Kedar Deobhankar

CHAPTER CONTENTS

Dr. Kedar Deobhankar

Dr. Kedar Deobhankar has rich and varied experience of over 25 years in the field of Public Health and Household Insecticides. He has worked with multinational companies engaged in Public Health and Vector control and Household insecticide business in various capacities and as Head R&D in his last assignment. He has supervised and monitored large scale trials in the field of Public health and Vector control in India, Sri-Lanka and Nepal with various formulations including impregnated bed-nets. He is one of the founder members and CEO of Ross Lifescience Private Limited engaged in Product Development and testing & evaluation of products related to Household Pest Management.

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Fly Problems in Human Habitations and their Management with Special Reference to Housefly

A. Purpose And Applicability

The purpose of this Simple Operation Procedure (SOP) is to inspect the premises of residences and establishments for the presence of houseflies, diagnose the species, to undertake their management using different standard methods available in an integrated approach, and to monitor their incidence at periodic intervals. The procedures outlined in this SOP are applicable to all premises/establishments covering residential, municipal and industrial facilities.

B. Operational Definitions

I. SOP

Standard operating procedure (Protocol for conducting studies mentioned herein)

II. *Musca domestica*

Common housefly is commonly seen in all the premises

III. Negative geotaxis

Occurring away from earth

IV. Negative phototaxis

Living away from light

C. Importance of Controlling Flies

Control of flies is of paramount importance due to following reasons:

i. Flies not only cause nuisance to humans and domestic animals but also are the carriers of various pathogens that transmit diseases like diarrhea, dysentery, typhoid, cholera and eye diseases like trachoma and conjunctivitis.

ii. Studies have shown that fly nuisance results in low milk yield in cows.

iii. Flies have been shown to have impact on tourist/hospitality business as their presence connotes unhygienic condition and is an unwelcome sight for guests.

iv. Flies also soil the surfaces on which they sit (newly painted walls etc.).

v. Others such as Stable flies (*Stomoxys calcitrans*) are obligate blood feeders and primarily attack cattle and horses for a blood meal. In the absence of these animal hosts they will bite people and dogs.

D. Cautions, Health and Safety Warnings

- It is also important to note safety considerations such as the location of pets and presence of small children.
- Take adequate care for personnel safety – While checking for the habitation of the houseflies and mapping of infestation spots.
- According to the World Health Organization (WHO), they are proven or suspected carriers of the organisms causing diarrhea, dysentery, cholera, & typhoid fever
- Houseflies (*Musca domestica)* are generally called synanthropic because of their close association with man.
- Studies have shown that they carry many pathogens (viruses, bacteria, protozoa, helminth eggs) both externally and internally.
- They breed in animal and human wastes and also in wide variety of organic debris produced by man.
- All insecticides are poisons. Read the entire label, including the small print before opening the containers and heed all warnings and cautions.
- Store pesticides in their original labeled containers out of reach of children, irresponsible people, and pets, and preferably keep under lock and key.
- Dispose of leftover spray materials and empty containers.

E. Equipment And Supplies

The planning of area wide fly control program would require following equipment:

- Knapsack/Compression sprayer with various nozzles
- ULV misters or fogging machines
- Plastic Buckets with measuring cylinders and mugs
- Sauce pans and scrapers
- Funnels with filters
- Flash lights to observe breeding places and resting sites for houseflies
- Personal Protective Equipment (PPE)- Hats, Gloves, Aprons, Goggles, Gum boots.
- Insecticides (relevant to location and treatment being considered)
- Diluents like water, Diesel oil etc.
- Manpower-Site Manager, Entomologist, Supervisors and spraymen
- First aid boxes and physician on call
- Vehicles, bicycles for transportation of material, workforce

F. Procedural Steps

1. Know basic information on Flies

i. Houseflies or *Musca domestica* are called synanthropic flies as they are in close association with man, and hence this SOP is dedicated to the management and control of the common housefly

ii. Apart from the common housefly, there are also flies from genera Fannia, Muscina, and the biting flies (S*tomoxys*), the blow flies (*Chrysomyia, Calliphora, Lucilia*) and flesh flies *Sarcophaga* which are encountered.

iii. In warmer climates, the filth fly, *M. sorbens* is of particular interest in this regard. It is closely related to the housefly and considered important in the spread of eye infections.

iv. Blowflies (Calliphoridae) and other flies have been associated with the transmission of enteric infections. These and other flies which are encountered are in the Fig. below:

Picture of Fly species	Name of Fly	Importance	Habitats
	Common housefly (*Musca domestica).*	Can cause widespread and severe problems for receptors	Larvae found in poultry, pig, and calf manure and in refuse. Adult readily disperses and enters buildings
	Lesser housefly (*Fannia canicularis).*	Can cause widespread and severe problems for receptors Larvae found in poultry manure and in refuse	Adult readily disperses and enters buildings
	Blow flies: Bluebottles / Greenbottles / Dump fly (*Calliphora / Lucilia*) Larvae found in carrion	Localized problems only	Larvae found in carrion and faecal material, commonly associated with putrescible waste. Adults tend not to disperse far
	Stable flies (*Stomoxys calcitrans)*	Localized problems only.	Larvae found in manure of large animals, e.g. cattle and pigs. Adult is blood-feeding, and tends not to disperse far.
	Fruit flies (Drosophila spp.)	Localised problems only. A small (2 mm) fly.	Larvae found in rotting vegetation or vegetable waste, e.g. greenwaste composting. Tends not to disperse far.

2. Know the characteristic habits

i. The breeding sites of these flies are animal and human wastes and wide variety of organic debris produced by man.

ii. Both male and female House flies can survive well on water plus sugar or other assimilable carbohydrates. Females require protein components for development of eggs.

iii. Houseflies have poorly developed smell receptors on the antennae and food is found by random exploratory movements aided by visual attraction and by smell at shorter distances

iv. Houseflies feed on all kinds of human food and garbage, excreta, sweat, animal dung etc.

v. During day time flies are congregate around feeding and breeding sources where mating also happens. These are mostly market places, garbage dumps, sewage sludge, restaurants, on the ground with low vegetation and open public latrines. During night time flies prefer to rest on edges, strings, wires etc. under the ceiling inside the buildings.

vi. Houseflies are good flyers and can move at the rate of 6-8 km per hour but are not migratory in nature.

vii. Preferred temperature for adult resting flies is 35-40 C and around 27 C for newly emerged flies. Flies die (heat paralysis) at temperatures above 45-47 C

viii. Newly emerged flies exhibit negative geotaxis and negative phototaxis. Adult flies exhibit no such preferences.

ix. Flies react to different colors in very different ways. Indoors they prefer dark surfaces usually black or red and avoid blue. Outdoors flies may prefer yellow and white and avoid black.

x. In field 50% of the flies die during first 3-6 days and very few reach an age of 8-10 days (without chemical treatment). In laboratory the mean life span of adult flies is around 17 days for male and 29 days for female (@25C and 45% RH)

xi. Flies have enormous breeding potential and the number of generations per year may vary from 10-30 depending on temperature and humidity.

3. Know Fly breeding and resting sites

Areas	Resting and breeding Sites
Urban areas	Garbage dumps, Sewage sludges, accumulation of plant and organic material, market places, fences, restaurants, open food sources, human excreta, latrines and inside apartments (kitchens, toilets, and edges like strings, chords etc.); clogged nullahs
Rural areas	Garbage and dung & manure heaps, human and animal excreta, aqua privies, open latrines, poultry and livestock sheds, mixed dwelling (having cattle shed), fences and other vertical surfaces, clogged nullahs

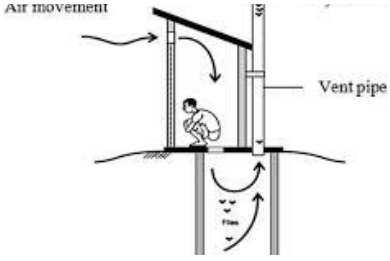
Typical Fly breeding and resting sites in urban / rural areas and domestic habitats

Garbage dumps

Sewage sludge with fly breeding

Manure with fly maggots

Livestock fly breeding site



Aqua privies with fly screen on vent pipe

Flies in apartment on window sills

4. Know life cycle of housefly

There are four states in their life cycle -

i. **Egg**: The eggs of the housefly are 1.2 mm in length. They are white in color and pilled shaped. The eggs are individually laid and piled up into small groups. A female housefly can lay up to 500 eggs in 3-4-day period, about 75 to 150 at a time

ii. **Larva**: The larvae start feeding immediately upon hatching. They are legless, whitish cream in color. Their heads have a pair of hooks for feeding purposes. When hatched, they are about 3-9 mm long, reaching about 7-12 mm in late larval stage. The optimal temperature for larval development. The optimal temperature for larval development is 35-38 C. Manure provides an excellent substrate for development but can also develop in soil having trace amounts of manure. The fully-grown larvae are able to crawl up to 50 feet to find cool and dry place to enter into pupal stage

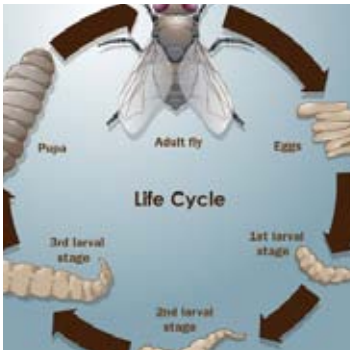
iii. **Pupa**: The housefly pupa is about 8 mm and turns black as pupa ages. Pupa is bean shaped and is encased in its larval skin. Pupa emerges into adult in 2 to 6 days

iv. **Adult**: The adult housefly is about 6-7 mm long. The newly emerged fly is soft, pale grey and wingless. It has an active wingless phase lasting 15 minutes. The young flies start feeding when they have become active after the wing stretching from 2-24 hours after emergence at 27 C. The adult body is divided into head, thorax and abdomen. Males are able to copulate the day after emergence. The number of eggs per oviposition is normally about 120. If undisturbed the female usually lays them in one cluster and often several females lay eggs in the same spot.

Bionomics of housefly

Minimum duration of different stages (days)	**35 C**	**30 C**	**25 C**	**20 C**	**16 C**	**<13 C**
Total days Egg+Larva+Pupa	6-8	8-10	11-13	18-21	36-42	No development
Maturation of eggs in female (pre-oviposition period) - days	1.8	2.3	3	6	9	
Total life cycle (days) Eggs+Larva+Pupa+ Maturation	8-10	10-12	14-16	24-27	45-51	

(adapted from WHO)



Life cycle and different stages of housefly

G. Fly Management Methods

The fly management procedure for most of the fly species remains more or less same and depends on treatment of breeding and target resting sites.

The procedural steps involve -

a. Recruitment of trained staff

1. Position trained personnel while dealing with fly management in public places and human habitations consisting of a trained entomologist along with spray operators and supervisor well acquainted with safe handling of insecticides, their storage and disposal.
2. Impart safety training in the safe use of pesticides and in the techniques of spraying, protective equipment, recognition of the early signs and symptoms of poisoning and first aid measures including resuscitation.

b. Locating the housefly habitats

1. Houseflies breed in variety of decaying, fermenting or rotting organic matter of both animal and vegetable origin.
2. Areas with smells of fermenting and putrefying material, which attract the flies.
3. Take in to consideration of their resting habits of House flies to understand potential places wherein treatment can be rendered.

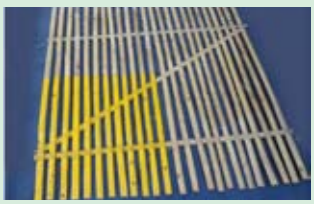
Time	Resting	Target areas
Day time	Mostly Outdoors	Market places, garbage dumps, sewage sludge, restaurants, on the ground with low vegetation
Day & night time	Indoors	Kitchen, aqua privies and animal shed and in night times mostly vertical surfaces on edges, strings, wires, ceiling etc

Other flies: (mostly outdoors)	Target areas/breeding areas
Blow flies (*Calliphora vomitoria, Phaenicia sericata*)	Breed on rotting animal carcasses. Found near meat processing plant, slaughter houses
Lesser houseflies (Fannia canicularis)	Tend to congregate in outdoor areas like patios, entryways and garages. Hovering near the face makes them annoying
Stable flies (*Stomoxys calcitrans)*	Stables, slaughter houses, cattle markets, dumped wastes

c. Fly counts for survey:

In order to evaluate fly control program, it is necessary to obtain reliable density of fly population before initiating control activities. Several methods exist for this purpose

Physical counting of flies

Method	Equipment	Procedure
Fly grill count (scudder grill) (indoors and outdoors)		Lower the grill over a fly concentration. Number of flies landing during 30 seconds interval is counted. Counts done same time of the day in same place for 3 consecutive days
Count of flies landing on baits (indoors)	Dishes, trays, plates, strips etc. with fly attractant/ bait (molasses, milk with sucrose)	Expose for 20 minutes and count the flies landing on bait. Do the count for 3 consecutive days at same locations/sites
Counts of estimates on available surfaces (indoors and outdoors)	Count number of flies where flies are known to congregate (animals, surfaces, partitions, kitchen platform, table surface or feeding troughs in stables)	Observe number of flies present during particular time on such surfaces. Repeat at least 3 times and compute mean reading
Trapping of flies (indoors)	 	Trapping of flies by light traps or sticky traps at particular time in the day could be used to estimate fly density
Maggot count	Monitor larvae by scraping the top 2 - 5cm layer from the surface of the manure or waste over an area of approximately 30 x 30cm.	The number of exposed larvae is then quickly estimated, and recorded. This should be carried out at 4 – 10 locations within each location

d. Mapping of housefly infestation

1. After estimating the fly densities and adult/maggot congregation spots mapping is done to establish infestation of various intensities which can be earmarked on the map by color codes as low, medium, high and very high- risk areas.
2. The identification of hot-spots based on presence of adult houseflies and maggots, in indoor and outdoor situation, would allow selection of chemicals and method of application to be rendered in the given area.

Schematic topography of the location wherein fly control needs to be conducted with location of houses (Geographical reconnaissance)

A schematic diagram of mapping of pest infested area (borrowed from internet)

= potential hot sites= fly infestation places

e. Initiation of Fly control measures:

e.1. Environmental Sanitation and Hygiene

- Brings long term control of flies in urban areas, villages, individual farms and hospitality industry.
- Chemical methods are complimentary to sanitary measures.
- Effective fly control be achieved by -
- Eliminate sources suitable to fly breeding a) by excluding flies (prevent egg laying) from waste and excreta b) by killing larvae in infested materials
- Prevent ingress of flies from other areas by eliminating sources of attraction

e.2. Elimination or reduction of fly breeding

Animal sheds, pens,stables etc -

- Remove regularly the animal dung and manure.
- Lay concrete flooring with proper drainage.

Poultry houses

- Remove droppings under the cages or net bottoms.
- Treat with systemic larvicides such as Larvadex containing Cyromazine through feed.

Dung heaps

- Remove the dung heaps regularly.
- Cover the heaps with plastic sheets to prevent the flies from laying eggs.
- The plastic sheet covering raise the temperature above 50 C which kills the fly larvae.

Human excrement

- Adopt proper disposal of human excrement through -
- Providing proper latrines,
- Educate public to bring change of habits,
- Remove the exposed feaces regularly.
- Instal functional aqua privies with a vent pipe and fly net to make them fly-proof.
- Cover the lids of pits to make them fly proof

Garbage disposal, collection and transport

- Providing fly proof garbage containers of sufficient capacity.
- Transport the garbage at pre-deteremined intervals to the final disposal site
- Avoid spillage of garbage during its transportation.

Sewage and waste water management

- Cover all sewage drains
- Cover sewage sludge with dry soil.

f. Community Education and Participation:

- Educate the community in co-ordination with municipal authorities for collection, transportation and dipsosal of waste.
- Educate the community to keep the neighbourhood clean through –

(a) education of children in school,

(b) dessimation of information to general public through demonstrations, television channels and news paper and

(c) involvement of key stakeholders- local politcians, legislators and administrators etc.

g. Non-Chemical methods of fly control

- Adopt physical killing methods like catching of flies in traps or using electric grids having sticky pads.
- Fix screens to windows and doors with 10 gauge mesh to prevent entry of flies.
- Fix doors of auto closing.
- Fix anti-fly or air curtains cutains in production facilities to keep away flies.

h. Chemical control methods

i. Larviciding (maggot control)

Elimation of fly breeding at source naturally eleminates maggots also. However, maggot control is beset with many problems. The breeding media (manure) not only keeps on accumulating and changing but also distribution of larvicide and its penetration in viscous media becomes difficult leading to poor control. Also use of conventional larvicides result in killing of nautural enemies of flies thus disrupting biological balance.

Typical breeding site with fly maggots for larviciding

ii. Insect growth regulators

Diflubenzuron and Pyriproxyfen are promising alternatives to conventional larvicides that can be used for control of fly larvae. These larvicides do not have effect on many non-target fauna in the manure and are eco-friendly with relatively very high safety margin to vertebrates.

(outdoors situation)

Product	Dilution	Application	Frequency	Target sites
Diflubenzuron 25 WP	Mix 15 mg in 5 litres of water	Spray over 10 square meters with compression sprayer having flat fan nozzle	7-13 days	Breeding sites in poultry, animal shed, sewage sludge etc
Pyriproxyfen 0.5% GR		20 g/square meter 10 g/square meter By hand granule applicator, blower with granule nozzle	2 weeks interval	livestock and poultry houses or waste treatment facilities

i. Residual spraying of target sites:

- Identifying areas where flies spend most of their time.
- Spot spraying with adulticides on surfaces where flies rest during day time and night time.
- Carry residual spraying is carried out by knapsack or compression sprayer with flat fan nozzle with the chemicals listed below.
- Use these insecticides on surfaces (on need base) wherever flies congregate in indoor or outdoor situations including refuse dumps, recreational areas, markets etc
- Take adequate care that the food items or utensils are not contaminated.

Schematic photo showing spot treatment with insecticides

Spray indoor wall surfaces with compression sprayer having a discharge rate of 750 ml/ minute at a distance of 45 cm from surface to cover the surface uniformly.

Treat any overhangings such as gunny bags. Observe due precautions of not spraying on cattle, fodder or potable water in case of mixed dwellings.

Product	Dilution	Application
B-cyfluthrin 2.45% SC	Mix 20 ml in 1 litre of water	Spray over 20 square meters for porous surfaces and over 40 sq meters for non porous surfaces
Cyfluthrin 5% EW	Mix 8 ml in 1 litre of water	Spray 50 ml per square meters
Imidacloprid 21% + B-cyfluthrin 10.5% SC	Mix 4 ml in 1 litre of water	Spray over 20 square meters
Deltamethrin 2.5% Flow	Mix 10 ml in 1 litre of water	Spray over 10-20 square meters
Alphacypermethrin 10 % SC	Mix 10ml-20 ml in 1 litre of water	Spray over 50 square meters
Propoxur 20% EC	Mix 25 ml in 1 litre of water	Spray 50 ml per square meters

j. Toxic baits

- Broadcast the baits in thin layers of 60-250 g per 100 square meter onto avialable dry surfaces at fly congregations.
- Sprinkle water on the dry baits to increase the effectiveness.
- Dissolve the baits sometimes in water and spray using compression sprayer on larger surfaces wherever the flies congregate.
- The sugar in the bait increase attractancy and gives effective reduction of fly population.
- The viscous bait solution can also be applied to strips, bands, chords etc which can be suspended under the ceiling in variety of situations like animal sheds, poultry farms,markets, shops and restaurants.

Products that can be used are specified below:

Product	Application	How to apply
Propoxur 2% bait	As dry scatter bait in indoor or outdoor situations	Manually broadcasted onto fly congregations
Imidacloprid 0.5% RB	Control of flies in outdoor situations as paint-on-application	Mix 200 g of product in 150 ml of water. Apply the mixture as "paint-on" on surfaces frequented by flies (small walls, window sides, stable fixtures etc)

The wall (small surfaces) is sprayed with the bait formulation (bait diluted in water) wherein the flies congregate.

k. Indoor space treatments:

- Apart from residual sprays which can be used for spot treatment on fly congregations, aerosols come in handy for rapid decrease in density in indoor locations (enclosed spaces) for giving immediate relief.
- The treatment is carried out when the maximum proportion of fly population is indoors (in the evenings).
- Following products can be used for obtaining rapid knock down of flies:

Aerosols (Indoor space treatment)
d-trans allethrin 0.25% w/w
Cyfluthrin 0.025% w/w + Transfluthrin 0.04% w/w
Transfluthrin 12% w/w AE

Aerosols for instant knockdown of flies in enclosed spaces

l. Outdoor space treatments

- Outdoor space treatment is recommended for quick elimination of fly population in outdoor situations at refuse dumps, markets, recreational areas, area-wide control in cities and towns etc. An example is provided below:

Product	Usage as	Dose per hectare
Deltamethrin 1.25 % ULV	Thermal fogging	50 ml in 10 litre of diesel oil
	Ultra low volume application	50 ml in 0.5 litres of diesel oil

Misting for control of flies

H. Reporting

- Data on density of adult flies from various houses and locations can be collected and tabulated (Table below).
- The number of days of observation depends on the need. The adult fly and maggot density is monitored on regular basis and treatments are rendered at pre-determined intervals. (depending on population build up).
- Earmark a storehouse for keeping record of all insecticides, other chemicals, PPE, spray equipment and rest of the paraphernalia.
- Maintain a register for all such items along with attendance register.
- Report template (can be modified as per need)

Fly management					
Pre treatment counts	Fly grill count	Landing on baits	Visual density on surfaces/cattle	Trapping of flies	Larva count
Day 1					
Day 2					
Day 3					
Total count					
Post treatment counts					
1 day after treatment					
% reduction over pre-treatment					
7 DAT					
% reduction over pre-treatment					
14 DAT					
% reduction over pre-treatment					
21 DAT					
% reduction over pre-treatment					
28 DAT					
>>>>>					
>>>>>					
Pre-treatment and post treatment counts determined at same place during each time interval					

I. References

1. Chemical methods for the control of arthropod vectors and pests of public health importance, WHO, Geneva-1984
2. WHO/VBC/86.937
3. Control Technology for the formulation and packing of pesticides, WHO, Geneva-1992
4. https://www.360environmental.co.uk/documents/Fly%20Management%20Guidance%20June%202018.pdf
5. https://sumitomo-chem-envirohealth.com/wp-content/uploads/2018/04/catalogue_Sumilarv0.5G.pdf

J. Checklist

Date of visit:

Areas visited:

Areas with high infestation detected:

Areas with recent treatment with success rate:

Management Action Plan

Chapter - 7

Cockroach Problems in Human Habitations and their Management

Dr. K. Malla Reddy

CHAPTER CONTENTS

Dr. K. Malla Reddy

Dr. K. Malla Reddy is a Professional Pest Management expert working from 1985. An expert rodent management professional, he is also a Master Trainer in Urban Integrated Pest Management. A well known Resource Person and Trainer for training programs in Structural Pest Management to pest and vector management professionals. He conducted extensive research in rodent ecology and management in urban situations with special reference to non poisonous sticky traps. Active member of Indian Pest Control Association and was past elected President.

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Cockroach Problems in Human Habitations and their Management

A. Purpose and Applicability

The purpose of this Simple Operation Procedure (SOP) is to inspect the premises of residences and establishments for the presence of cockroaches, diagnose the species, to undertake their management using different standard methods available in an integrated approach, and to monitor their incidence at periodic intervals. The procedures outlined are applicable to all premises/establishments covering residential, municipal and industrial areas.

B. Operational Definitions

1. Harbourage
Places which afford habitation of cockroaches for their survival

2. Habitats
Places where the cockroaches can perform all their activities

3. Mapping of infestation
After a technical survey, plotting the spread of cockroach populations on a location/locality map to give focused attention

4. Cocoons/Ootheca
An encapsulated case containing group of eggs delivered by cockroaches

5. Insecticide
The chemical which kills the target insect pests and cockroaches

6. Active ingredient
Active content of a pesticide in various formulations viz., baits or spray fluid or granules etc.

C. Cautions, Health and Safety Warnings

- It is also important to note safety considerations such as the location of pets and presence of small children.
- Take adequate care for personnel safety – While checking for the habitation of the cockroaches. mapping of infestation spots.
- According to the World Health Organization (WHO), they are proven or suspected carriers of the organisms causing diarrhea, dysentery, cholera, leprosy, plague, typhoid fever and viral diseases such as poliomyelitis.

- Cockroaches are filthy pests. They can spread disease, contaminate the food and cause allergies and even asthma. Cockroaches can pick up disease pathogens on their legs and bodies as they crawl through decaying matter or sewage and then transfer these germs to food or onto food surfaces.
- All insecticides are poisons. Read the entire label, including the small print before opening the containers and heed all warnings and cautions.
- Store pesticides in their original labeled containers out of reach of children, irresponsible people, and pets, and preferably keep under lock and key.
- Dispose of leftover spray materials and empty containers

D. Equipment And Supplies

The equipment required to conduct a professional cockroach inspection include heavy duty flash light, a mechanic mirror a flushing agent and a screwdriver. Hand Magnifying lens, plastic vials.




The following steps shall be followed:

- Carry heavy duty flash light, a mechanic mirror a flushing agent and a screwdriver for inspection.

E. Procedural Steps

The procedural steps include locating the cockroach habitats, mapping their distribution in the locality/premises, initiating both chemical and non chemical methods.

i. Locating the cockroach habitats

The primary goal of cockroach inspection is to locate as many cockroach hiding places or “harborages” as possible to determine insecticide treatments and other management activities. A typical search should begin in the kitchen, bathroom, water sinks, storage areas, dining areas, behind and under food processing equipment, and loading and unloading areas. The search should then extend to all adjacent areas. The following procedures shall be adopted during the inspection:

- locating the cockroach habitats - The habitats for cockroaches include - Manholes, Rocky areas, wall cracks, shoe racks, parking area, dustbins, water tank, ornamental plant pots, railway tracks etc.
- Cover public places like roads rail tracks parks etc.

- Take block wise observation on presence of cockroaches.
- For public places, take observations on presence of cockroaches in 5% of individual premises randomly. The observations need to be considered different type of unit holding viz., 2bhk, 3bhk, villa etc.
- Take adequate care for personnel safety – While checking for the habitation of the cockroaches. mapping of infestation spots.

ii. Mapping of infestation spots

After locating the cockroach habitations, mapping needs to be done on the indoor and outdoor areas. The map should include spots of all cockroach sightings, area where harborage site is spotted, conditions which are conducive to cockroach presence, level of sanitation, location of sensitive areas and other treatment considerations. This leads to customization of various insecticide application and other management efforts ensuring successful result with non target species safety and minimum number of treatments.

- Super impose areas based on infestation levels on the location map.
- Give different colours for low, moderate and higher infestations.

Mapped area with different infestation levels (H, M or L)

iii. Diagnose species of public health importance

Although four species of cockroaches occur in india, German cockroach (*Blatella germanica*) and American cockroach (P*eriplanata americana*) are of common occurrence in India

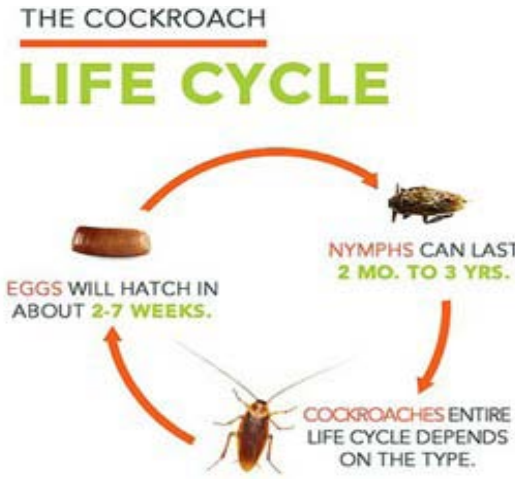
German Cockroach (*Blatella germanica*)

The characteristic features are as below:

1. Lives in cracks, crevices and dark spots in the building provided by furniture, wall cabinets and numerous household items, which provide the optimal conditions for growth and development.
2. They are brown to dark in color, 1.1 - 1.6 cm long with two block stripes behind the head and nymphs resembling the Adults
3. The females produce 4 to 8 egg capsule in its life time, each capsule (ootheca). The capsule is a tiny, brown, purse-shaped capsule. Containing 30 – 40 eggs.
4. Nymphs do not possess wings and complete development takes about 60 days.

Male German Cockroach with 2 dark bands

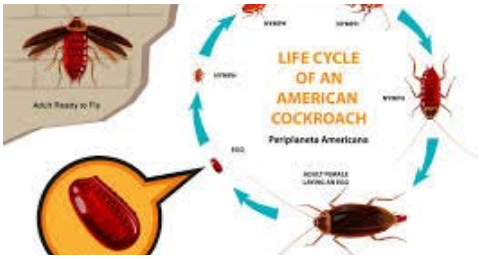
Female with protruding ootheca



American cockroach (*Periplanata americana*)

The characteristic features are as below:

1. American cockroaches normally live outdoors and are common in sewer systems.
2. They live in warm and humid environment and common in store rooms, cabinets, manholes, drains and all dark places in the premises.
3. On entry inside homes, they often go to bathrooms, kitchens, laundry rooms and basements.
4. American cockroaches provide signs of their presence through their droppings in the dark areas where they hide and often confused for mouse droppings.
5. The egg cases can be found in basements, in laundry rooms or kitchens, under cabinets or behind appliances.
6. They are reddish brown in color and varies from 34 to 50 mm in length
7. The area behind their head is outlines with yellow band.
8. The females make protective cases – capsules containing about 16 eggs, and deposits them in a warm, humid area.
9. On hatching tiny nymphs emerge, which are reddish brown in color resembling adults and mould 6 - 14 times in 6 - 20 months to mature. The adults live up to 22 months.



iv. Management of Cockroaches

Sanitation measures

- Remove food and water sources using through cleaning procedures since Sanitation deprives cockroaches food, moisture and harborage needed for their survival.
- Eliminate cockroach harborages by caulking or similar structural repairs.
- Employ sticky barriers using rodent glue board adhesive or special insect trap adhesive to prevent cockroaches from climbing the legs of tables or other furniture.
- Maintain higher temperatures greater than 120°F for several hours, or cold at 0°F for 60 minutes (or several hours at 32°F), where insecticides cannot be used or no residues are permitted.
- Keep counters, food preparation surfaces, kitchen appliances and floors as clean as possible.
- Periodically, intensively clean kitchen areas, in particular the floor, focusing on areas where grease accumulates, such as drains, vents, ovens and stoves. Put screens on vents, windows and ducts to reduce roach passageways.

Pictures of clean kitchen and caulking & similar structural repairs

- Caulk around the edges of screens to make a tight barrier.

Habitat Management

- Keep food in tightly sealed, roach-resistant containers and leftover food inside a refrigerator.
- Store food waste and other organic materials in plastic containers with tight-fitting, snap-on lids.

Picture of food waste in plastic container with tight fitting snap on lids

- In the areas infested by American cockroaches, remove dead leaves or rake mulch away from the foundation.
- Check infested grocery bags when brought inside for cockroaches before storing.
- Keep grocery bags in outside storage areas.
- Check large openings around outside drainage lines and sewer vents and fix screens or sealed.
- Seal gaps between door frames and doors with weather stripping.

Chemical Management

Insecticide application/s should be complementary to above sanitation and habitat management measures but should not be exclusive. Page: 10

The following insecticides are recommended for cockroach management in India

Recommended chemicals for cockroach management			
Namd of insecticide with Active ingredient (a.i.)	**Brand name**	**Formulation**	**Recommeded dosage**
Imidacloprid 21% Beta Cyfluthrin 10.5%	Temprid	SC Formulation	4 ml/1L
Alpha cypermithrin 10% SC	NT COCK	SC Formulation	20 ml/1L
Cyfluthrin 050 EW	SOLFAC	EW Formulation	15 ml/1L
Deltamethrin 2.5% SC	K-Othrine	SC Formulation	15-20 ml/1L
Fipronil	Agenda	EC Formulation	
Fipronil	Maxforce	Bait station, gel	Small spots
Imidacloprid	MAX FORCE Quantum	Bait station, gel	Small spots

- The insecticide application shall be made as crack and crevice, spot or general.

Prepare the spray fluid as below:

- Add water (1/2 -1/3) volume of solution tank.
- Add pesticide according to label dilution rate.
- Replace pump assembly, tighten and shake vigorously for Uniform mixing open the assembly.
- Add water up to the desired level replace pump assembly, tighten and shake vigorously for uniform mixing.

The following is the spraying procedure

- Select appropriate spray nozzle.
- Pump until a tank pressure of 20 psi is reached (approximately 10 times pumping).
- Spray smoothly until the point of runoff (20 inches from surface)
- Upon completion of work, rinse solution tank with ½ litre of water.
- Pump thrice spray into an empty container.
- Repeat the procedure 3 times.
- Keep reinstate for use the next day.

Post spray actions

- Store solution tank empty and inverted, ready for next use.
- Use reinstate again in preparing a solution of the same chemical the next day.

- Use ULV treatments for crack, crevices and void applications if legally registered. Use gel formulation in cracks and crevices to have long lasting efficacy.

v. Monitoring

- Confirm that previous treatment was effective.
- Check for new cockroach activity.
- Identify changes to the home or landscape to find vulnerability to cockroach invasion.
- Re inspect the treated premises as a follow up in two weeks time.
- Place cockroach monitors in identified strategic locations in treated premises this will help to provide pest sighting report to the authorities.

- The following are cockroach monitoring traps.

F. Data and Records Management

Record keeping

Type of Premise	Area in premise	Roach infestation	Type of service Gel/Spray	Remarks
Individual	External area			
	Kitchen/store/ Refridgerator/ Appliances			
	Ward robes			
	Bathrooms/Sinks			
Establishments	External area			
	Kitchen/Dining			
	Store			
	Wash rooms/ changing rooms			
	Logistic areas			
	Sewage lines			

Forms and record keeping are essential part considering regulatory inspections and legal provisions.

G. References

Bennett G.W and Owens J.M. 1986. Advances in Urban Pest Management. Van Nostrand, New York.

Cornwell P.B. 1968. The Cockroach, Volume I. Hutchinson of London, London.

Rust M.K, Owens J.M and Reierson D.A. 1995. Understanding and Controlling the German Cockroach. Oxford University Press, Oxford.

H. Attachments / Checklists

Equipment

1. Residual sprayer

2. Gel Applicator

Checklist (check mark for completed tasks) – for each pest it needs to be

1. Date and time of visit
2. Verified/inspected the areas as below:
   - I. Xx
   - II. Xx
   - III. xxx
3. Applied following measures for management:

Area inspected	Type of measure applied	Input type and quantity applied	Follow up observations 7th 14th 21st day

CHECKLIST OF COCKROACHES				
Name of the Client :		Frequency :		
Pests Covered : COCKROACHES		Month:		
			Chemical used and Dilution:	
S.No	**Date**		**Date**	
	Area	**Checked By**	**verified By**	**Remarks**
1				
2				
3				
4				
5				
6				
7				

Technician Name & Signature

Authorized By

Client Remarks

Technician Remarks

Chapter - 8

Ticks and Mites in Human Habitations and their Management

Dr. N. Balakrishnan

CHAPTER CONTENTS

Dr. N. Balakrishnan

Dr. N. Balakrishnan is a bio-medical scientist with Doctorate from Pondicherry Central University. He was Joint Director at National Centre for Disease Control under Ministry of Health and Family Welfare, Government of India and incharge of Plague Surveillance Unit located at Bangalore. He possesses vector control professional experience of about 38 years. He has rich number of publications in National and International Journals. Guest faculty for Vector Control Research Center, Pondicherry and other Universities. An academician associated with doctoral programs of 9 Universities. His areas of Research interest are - vector borne Diseases, viz., Dengue, Filariasis, Malaria and Japanese Encephalitis; Rodent borne ecto parasitic diseases, viz., Plague, Tick and mite borne diseases; Surveillance of Zoonotic diseases and their control, and Emerging and reemerging zoonotic diseases of public health importance. Currently associated as a Consultant with a research project on Kyasanur Forest Disease (KFD) - a tick borne disease at ICAR-NIVEDI, Bangalore.

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Ticks and Mites in Human Habitations and their Management

A. PURPOSE AND APPLICABILITY

The purpose of this Simple Operation Procedure (SOP) is to inspect the premises of residences, public parks, grazing land and fields for the presence of ticks and mites, diagnose the species, to undertake their management using different standard methods available in an integrated approach, and to monitor their incidence at periodic intervals. The procedures outlined in this SOP are applicable to all premises/establishments covering residential, municipal and public places.

B. OPERATIONAL DEFINITIONS

1. **Ecto-parasites**
   Insects living on the skin of all small mammals
2. **Ticks and Mites**
   Small Arthropods belonging to class arachnida and sub class Acari.
3. **Rodents**
   Small mammals having teeth adopted to grow throughout their life time and a permanent reservoir.
4. **House shrew**
   Insectivore (sentinel animal) seen in human habitations

C. IMPORTANCE OF CONTROLLING TICKS AND MITES

Control of ticks and mites is of paramount importance due to following reasons:

- Ticks and mites are not only nuisance to humans and domestic animals, but also cause irritation by their bites, blood feeding.
- They also act as the carriers of various pathogens causing diseases like Tick typhus, Kyasanur Forest Disease (KFD), Relapsing fever and Cremian Congo Haemorrhagic Fever (CCHF) in man and many infections in animals.
- Mites are responsible for causing scrub typhus, scabies and dust allergies.
- Tick bite nuisance results in blood loss and anemia in animals.
- Many of the domestic/pet animals are infested with these ecto-parasites and humans get various pathogen infections through these ectoparasites.
- The solid waste management and environmental sanitation are of primary importance, since garbage favours the proliferation of rodents which are the primary reservoirs for the viral and rickettisial pathogens causing tick and mite borne diseases.

- The environment degradation by deforestation, conversion of forest land to agricultural fields/plantations, residences are the reasons for the increased occurrence of tick and mite borne infections in many parts of the country.
- Ticks and mites feed on rodents, small mammals, wild and domestic animals like cattle and dogs for their blood meal. In the absence of these animal hosts they will bite people and transmit disease pathogens.

D. CAUTIONS, HEALTH AND SAFETY WARNINGS

- It is also important to note safety considerations such as the location of pets and presence of small children.
- Take adequate care for personnel safety – While checking for the infestation of ticks and mites in animals and surrounding areas and mapping of infestation spots.
- They are proven as the organisms causing many tick borne diseases like tick typhus, KFD & CCHF as well as scrub typhus and scabies by mites.
- All life stages of ticks are obligatory blood feeders in man and animals where as the mites larvae are blood feeding and adults are free living.
- Studies have shown that they carry many pathogens (viruses, bacteria, protozoa, helminth) responsible for causing both animal as well as human diseases.
- Ticks and mites breed in grass lands and vegetation abundant in and around human habitations, agricultural farms and forests and insecticidal treatment is necessary to control their population.
- All insecticides are poisons. Read the entire label, including the small print before opening the containers and heed all warnings and cautions.
- Store pesticides in their original labeled containers out of reach of children, irresponsible people, and pets, and preferably keep under lock and key.
- Dispose off leftover spray materials and empty containers

E. EQUIPMENT AND SUPPLIES

The planning of area wide fly control program would require following equipment:

- Knapsack/Compression sprayer with various nozzles
- Dusting equipments for application of insecticides.
- Plastic Buckets with measuring cylinders and mugs
- Sauce pans and scrapers,
- Berlese Funnels with filters

- Rodent trapping materials like wounder traps, Sherman traps and baits.
- Personal Protective Equipment (PPE)- Hats, Gloves, Aprons, Goggles, Gum boots.
- Repellents like DMPoil, DEPA to avoid tick bite.
- Insecticides (relevant to location and treatment being considered)
- Diluents like water, Diesel oil etc.
- Manpower-Site Manager, Entomologist, Supervisors and spraymen
- First aid boxes and physician on call
- Vehicles, bicycles for transportation of material, workforce

F. PROCEDURAL STEPS

1. Know basic information on Ticks and Mites.

- Ticks and mites, collectively known as the Acari belong to the Class: Arachnida and constitute the second most diverse group of animals on the planet and affect the human health as parasites, vectors of disease, and producers of allergens.
- They differ with other insects due to (i) fused head, thorax and abdomen as one body segment, (ii) do not possess wings and antennae and even nymph and adult stages have four pairs of legs.

2. Ticks, Life cycle and Management

i. Ticks belong to the Super family - Ixodoidea,

ii. Family - Ixodidae is represented with *Ixodes* (common tick) and *Boophilus* (jungle tick)

iii. Family - Argasidae represented with *Ornithodorus* (Soft/domestic ticks, oval with leathery cuticle)

iv. The body of tick consists of gnathostoma comprising the mouth and feeding parts, and idiosoma bearing the legs, genital pore, spiracle and anal aperture

v. They possess Haller's sensory organ, which can detects hosts, the tick, being an obligate parasite for survival – via olfaction and the sensing of humidity, temperature, and carbon dioxide.

vi. Ticks have two distinct body parts- Cephalothorax & Abdomen and four pair of legs. Antennae –absent, Eyes – may or may not be present)

Differences between Ixodid (Hard) and Argasid (Soft) ticks

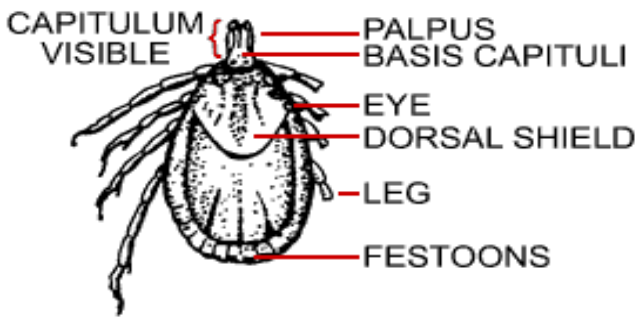
What Are The Differences Between Hard Ticks And Soft Ticks?		
Feature	**Hard Tick**	**Soft Tick**
Scutum (dorsal shield)	present	not present
Capitulum (mouth parts)	anterior, visible from above	ventral, not visible from above
Nymphal stages	one	several
Adult feeding time	several days	30-60 min.
Female blood meals	one	several
Egg laying events	one	several
Total eggs laid	3,000-8,000	400-500

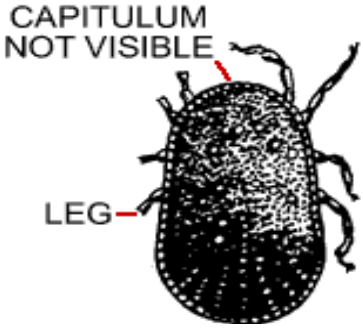
i. **Morphological characters of Hard and soft ticks:**

➢ The hard ticks are oval in shape with dorso-ventrally flattened body measuring about 3-23 mm length depending on the species and feeding status.

➢ The females are nearly always bigger than males, and take larger blood meals they enlarge much more than males during feeding.

➢ At the anterior end is the capitulum or "False head" and its base is called basis capituli with hypostome projecting anteriorly and has teeth arranged in rows.





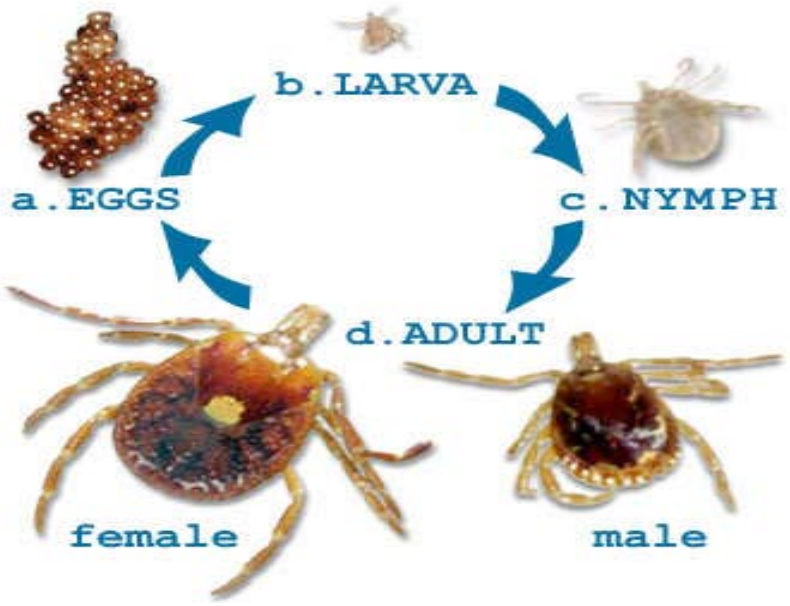
➢ Hard ticks have a hard dorsal plate, shield or scutum is absent in soft ticks.

➢ In males the scutum is large and covers almost the either dorsal surface of the body.

➢ In female it is much smaller and is restricted to the anterior part of the body.

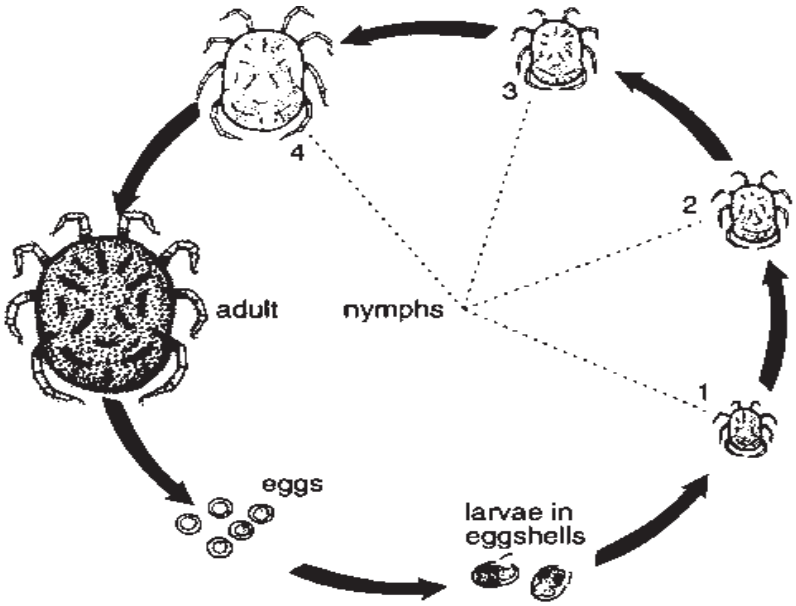
➢ Where as in soft ticks the scutum is absent and the body is oval in shape covered with mammillae. The head and legs are in the ventral side.

ii. **Life cycle of Ixodid (Hard) ticks**



- Female hard tick feeds once and lays one large batch of eggs (even up to thousands), and dies.
- Both sexes require several days feeding before copulation.
- Mating of hard ticks usually occurs at host animal
- After the male hard tick becomes engorged, copulates with one or more females and then dies.
- Insemination occurs on the host when the male crawls beneath the female and transfer of spermatophore takes place.
- After mating, female ingests large quantities of blood and drops down on the ground in the resting place of the host or in the field.
- It finds a suitable niche and after a gestation period of several weeks, starts laying eggs and continues for 15 to 20 days. Fully fed female may lay from 100 to 10,000 eggs.
- The incubation period of the eggs variable from few weeks to several months depending on the prevailing temperature.
- Life cycle consists of four stages egg, larva, nymph and adult.
- The complete survival of hard ticks takes 3-6 months and longer life span favours propagation and transmission of disease pathogens
- The larva, nymph adult stages facilitate disease transmission through blood feeding.

iii. Life cycle of Argasid (Soft) ticks



- ➢ The life cycle of soft ticks is similar to hard ticks but the life span is prolonged with many nymphal stages.
- ➢ The soft ticks live within the nidus/nest of the host animal.

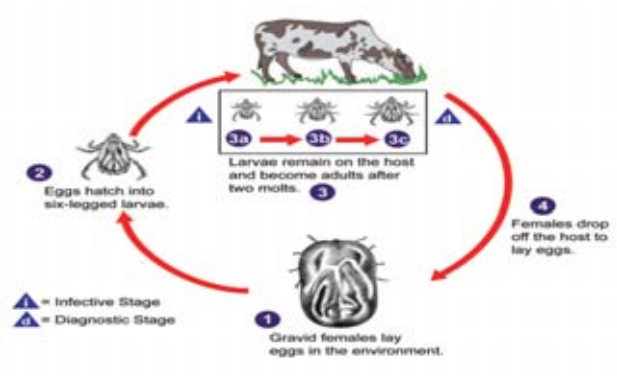
iv. Life cycle of one host two host and three host ticks

One-host Tick: The larvae, nymph and the adult, all feed on the same host. Molting also take place in the same host and the blood engorged female ticks dropped to ground to lay their eggs. This one host ticks like *Boophilus* are less likely to acquire infection with pathogen- little or no Medical importance.

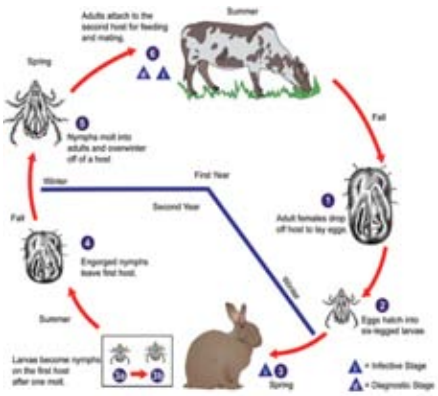
Two-host Tick: In 2-host Ticks like *Hyalomma* and *Rhiphicephalus*, the larvae and nymphs feed on the same host, but the adult feeds on different host.

Life cycle of Three-host Tick: In species like *Ixodes, Rhiphicephalus* and *Haemaphysalis,* the larvae, nymph and adult feed on three different individual hosts of same or different species and drops after moulting.

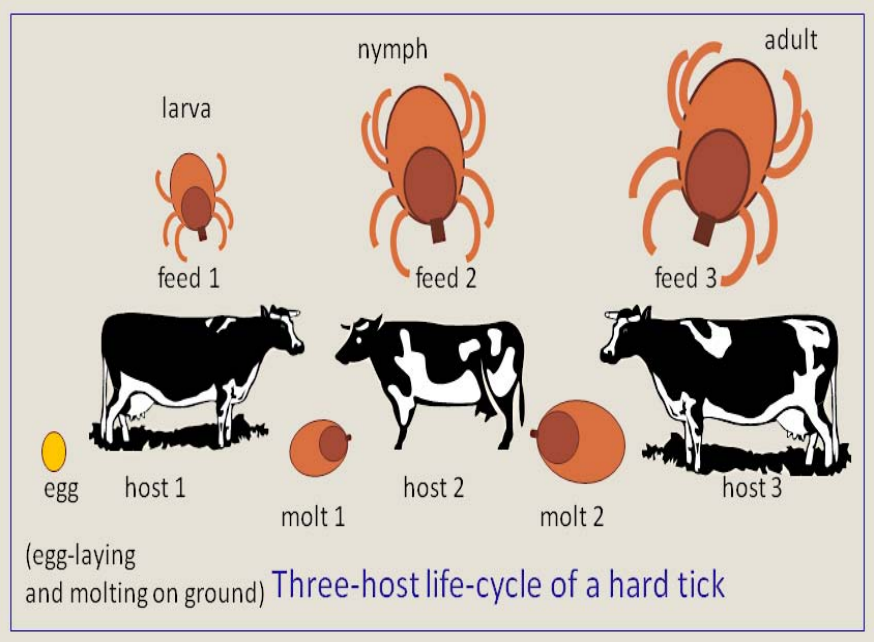
Life cycle of One Host tick



Life cycle of Two Host tick



Life cycle of Three Host tick



v. Questing

➢ Ticks use chemical stimuli, airborne vibrations, and body temperatures to locate mammals

➢ Simultaneously, the tick is using chemical stimuli such as CO2, NH3, phenols, humidity, and aromatic chemicals to determine the location of mammals. The ticks also use airborne vibration and body temperatures to seek

vi. Tick collection methods

1. Collect Ticks by
   a. flagging of the forest vegetations and ground,
   b. collect from Animals and
   c. collect from rodents trapped from the localities.
2. Evaluate the density of tick infestation on a host in term of tick index which represent average number of ticks per host

   TICK INDEX = Total number of ticks collected/Total no. of hosts examined for ticks
3. Cover a variety of animals to obtain a complete picture of tick prevalence is an area.
4. Calculate the tick infestation rate -

   TICK INFESTATION RATE = No. of animal found positive for tick /Total animal examined

5. Carry out tick collection by trapping rodents by using live traps.
6. Tick collection need to be carried in hot spots of monkey death areas to monitor the KFD virus activities.
7. Majority of the virus isolations will be from nymphs during the dry season (January to May) and adult isolations during the monsoon season.

vii. Tick Management measures

For effective results, IEC need to be imparted to the public on the ticks and ticks borne diseases., vector control measures in the forest peripheral and high risk villages to be carried out, entomological/ epidemiological surveillance should be undertaken in disease infected areas. Adopt Integrated tick control strategy In the areas endemic for tick borne diseases with the following components -

a) Surveillance: Sampling to identify tick habitats where control is needed.

i. Collect of free living ticks- unfed larvae, nymphs and adults by flagging/ drag net method and record per man hour density.

ii. Collect ticks from domestic and wild animals to determine the tick index and isolation of virus from them.

iii. The frequency of sampling at monthly intervals and the frequency may be increased during epidemics.

b) Vegetation management: Physical or chemical measures can be used to reduce and isolate tick habitats.

i. In areas with tick infestation like camp sites and parks, ticks can be controlled by removal of vegetation serving as their habitat by cutting, mowing or by applying herbicides.

c) Host management: (Removal or exclusion of host animals Method)

i. Tick populations can be controlled by removing of animals on which they usually feed.

ii. Fences may also be made to exclude wild animals from entering into human habitation.

1. Targeted chemical control:

i. In areas with tick infestation they can be controlled by insecticidal application mainly by applying bio degradable insecticidal dusts.

ii. Treat the animal houses, residences, furniture's and wall crevices and cavities with residual insecticides.

iii. The heavy tick infested animals also treated with insecticidal dusts and formulation on their body.

iv. Spraying should be undertaken in the forest tracts frequented by the villagers.

v. Surveillance and monitoring of ticks infestation on animals and occurrence of human cases in an locality on long term basis.

2. Insecticidal formulations:

Various insecticidal formulations can be applied to domestic pets, such as dogs, to get rid of their ticks.

i. Recommended treatment includes solution of 0.5% Dichlorovos (DDVP), 1% Carbaryl (Sevin) or 3-5% Malathion can be applied to the coats of animal habitats.

ii. The dipping of sheep and cattle, and sometime other livestock, in acaricidal bathes, or spraying them with insecticides.

3. Cultural practices:

i. Lifestyle changes to limit the exposure of ticks.

ii. Avoid sitting and lying down on tick infested ground.

4. Personal protection:

i. Protective clothing,

ii. repellents like DMP oil, DEET formulations in the exposed body parts and checking for removing of ticks.

iii. Washing of clothes and body with hot water and soap need to be undertaken after visiting the forest to get rid of tick infestation.

iv. Vaccinating the people at risk and animal handlers for the specific tick borne diseases.

3. Mites Life cycle and Management

➢ Mites are small arachnids ranging from 0.5- to 2.0 mm in length, parasitic on vertebrates characterised by having 4 pairs of legs.

➢ Although parasitic mites are commonly are external parasites, some species infest the inner and middle ear, the respiratory passages and lungs, skin, intestine and bladder of vertebrate.

➢ Mites can be differentiated from ticks through the absence of Haller's organ on the tarsus of the first pair of legs.

➢ The hypostoma of mites is not modified as a hold fast organ and not provided with recurved teeth.

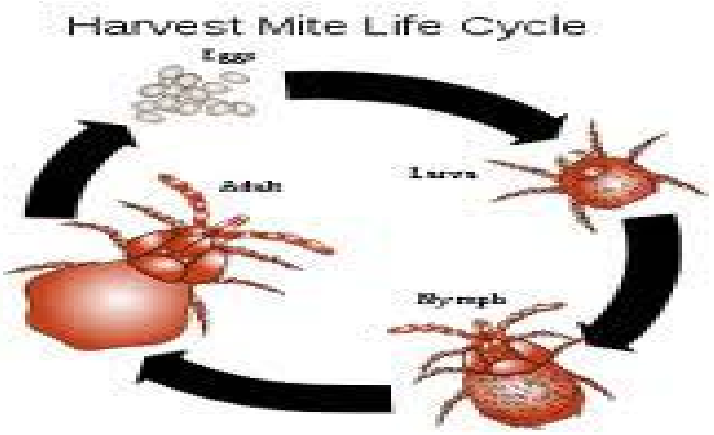
➢ In common with ticks, mites are two types having medical importance, one cause scabies and the other scrub typhus.

➢ Scrub typhus is a rickettisial disease caused by the organism *O. tsutsugamushi* and transmitted by the larval stage of *Trombiculid* mites.

➢ The Tr*ombiculid* mite and the larvae are called chiggers. *Leptotrombidium deliense* and *L. akamushi* are the mites transmiting disease scrub typhus.

a. Vector biology

➢ *Leptotrombidium* mites are mainly found in grassy fields, shruby areas, forests, abandoned rice fields and cleared forest.



➢ Haller's organ is a complex sensory organ possessed by ticks. The organ detects hosts – which the tick, being an obligate parasite, must find in order to survive – via olfaction and the sensing of humidity, temperature, and carbon dioxide and then becomes active.

➢ The larvae are active and require blood for their maturation

➢ Whenever host-passes nearby larvae crawls upon the host and after getting a suitable site start feeding till fully engorged (2-10 days) on rodents the most suitable feeding site is ear pinna.

➢ The larvae are mainly found in shrubs, low vegetation and abundant rodent species , which acts as a host for mite. Some of these areas are small foci and are known as mite islands.

➢ After full engorgement larvae dropped off the host and remain quiescent for sometime in the soil and changes in to protonymph or Nymohocrysalis (inactive non –feeding stage). The protonymph then changes into Deutonymph

➢ This stage is active , predaceous and sexually immature. After feeding it increases in size and transform into tritonymph or pupa or imagocrycalis which ultimately hatched into adult .

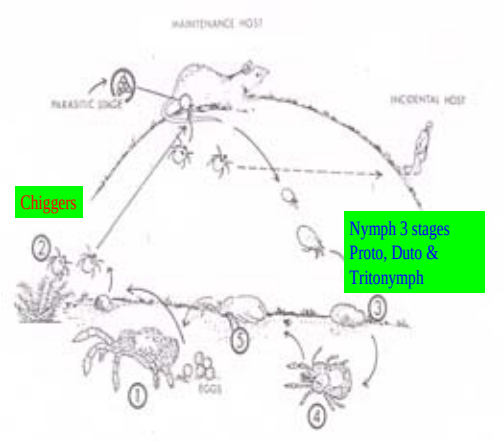
➢ After attaining maturity it starts laying egg and cycle repeated. The complete life cycle take about 2-3 month under normal conditions.

b. **Mode of transmission of scrub typhus:**

- ➢ It is a zoonotic disease prevalent in hilly forest tracts on Himalayan range originally, but penetrated to entire country at present.
- ➢ Infection to man is accidental because of changes in environment and expansion of villages and towns in to forest tracts due to agriculture practices, urbanization, industrialization and reclamation.
- ➢ Epidemic of scrub typhus depends on presence of *Leptotrombidium* mites in good number and reservoir rodent – *Rattus rattus*
- ➢ Pathogen is Orientia (R.) tsusugamushi

c. **Entomological surveillance for scrub typhus:** Indices for mite surveillance include -

- ➢ qualitative & quantitative information on the vector mite chigger index and rodent species
- ➢ seasonal prevalence of vector mites and rodent species
- ➢ prevalence of pathogen rickettsiae in rodent by serology and culture
- ➢ susceptibility status of vector mite to repellent and insecticide
- ➢ meteorological data viz., temperature, humidity and rainfall and terrain features



Life Cycle of Trombiculid mite
(Total life Cycle 40-50 days)

d. **Sampling technique of Mites:**

- ➢ Trap the rodents and shrews in live traps and examine them for the presence of these mites.
- ➢ They should be first anaesthesized with chloroform or killed by stunning carefully and then soaked and shacken in water containing few drop of detergent solution.

- ➢ The animal should be put into plastic bag for further examination.
- ➢ The water containing detergent solution should be transferred to petri dish and examined under dissecting microscope for presence of mites.
- ➢ Chiggers are usually yellowish or orange in colour and concentrated in the ears or in the groin region of their hosts.
- ➢ Mites preserved in 70% alcohol should be cleaned with water and mounted on glass slides using Hoyer's media.
- ➢ Trap and examine sentinel animals laboratory rodents or shrews also.
- ➢ Collect the chiggers by combing of live or anaesthetized rodents and mount in Hoyer's Medium for further identification and calculation of chigger index (Critical value: >0.69 per rodent and 0.68 for House shrew),
- ➢ Chigger infestation rate (CIR)= No. of mites collected/No. of Rodents found positive
- ➢ Index above this level is signal for outbreak/ epidemic in a locality
- ➢ Conduct regular sero surveillance for detection and isolation of *Rickettsia* antibodies.
- ➢ Also conduct periodic susceptibility test against vector mites.

e. **Prevention and control measures:**

The vector mites of scrub typhus should be controlled to prevent the disease in their islands.

i. Eliminate these foci or islands by treating the ground and vegetation with residual insecticides, rodent control, and environmental sanitation.

ii. Persons who cannot avoid infested terrain should wear protective clothing, impregnate their clothing and bedding with a miticide (e.g. benzyl benzoate) and apply a mite repellent, diethyl toluamide, to exposed skin.

iii. Administer 200 mg doxycycoine at weekly interval to reduce clinical illnesses.

iv. There is no effective vaccine developed so far for humans mainly due to serotype heterogeneity of the organism.

v. Infection could also be prevented by avoiding sleeping on the ground, impregnation of clothing, socks and shoes with repellent like Benzyle benzoate, butyle pathoate, DEET, Dimehtyl carbamate etc. Repellant can also be applied on body to avoid mite bites.

vi. Clean the shrubs and low/scrub vegetation in those areas where mite infestation is reported and rodent population is abundant.

vii. Removal and burning of ground cover, followed by scraping and ploughing at the top soil, render the areas unsuitable for chiggers.

viii. Prevent chiggar bites using their bite repellents in open/forest areas.

f. Residual spray on Vegetation:

Undertake spraying of suitable insecticides like Diazinon, fenthion, malathion, propoxur and permethrin up to the height of 20 cm. around houses, hospitals etc in areas, where removal is not possible to kill the mites.

g. Chemical Control:

a. Spray with DDT, Malathion in outdoors after undertaking environmental sanitation.

b. Use chlorinated hydrocarbons, which are very effective in killing chiggers on the ground.

c. Dieldrin, fenthion,lindane, malathion and propaxur can be applied as emulsions, suspensions or dusts.

d. Hand operated or power operated sprayers or dusters can be used for the application of dieldrin at 2.8 kg of a.i./ha, lindane at 5.6 kg of a.i/ha.

e. Use of insect repellents such as dimethyl phthalate, diethyltoluamide,dibutyl phthalate, ethyl hexanediol and benzyl benzoate may be of help in reducing the likelihood of people getting infected with mites. Clothing can also be impregnated with suitable repellents.

f. Rodent management using rodenticides brings affective result since they are permanent hosts, especially at times of clearance of forest areas for the developmental activities.

G. References

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2. WHO/VBC/86.937
3. Control Technology for the formulation and packing of pesticides, WHO, Geneva-1992
4. Jan A.Rozendaal (1997) Vector control Methods for use by individuals and Communities WHO, Geneva
5. https://sumitomo-chem-envirohealth.com/wp content/uploads/2018/04/catalogue_ Sumilarv0.5G.pdf

H. Checklist

Date of visit:

Areas visited:

Areas with high infestation detected:

Areas with recent treatment with success rate:

Management Action Plan

Chapter - 9

Bedbug Problems in Human Habitations and their Management

Dr. K. Malla Reddy

CHAPTER CONTENTS

Dr. K. Malla Reddy

Dr. K. Malla Reddy is a Professional Pest Management expert working from 1985. An expert rodent management professional, he is also a Master Trainer in Urban Integrated Pest Management. A well known Resource Person and Trainer for training programs in Structural Pest Management to pest and vector management professionals. He conducted extensive research in rodent ecology and management in urban situations with special reference to non poisonous sticky traps. Active member of Indian Pest Control Association and was past elected President.

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Bedbug Problems in Human Habitations and their Management

A. Purpose and Applicability

The purpose of this Simple Operation Procedure (SOP) is to inspect the premises of residences and establishments for the presence of bugs, Identify bed bugs, their life cycle and signs of their infestation. Explain the economic importance of bed bugs, locating nesting & breeding areas, common route of entry of bed bugs in the building and their management by integrating various methods with appropriate products & equipment.

B. Operational Definitions

Pathogens

Micro organisms which cause diseases to humans and Animals.

Harborage

Place where the bed bugs preferred to live

PPE

Personal protection equipment.

Active ingredient

Active content of pesticide in various formulation.

C. Cautions, Health and Safety Warnings

- Bed bugs are known to transmit about 40 pathogens to human beings and also cause bugs scars due to their bites. The pathogens include *Coxiella burnetii*, *Wolbachia* spp among bacteria, *Aspergillus* spp among Fungi, *T.cruzi* among parasites and hepatitis B virus (HBV) and human immunodeficiency virus (HIV).
- Bed bugs (Cimex lectularius) are small, oval shaped, wingless insects, about the size of apple seeds. They typically feed on a diet consisting solely of blood once a week, but they can live for months without feeding. They usually come out at night to feed on the blood of people and animals, biting their victims as they sleep.
- Some people however can have an allergic reaction to the bite, developing itchy welts. Scratching the bites can lead to infection.
- All insecticides are poisons. Read the entire label, including the small print before opening the containers and heed all warnings and cautions.

- Store pesticides in their original labeled containers out of reach of children, irresponsible people, and pets, and preferably keep under lock and key.
- Dispose of leftover spray materials and empty containers

D. Equipment and Supplies

- Heavy duty flash light,
- Hand Magnifying lens &
- Hand gloves.




- The following steps shall be followed:
- Carry heavy duty flash light, a mechanic mirror for inspection.
- Wear vinyl or latex gloves when you check for bedbugs.
- This can protect your hands from being bitten by live bed bugs and the gloves will prevent you from coming into contact with blood from smashed bed bugs

E. Procedural Steps

- The procedural steps include locating the bedbugs habitats, mapping their distribution in the premises/locality, initiating both chemical and non chemical methods.

i. Locating the Bedbug habitats

- Adult bed bugs are around $\frac{1}{4}$ inch (0.64 cm) long and they have 6 legs. A bed bug that›s recently fed on blood will be bright red and round. Once it digests the blood, it will turn a darker brown color and become flat. If the bed bug hasn›t fed in a while, it will be a pale brown color.
- Since bed bugs feed on blood, they can leave behind red or rusty stains if they get smashed.
- The color may be bright red if the bed bug was recently crushed or the stain may be dark if the bed bug was smashed a while ago.
- Inside furniture and upholstery


- Within pleats of curtains
- In corners of desks and dressers
- laundry or other items on the floor or around the room.

ii. Mapping of infestation spots

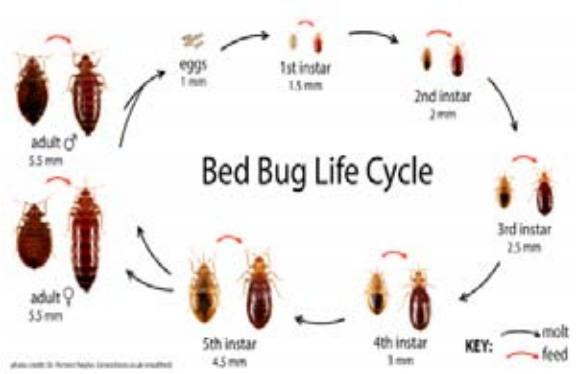
- After locating the bugs habitations, mapping needs to be done on the indoor and outdoor areas for customizing various insecticide application and other management efforts ensuring successful result with non target species safety and minimum number of treatments.
- Bed bug excrement will look like very small black spots (about this size: •).


iii. Know about the species

- Bed bugs seen in residential premises, schools, retail facilities, office buildings, libraries, trains, Aircrafts, ships and other public areas are about 3/16- inch long, oval, flat, and rusty-red or mahogany in color.
- The bed bug is flat and thin when unfed but becomes more elongate, plump, and red when it is full of blood.
- Four-segmented antennae are attached to the head between the prominent compound eyes.
- A three segmented beak, or proboscis, is located beneath the head and passes back between the front legs.
- The bed bug cannot fly as its wings are reduced to short wing pads.

- Female bed bug lays her eggs 200-500 within her lifetime.
- Eggs hatch in about seven days and the nymphs molt five times, taking a blood meal between each molt.
- Development time from egg to adult is 21 days.
- The adult can live for almost one year.
- The bed bug hides in cracks and crevices during the day, It leaves these harborage areas at night to feed on its host which include humans, birds, and family pets.
- The blood meal requires three to ten minutes and usually goes unnoticed by the victim.
- After feeding, the bite site may become inflamed and itch severely in sensitive people.

iv. Life Cycle



a. After mating, females lay white, oval eggs (1/16” long) into cracks and crevices.

b. An individual bed bug can lay 200 to 250 eggs in her lifetime.

c. The eggs hatch in 6 to 10 days and the newly emerged nymphs seek a blood meal. Egg produces small colorless nymph, having the general body appearance similar to that of adult.

d. Nymph undergoes a gradual metamorphosis through five instars, with a nymphal period of 35 – 45 days to became an adult. Nymph must have blood meal during each instars to moult to the next stage.

e. Immature nymphs molt five times (they shed their outer exoskeleton) before reaching adulthood.

f. After the final moult, both the sexes are fully mature then mating may take place.

g. Female should have blood meal before laying the eggs.

h. A male is capable of mating several females in a day.

i. There may be three or more generations per year. All ages are found in a reproducing population.

j. Both adult and Nymphs of bedbugs can survive longer period without food or under unfavorable conditions.

v. Management of Bed Bugs

Bed bug control can only be maintained through comprehensive treatment strategy that incorporates a variety of techniques and vigilant monitoring.

1. Sanitation measures

a. Remove the bedspread, comforter, or duvet and shake it out before you look for signs of bed bugs. Then carefully pull off the sheets and mattress protector. Go slowly so any bed bugs don't fly off of the sheets into the room. Dark blood spots on sheets and bedding may indicate bed bug feeding.

b. If you have a mattress protector that's designed to stop bed bug infestations, check the protector near any seams, zippers, or gaps.

c. Move furniture to the edge of the room so you can peel back rugs. Look for signs of bed bugs on the underside of the rug and on the floor itself.

2. Heat treatment

a. For hospitality industry in entire world, it was proved that 'Heat' is an effective method to kill bed bugs without any pesticide use and environmentally friendly method.

b. All hotels and Health industry (Hospitals) are vulnerable for bed bugs and commercially Colorado Tri-Fla systems are found to be effective generating heat, which can kill bed bugs (adults, larvae and eggs) up to 32 square meters effectively.

c. The specifications of each system are - One ER5000-I: 5000 watt heater, 17100 BTU's,

800 CFM; Two ER1800-I: 1800 watt heaters, 12300 BTU's, 400 CFM; Three fans: Total of 5160 CFM of airflow – model and colour may vary; Remote Temperature Monitoring System: Cellular-based, 5 sensors; One thermal IR camera – model and colour may vary compatible with any international 240-volt plug and CE Mark

3. Habitat Management

a. Use vacuum cleaner to remove some of the bugs.

b. Bed bugs can be controlled with thorough applications of residual insecticides applied to cracks and crevices, behind baseboards, and into other known or suspected harborage areas. Furniture, especially mattresses and box springs.

c. Should also be lightly sprayed. Used furniture, particularly bed frames and mattresses, are of greatest risk of harbouring bed bugs and their eggs.

d. Bed bugs cannot climb polished glasses or metal easily and they don't fly. In older stages can survive longer without feeding than younger ones.

e. Repair cracks in walls, seal bedroom windows and door frame gaps.

f. Hang personal items such as bags, briefcases and coats from a door knob or hook to keep them off of the floor.

g. Minimize the items you take into a potentially infested environment - take only what you need.

h. Protect all belongings that you take into an infested environment by putting them into sealable plastic containers or bags and placing them in the middle of the room.

i. Avoid contact with bedding material or furnishings in sleeping areas unless required, and don't sit on furniture with fabric or lean on walls.

j. Check wheelchairs or stretchers regularly for bed bugs.

k. Cover up your clothing when entering a potentially infested environment by wearing personal protective equipment (PPE) such as disposable gloves, shoe covers and coveralls, or as is appropriate for the work you are doing (i.e. handling potentially infested mattresses as opposed to going into a home to meet with a client).

l. Consider changing into work clothes and shoes when you get to work and removing them before you go home (when there is a risk of infestation). Keep your clothing items in sealed plastic containers or sealed plastic bags to avoid bed bug contact.

m. Inspect your shoe treads, clothing, cuffs, pockets collar and belongings after leaving your worksite or office for small black (fecal matter) or dark red (blood) stains, along with both live and dead bed bugs.

4. Chemical Management

a. Insecticide application/s should be complementary to above sanitation and habitat management measures but should not be exclusive.

b. Proper use of pesticides may be one component of strategy, but will not eliminate bed bugs alone.

c. Bed bugs have developed resistance to any commonly used pesticides.

d. Some products and application methods may actually make the problem worse.

e. In that case one must consult a qualified licensed IPM pest management professional upon the discovery of bed bugs.

f. The chemical treatment has to be repeated after 15 days once again for effective control of Bedbugs.

g. The following insecticides are recommended for bed bug management in India.

Active ingredient (a.i.)	Brand name	Formulation with recommended dosage
Imdacloprid 21%, Beta cyfluthrin 10.5% SC	Temprid	4 ml/1 ltr water
Lamda-cyhalothrin 10 WP	Icon/Sentry	WP (05 gms / 1 lt water)
Cyphenothrin 05% EC	Gokilaht 5 EC	EC Formulation (20 ml/1 Lt water
Deltamethrin 2.5% SC	K-Othrine	SC Formulation (10 ml/ 1 Lt. Water)
Propoxure 20% EC	Flycobait	EC Formulation (25 ml /1 Lt water)
RTU Aerosol		Targeted Crack-Crevices Treatment Only

5. Monitoring

a. Confirm that previous treatment was effective.

b. Remember to check fold out couches, bassinets and cribs for bed bugs

c. Need to tip the furniture over so you can examine underneath it.

d. Put policies and procedures in place for reporting of bed bug infestations (on-site and off-site workplaces).

e. If the desk or bedside table has hollow legs, unscrew them and inspect the inside of the legs.

f. Bed bugs can actually use electrical outlets to travel to other rooms. If you find bed bugs in 1 outlet, you must check the other rooms in your house or hotel.

g. If the rug is covering a wooden floor, check the tiny gaps between the floor planks for bed bugs.

h. Check cracks in the plaster or walls since bed bugs can also hide in these small spaces.

F. Data and Records Management

Forms and record keeping are essential part considering regulatory inspections and legal provisions.

Area inspected	Type of measure applied	Input type and quantity applied	Follow up observations 14th Day

Room Size, Heaters, Fans, Amperes Required for Heat Treatment

Number of 240-Volt Tri-Flo Heaters / Fans Required to Eradicate Bed Bugs									
Number of ER1800-I Heaters / Fans Required to Eradicate Bed Bugs									
Room Length (meters)	Room Width (meters)	Ceiling Height (meters)	Room Size (cubic meters)	Temp. Rise °C	BTU's required	Watts	Quantity ER1800-I	Quantity fans	Amps required
3	3	2.5	22.5	40	25,389	7,440	5	2	38
3	4	2.5	30	40	30,597	8,967	5	3	38
4	4	2.5	40	40	36,456	10,684	6	3	45
Number of ER5000-I Heaters / Fans Required to Eradicate Bed Bugs									
Room Length (meters)	Room Width (meters)	Ceiling Height (meters)	Room Size (cubic meters)	Temp. Rise °C	BTU's required	Watts	Quantity ER5000-I	Quantity fans	Amps required
4	5	2.5	50	40	42,315	12,401	3	4	63
4	5	3	60	40	48,174	14,118	3	4	63
5	6	2.5	75	40	55,335	16,217	4	4	84
5	6	3	90	40	62,496	18,315	4	5	84
Combination of Tri-Flo Heaters / Fans Required to Eradicate Bed Bugs									
Room Length (meters)	Room Width (meters)	Ceiling Height (meters)	Room Size (cubic meters)	Temp. Rise °C	BTU's required	Watts	Quantity **Combined**	Quantity fans	Amps required
3	3	2.5	22.5	40	25,389	7,440	1 ER5000 2 ER1800	2	36
3	4	2.5	30	40	30,597	8,967	1 ER5000 2 ER1800	3	36
4	4	2.5	40	40	36,456	10,684	2 ER5000	4	42
4	4	2.5	40	40	36,456	10,684	1 ER5000 3 ER1800	4	44
5	6	2.5	75	40	55,335	16,217	2 ER5000 3 ER1800	4	65
5	6	3	90	40	62,496	18,315	2 ER5000 4 ER1800	5	72
6	7	2.5	105	40	69,657	20,414	3 ER5000 3 ER1800	5	86
6	7	3	126	40	78,120	22,894	4 ER5000 2 ER1800	5	99

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H. Attachments/Checklists

Checklist (check mark for completed tasks) – for each pest it needs to be

i. Date and time of visit

ii. Verified/inspected the areas as below:

iii. Xx

iv. Xx

Applied following measures for management:

CHECKLIST BED BUGS				
Name of the Client :	Frequency :			
Pests Covered : BEDBUG	Month:			
			Chemical used and Dilution:	
S.No	**Date**		**Date**	
	Area	**Checked By**	**verified By**	**Remarks**
1				
2				
3				
4				
5				
6				
7				

Technician Name &
Authorized By
Client Remarks
Technician Remarks

Chapter - 10

Survey and Diagnosis of Rodent Pest/Vector Species of Economic Importance in Human Habitations and Planning Processes in their Management

Dr. A.M.K. Mohan Rao

CHAPTER CONTENTS

Dr. A.M.K.Mohan Rao

Dr. A.M.K.Mohan Rao is a Globally recognized rodent ecologist having worked on their management from 1974 integrating ecological principles in to management practices. He was Former Joint Director, Vertebrate Pest Management, National Institute of Plant Health Management, Ministry of Agriculture and Farmers Welfare, and currently assisting Government of India institutions - MANAGE and NIRD in developing skill based training programs and curricula in Pest/Vector Management in Human Habitations. Member In Editorial board of world renowned Elsevier group of publications. Guided research theses in vertebrate ecology and management. Served as Member Secretary in Scientific Advisory Committee on Rodenticides, CIB&RC, and Expert Committee on Rodent Control, Govt of India. He is a Member, Species Survival Committee, IUCN, Switzerland and Member, Vector Control Working Group for Asia and Pacific, Geneva. Senior International Consultant for FAO of United Nations assisting the Global body on rodent management in various countries and bagged FAO's prestigious Edouard Saouma Award in 2003 for TCP in PR China. Represented India at International fora.

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Survey and Diagnosis of Rodent Pest/Vector Species of Economic Importance in Human Habitations and Planning Processes in their Management

A. Purpose And Applicability

The purpose of this Simple Operation Procedure (SOP) is to inspect the premises of residences and establishments for the presence of rodents, diagnose the species present in the habitations, to inspect the premises/public places to assess their infestation rate, distribution, damage symptoms, and to monitor their incidence at periodic intervals. The procedures outlined in this SOP are applicable to all premises/establishments covering residential, municipal and industrial facilities.

B. Definitions

i. Rodents

Rodents are smaller mammals with a habit of gnawing the food and non food items to arrest their incisor growth (@0.4 mm/day normally).

ii. House rats

The rats with black dorsal colour and longer tails are House rats, which are also called roof rats.

iii. House mice

The rodents of smaller size of about 25 g seen often in houses and food storage/outlet areas are House mice with faster breeding and nibbling habits.

iv. Lesser bandicoots

Moderate body weight rodents with rough dorsal hair invading the exteriors of establishments and premises, living in burrows dug by them are lesser bandicoots.

v. Larger bandicoots

Rodents with larger body weight (500 g or more) often causing damage to the flooring and digging very big burrows in open areas viz., roads, drain canals, poultries etc.

vi. Rodent burrows

Some rodents have habit of digging holes in the soil for their inhabitance and called as burrows.

vii. Tracking and tracks

Rodents travel in specific pathways inside the premises as well as in open areas leaving the

signs of their pathways. These are tracks, which can be used for their infestation assessment.

viii. Trapping index

In order to know the rodent infestation, traps are set on their runways and average of their capture per trap is worked out, called as trapping index.

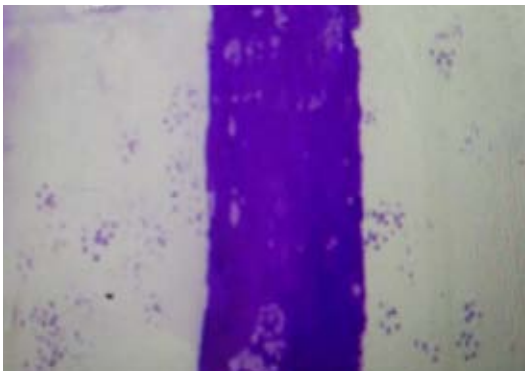
C. Cautions, Health And Safety Warnings

- It is also important to note safety considerations such as the location of pet animals and presence of small children.
- Take adequate care for personnel safety – While checking for the habitats and burrows of the rodents in the infested areas.
- According to the World Health Organization (WHO), they are proven or suspected carriers of various zoonotic diseases directly or through arthropod ectoparasite bites viz., plague, enteric infections, leptospirosis, salmonellosis and Hanta/Arena viral diseases.
- Rodents can spread diseases, contaminate the food and can cause allergies and even asthma.
- Handle the snap and other types of traps with care during infestation measurement.

D. Equipment and Supplies

The equipment required to inspect the premises need sampling through trapping and tracking.

The traps are spring based snap traps or multiple catch rat traps.



Choose Vinyl tiles measuring 30X15 cm as tracking tiles.

- Treat with different locally available washable tracking materials like rangoli or stamp pad ink in middle of the tile,
- Which leaves clear foot prints (as in the picture) once rodent passes through the tile as in the picture.

E. PROCEDURAL STEPS

1. Survey of human habitations

The first action is survey of the affected area/premises. Rodents in human habitations are commensal sharing the human shelters and food. As on now specific operation procedures are not existing urban environs. Urban rodent surveys would indicate information on spread and level of rodent infestations and factors for environmental health deficiencies that support commensal rodent populations in housing and on premises.

Opening of Larger bandicoot in a public place

Burrow complex of Lesser bandicoots in a public place

Such surveys should include premises of residential, commercial, and civic buildings; vacant lots; and public areas. Surveys inside the premises should include within premises on signs of rodent movement and infestation. Burrow complexes of Lesser bandicoot at a public place are shown in the figure. One can see the presence of chain of rodent burrows in urban environs, each opening representing presence of one adult bandicoot. This indicates the infestation rate of these bandicoots as per "Burrow count" method of assessment of rodent infestation in a unit area.

2. Inspection of Premises/storage situations

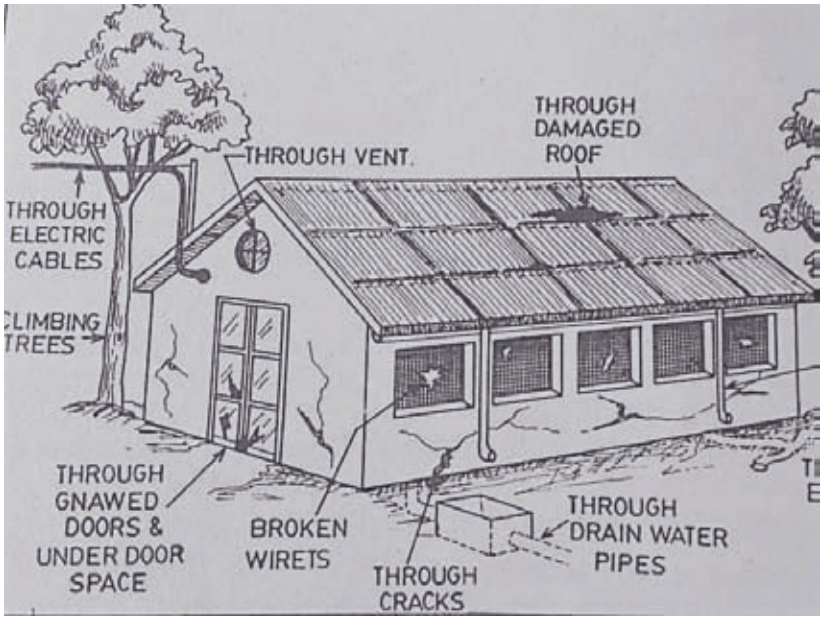
Inspection of the public areas as well as residential premises for rodent infestation is to be performed as a first step. The procedure of the inspection in public places could be done as above. Following are the steps for inspection of premises in an area:

1. Observe the following around the premises and mark them on the layout of the area.

- *Rodent burrows*
- *Drainage canals*
- *Holes at the base of compound wall*
- *Garbage dumps*

2. Observe the following on the building/premises and mark them:

- *Branches of trees overhung on the premises*
- *Wires from poles to the premises*
- *Holes in the walls*
- *Drainage pipes*



3. Observe for rodent "signs" inside the premises, room wise and mark them.

- *Faecal pellets adjoining walls or corners*
- *Rat holes, if any, active/inactive*
- *Rat/mouse paw markings*
- *Rat runways*
- *Rat smears on beams, wiring etc.*
- *Base of the doors for space*
- *Windows/ventilators connecting any wiring or on roof*
- *Drainage*

Special care should be taken while inspecting storage areas. Based on the layout marked the following actions may be initiated based on the severity/intensity of the problem.

3. Infestation levels in premises

Two methods could be followed for measuring rate of infestation.

3.1. Burrow count

As elucidated above, burrow count method in a unit area could be used for measuring Bandicoot infestations before and after control measures to arrive at rodent control success. The background of it is – Lesser/Smaller bandicoots are solitary in living and hence each active burrow (fresh scooped soil before the opening) indicates presence of one adult bandicoot. This gives a rough infestation level of them in open areas and around building complexes.

3.2. Tracking index

- House rats and mice will not make any burrows and live inside the rooms. Tracking tiles are solution in such cases. A tracking tile is venyl plate/sheet of about 30 X 15 cm. (as in Fig above) and needs to be kept on rodent runways aligning the walls.
- Before placement of the tracking tile, apply 2 cm patch of Rangoli or Stamp pad ink on the surface as in the Fig.
- Observe next day morning for the rodent foot prints on these tiles (as in the picture) since rodents roam freely on their regular pathways.
- The number of tracking tiles with foot prints are considered as positive and without foot prints was considered as negative.
- The data on positive and negative tiles was recorded daily in the morning continuously for 5 days. Calculate the tracking index using below formula:

$$\text{Tracking Index (T.I.) \%} = \frac{\text{No. of tracks touched by rodents}}{\text{No. of tracks laid}} \times 100$$

- Basing on the tracking index values the rodent incidence is classified as mentioned below

Tracking Index Vs rodent infestation

Tracking index	Rodent infestation level
<30%	Low
30-60%	Medium
>60%	High

3.3. Planning for Urban Metropolitan Cities

Metro cities afford ideal situation for rodent survival due to apartment complexes, uncleared garbage in public places and non treatment in sewage/drainage systems. Such planning resulted in deratization in Budapest, Capital city of Hungary for 33 years.

i. Drainage systems are ideal rodent movement routes and areas of higher rodent populations because of undisturbed condition, stable climate, year round breeding without climatic fluctuations with minimum or no threat from predation.

ii. Re-infestations occur from sewage or drainage systems often since rodent control measures are often undertaken 'above ground areas' only. The underground drainage systems serve as reservoirs for rat population, adopt simultaneous rodent control measures at above ground and underground systems.

iii. In order to have long term impact of rodent control, adopt following steps:

1. Develop special code system related to Macro habitats or larger complexes

2. Identify distinct smaller or Micro habitats within the Macro habitats which are different from each other.

3. Determination of rat infestation levels in public places through -

- Observe live rat movements
- Observe gnawing traces and fecal pellets
- Rodent burrows
- Observe foot prints and movement tracks
- Observe consumption of non poisoned baits
- Information from inhabitants

iv. Assess building related and unrelated rodent occurrence

- Observe sewage system within the building
- Observe public sewage system not belonging to buildings
- Building unrelated occurrence in other areas

v. Make strategy and management planning based on this data.

4. Identification and characteristics of rodent pest/vector species

It is essential to identify the type of rodent pests/vector present in urban habitations to make ecological planning for their management.

- Rodents attained their name due to their gnawing habits of a pair of incisors they possess. They have perennial growth at 0.4 mm per day and unless that growth is checked, the individual will meet its death with the growing incisor (as in figure).
- Four rodent species are frequented in human habitations. Their habitats, characterstics and morphological features are as under:

4.1. Norway rat (Rattus norvegicus)

- Seen in coastal port towns.
- Norway rat of Brown rat or Sewer rat is coastal port dwelling rodent.
- It is moderate in size around 120 g. body weight.
- It has blunt nose with shorter tail than head and body.
- It is night time active (nocturnal) making burrows in and around drainage channals.
- Digs extensive burrow systems along foundation of buildings, under concrete or near rubbish piles.
- Breeds all through the year with annual productivity of 25.1 young ones/female.
- Prolific breeder and vector transmitting diseases like Leptospirosis signifying its periodic survey (surveillance) to plan remedial measures.

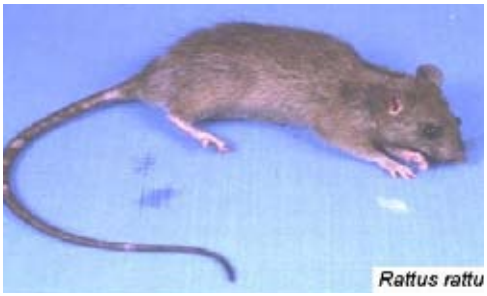
Norway or Sewer rat (Rattus norvegicus)

Makes burrows on sewers

4.2. The House Rat (Rattus rattus)

- The commonly occurring House rat or Black rat, Roof rat, or Ship rat is moderate (80-120 g.) burrowing rodent with short, bicolour and ringed tail that is longer than head and body length.
- The tail is longer than head and body adopted for climbing on roofs.
- It is nocturnal with its activity confined to night hours.
- It is a non burrowing rodent and move through holes present in the urban habitats.

- Breeds throughout the year and have the annual productivity of 46.6 young ones/ female.



Points of House rat entry in premises

4.3. House mouse (*Mus musculus*)

- Most commonly seen tiny rodent (20 g.) with bicolour tail longer than head and body.
- They infest indoors i.e. houses, backyards, gardens, godowns, and grain warehouses.
- They nibble sacks and feed on great variety of foods in houses and commercial establishments; thus they have also nuisance value.
- They make smaller burrows inside the warehouses and can be seen on closer observation.
- They are active in night time.
- Breed throughout the year with shorter maturity period (45 days) with annual productivity is 31 young ones/female.

4.4. L*esser Bandicoot Rat (Bandicota bengalensis)*

- Moderate sized rodent (around 150 to 300 g. body weight) with short tail.
- It has coarse hair on the body, sometimes with long black tipped piles throughout the dorsal surface.
- Adopted to live in crop fields as well as in human habitations.
- They are active in night time.
- They dig burrows aligning to residential complexes, public places like parks, vacant lands etc and keep scooped soil before the entrance (as in picture below).
- It breeds throughout the year, litters 9 to 11 times a year producing about 70 young ones per annum.

Lesser bandicoot (Bandicota bengalensis)

Burrows of Lesser bandicoot

4.5. Larger Bandicoot Rat (Bandicota indica)

- Very large rat of above 1 kg body weight with short tail than head and body.
- Commonly can be seen in neglected public spaces, poultry/dairy sheds and larger burrow openings.
- Cause extensive damage in storage and to flooring in habitations.
- It is a seasonal breeder (October to April) with a maturity period of 160 days and annual productivity of 20 youngones per female.

5. Preparation of Action Plan

- Rodent management planning in urban local bodies need (a) strategy planning followed by (b) Management planning. Quite often strategy planning is taken as total planning leading to failure.
- Fix long term objective
- Prepare strategy plan identifying major approaches of management
- Then workout the management planning based on each strategy.
- Management

After a survey of urban environs is made in public places and premises and identifying the major rodent species infested, the next step is preparing a plan of action.

(i) Fixing long term objective

- Prepare an ideal long-term objective towards which a programme can strive.
- However, there can be practical short-term objectives attainable within a reasonable period of time and definable in measurable terms
- Monitoring should be an integral part through which plan can be changed, if needed.

(ii) Action to implement the programme

- The approach should be based on deratization should be based on the principle that control in the above ground premises and in the underground sewer should be performed simultaneously.
- This takes priority while dealing with rodent control in major metropolitan cities in India.
- Collection of planning information should be based on the planning information already collected in relation to a series of questions as follows:

1. Detection of need for control

(a) What methods are currently being used to detect the need for control?

(b) What detection methods should be used?

(c) What action is needed to improve the existing methods and to introduce new methods

2. Control technology

(a) What control methods are currently being used?

(b) What control methods are needed to be used?

(c) What action is needed to introduce new and improved techniques?

3. Resources

(a) What resources in terms of numbers and different types of personnel, equipment, materials and finances are currently being used?

(b) What resources are further needed?

(c) What action is needed to modify old resources and obtain new resources?

4. Human social attitudes

(a) What social attitudes of man are currently affecting rodent control?

(b) What attitudes are needed?

(c) What action is needed to adjust the available technology to existing attitudes or to modify attitudes beneficially?

6. Micro-level Planning

The steps that need attention on proper planning in unit areas are indicated below:

Step I: Situation Analysis

- Species of the area
- Position of infestation
- Condition of surrounding areas
- General lay out and situation of cropping season
- Decision on control

While making situation analysis the available resources, control technology and human attitudes are to be precisely judged.

Step 2: Control Design

- Type of control
- Hygiene
- Proofing
- Chemicals/natural products to be used
- Area to be controlled
- Time of control
- Staff requirement, people to be involved etc.

Step 3: Control Preparation

- Make a plan of action
- Inform people involved for community participation
- Obtain equipment required
- Fix dates for various phases of control action
- Prepare rodenticide baits if necessary

Step 4: Rodent control

- Carry out control activity

Step 5: Monitoring

- All planned actions need monitoring for amending, if need arises to conform to the original plan.
- This situation may require a amending in the original plan.
- Check signs of activity

- Note areas which require further action
- Decide on further action and type of action
- Continue monitoring

Step 6: Maintaining low rodent population density

- ♦ Complete management actions before on set of monsoon
- ♦ They start breeding with onset of the monsoon and post monsoon months and rodent population reaches peak quickly and it becomes difficult to control them.
- ♦ Use acute poison like zinc phosphide, aluminium phosphide in case of serious rodent infestations only. Legal provisions need to be considered while planning aluminium phosphide fumigation.
- ♦ Use anticoagulants or other structural modification or environmental sanitation (for prevention) during low rodent density situations.
- ♦ Integrating these three measures, viz., application of chemical inputs with structural modifications and clean premises/public places, can bring maximum reduction of rodent populations.
- ♦ Use bait stations wherever feasible considering their safety.

6. Timelines for implementation of the Plan

- Conduct monthly surveys in all urban habitations like parks, open areas, drains, canals, roads, garbage dumps, office complexes.
- The periodicity can also be decided based on the local situations.
- However, summer months are desirable since low rodent infestation would be there at that time.
- Further, on monsoon entry, bacterial diseases can flare up, and hence summer months need to be targeted for rodent vector control.

F. Data and Records Management

Forms and record keeping are essential part considering regulatory inspections and legal provisions.

1. Identification of hotspots in the urban area with monitoring plan

Rodent species existing	Endemic areas	Monitoring plan

2. Monthly rodent infestation observations as a monitoring tool

Month	Infestation rate (burrows in unit area)	Infestatioin level (Low/Moderate/High

Upto 25 burrows per hectare is Low

Between 25 to 50 burrows per hectare is Moderate

Above 50 burrows is High

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WHO 1974. Ecology and control of rodents of public health importance: Report of a WHO Scientific group. WHO Technical Report Series 553, Geneva, 1-42.

H. Attachments/Checklists

Equipment List with specifications

1.

2.

3.

4.

Checklist (check mark for completed tasks) – for each pest it needs to be

1. Date and time of visit
2. Inspected and applied following measures for management:

Date and Time of visit	Area visited with vulnerability	Major rodent species	Level of infestation, History and Remarks

Chapter - 11

Extension Strategies on Management of Rodent Pests/Vectors in Urban Habitations

Dr. A.M.K. Mohan Rao

CHAPTER CONTENTS

Dr. A.M.K.Mohan Rao

Dr. A.M.K.Mohan Rao is a Globally recognized rodent ecologist having worked on their management from 1974 integrating ecological principles in to management practices. He was Former Joint Director, Vertebrate Pest Management, National Institute of Plant Health Management, Ministry of Agriculture and Farmers Welfare, and currently assisting Government of India institutions - MANAGE and NIRD in developing skill based training programs and curricula in Pest/Vector Management in Human Habitations. Member In Editorial board of world renowned Elsevier group of publications. Guided research theses in vertebrate ecology and management. Served as Member Secretary in Scientific Advisory Committee on Rodenticides, CIB&RC, and Expert Committee on Rodent Control, Govt of India. He is a Member, Species Survival Committee, IUCN, Switzerland and Member, Vector Control Working Group for Asia and Pacific, Geneva. Senior International Consultant for FAO of United Nations assisting the Global body on rodent management in various countries and bagged FAO's prestigious Edouard Saouma Award in 2003 for TCP in PR China. Represented India at International fora.

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Extension Strategies on Management of Rodent Pests/Vectors in Urban Habitations

A. Purpose And Applicability

The purpose of this Simple Operation Procedure (SOP) is to make strategy planning followed by planning management actions with respect to rodent pests/vectors in the urban situations and to monitor their incidence at periodic intervals. This include rodent control in public places, different establishments and premises of residences ensuring public safety. The procedures outlined in this SOP are applicable to all urban areas as well as urbanizing/ industrializing rural areas.

B. Operational Definitions

i. Rodent management

Managing rats and mice to below tolerable levels using different control methods, viz., preventive, curative, environmental sanitation etc.

ii. Environmental sanitation

Keeping the residential blocks, premises, structures and public areas clean without garbage to discourage rats and mice inhabitable with low reproductive rates.

iii. Trapping techniques

Methods of trapping (setting and disposal of trapped rats and mice) rats using either live traps or kill-type traps.

iv. Rodenticide baits

Poison carrier material for rat and mouse control

v. Baiting techniques

Methods of applying various baits for the rats and mice making them to eat more poison carrier material

vi. Biological control

Using predators like cats and raptors like owlets to kill the rodents in human habitations

vii. Infestation monitoring

Periodic inspection of premises and human habitations for the presence of rats, mice and bandicoots after rodent management operations

viii. Tracking and tracks

A method often used to check the presence of rats and mice in human habitations spreading fine inert dusts (rangoli) on rodent runways.

ix. Trapping index

An index of presence of rats and mice through trapping before and after control operations to measure the control success.

C. Cautions, Health and Safety Warnings

- Keep warning sign boards in areas assigned for rodenticide baiting treatments.
- Note safety considerations such as the location of pet animals and presence of small children.
- Take adequate care for personnel safety while –
    i. preparing and handling chemical baits.
    ii. checking the habitats and burrows of the rodents in the infested areas.
- While organizing community based rodent control campaigns, antidotes be kept in reserve to attend any unexpected eventualities.
- Handle the snap and other types of traps, bait stations with care during rodent control measures.
- Precautions while using rodenticide baits:
- Know-how of the operation should be told to the public always in local language followed by demonstrations by departments concerned.
- Baits should always be placed late in the evening, as most of the rodents are active during night.
- Keep poisons away from the reach of children, pet animals, drugs and food.
- Smoking, eating and drinking should be totally avoided while handling the poison.
- Containers of the poisons should be opened in a well-ventilated room. Unused baits, containers and dead rodents should be buried deep.
- Clean the hands, eyes and nose thoroughly after preparation of baits as well as after distributing the poison baits.
- Ensure that the antidotes of poisons are available with the doctor for use in case of any accidental ingestion of poison.
- Acute poison bait is generally better accepted and an improved kill obtained by laying prebait for a few days before hand. The bait laid should be the same as that used later in the poison treatment.
- Acute poison baits should not be exposed for more than one day.

D. Equipment and Supplies

- The equipment required for rodent control include traps, bait stations.
- The supplies include the inputs viz., baits, vegetable oils (rodenticide binding media), rodenticides etc.

E. Procedural Steps

1. Acquire basic knowledge

- Generally, public consider rodent management as physical killing, which is not true.
- It is manipulating their behaviour to avoid them as problematic in the environs for commodity loss or transmission of diseases to humans and livestock including poultry.
- Following reasons could be assigned for it
- Flexible skeletal framework,
- Breeding propensity switching from normal breeding to fast breeding,
- Behavioural adaptations like exploration, new object reaction, nocturnality, fossoriality, resistance to rodenticides etc.
- Hence, acquire good knowledge on their behaviour, feeding range and reproductive profiles.

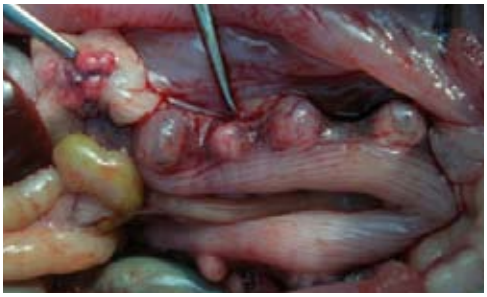
2. Understand basic principles

- look at difference between urban v/s in-house/premise management,
- fix sound objective with assessment feedback. Number of dead rodents are not criterion for measuring the success,
- reduce gap between knowledge and practice,
- plan sustaining measures based on premises/area inspection
- consider presence of non target species safety in the vicinities,
- Adopt legal measures firmly
- Create awareness among clients, public and professionals and
- plan and coordinate with technical teams as well as area residents.

3. Prevention of reproduction bouncing

Rodents exhibit two types of reproductive features based on habitat sustenance.

- In a stable or seasonally predictable environment will have limited population (stable or *k-selected)* due to the limited availability of food and other resources.
- The growth is logistic with litter sizes between 6 to 8 youngones per female (as in figure) due to constant availability of food, water, and harbourage.
- The population size depends on density dependent factors such as competition for food or nesting sites.



However, when more food and harbourage become available (through uncleared garbage and killing part population), the residual rodent poulation bounces produce more young ones irrupting the population or *r selected* with a slow start and *accelerating to* a litter size of up to 20 youngones per female (as in figure). Environmental events like flash floods also lead to similar results. Hence, while planning this major aspect of reproductive bouncing needs to be considered.

4. Interventions for Rodent Management

Recent interventions opened up new methods of application, newer approaches and rationality.

4.1. Regular garbage collection and disposal

- Collect on daily basis the garbage in garbage bins (unlike in figure below) from residential premises and commercial complexes
- Make citizens to use garbage collection bins as below:
- Dispose of the daily collected garbage.

Trash collection Bin

Thrown over trash attracting which attract rats and mice

Trash collection vehicle for regular disposal

4.2. Rodent entry prevention and Rodent-proofing

- First step in rodent management is preventing their entry into premises through rodent proofing.
- It deprives their regular food and water spots.
- Rodent-proofing also improves acceptance of baits as the area for rodent movement is reduced.



- The rodent-proofing is achieved by inspection of premises.
- Observe the normal entry points for rats to enter in premises.
- Watch the kitchen areas, which are normal movement points for rats and mice



Examine the following -

- Perimeters of the structure such as the four walls and the roof and floor;
- Doors and windows;
- Utility pipes, drains, manholes and conduits connecting the structure to public services;
- Electric conduits, wires, cables, AC ducts
- Gardens/lawns/compound walls for burrows and
- Adjoining structures, trees and paths as access ways.

Adopt following Rodent-proofing measures

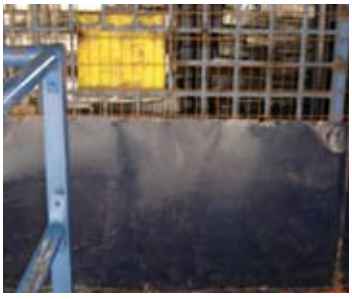
- Based on premises inspection, rodent proofing is done using any appropriate construction material, such as cement, metal sheets, metal mesh and sealants.
- Avoid wood and plastic as far as possible since rodents can chew through these materials and will gain access over time.
- Galvanized sheet metal, 24 gauge or heavier, is recommended for most general use.
- Cement patching powder is similar to cement. Most brands harden in less than 4 h and provide good to moderate rodent exclusion.
- Epoxy and fibre glass resins can be used as hole-filling materials. Many formulations harden quickly and are very durable, weather resistant and rodent proof.
- Butyl caulking with rubber-based **caulk** achieving durable, long-lasting seals between all types of masonry, steel, glass and other materials up to 2 cm wide and 1 cm deep.

Proper closure of gutter pipes

Removing gaps on door joints

Door without any gaps

Metal grill for Prevention



Metal sheet at base for Prevention

Rat guard on the beams to prevent House rat movement

4.3. Use of traps to tackle urban rodent infestations

Various types of traps are available in market to tackle urban rodents, viz., non-poisonous sticky traps, kill type snap traps and live traps (wonder traps).

4.3.1. Non poisonous sticky (Glue) Boards

- These are 'ready-to-use glue boards' with the boards coated with poly butane (sticky substance) to remove local infestations.
- Their usage is discouraged by Ministry of Environment and Forests on humane aspects.
- They will not be affective in public places due to dust or moisture.
- Check these traps frequently and dispose of rodents humanely.

None poisonous sticky trap

Snap (kill type) trap

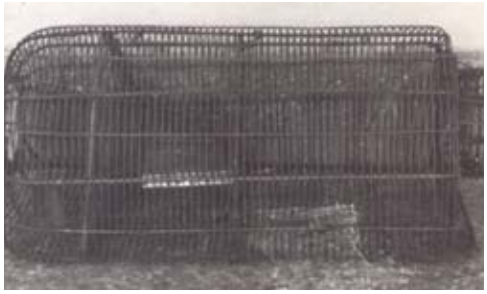
4.3.2. Snap (kill) traps

- Snap traps in various types and sizes are available in market.
- They are effective in killing rodents at low infestation levels.
- Set the traps on rodent runways during their activity period i.e., night time.
- Remove the dead rodent at the earliest from the trap.
- Clean the traps with water once a rodent is trapped.

4.3.3. Cage (live) traps

- Use these traps to trap rats and mice in isolated and low-level infestation situations.
- Don't release the trapped rats outside the premises, which makes them to reach back.
- Wash them thoroughly before next use to remove any warning pheromone deposited on the trap.

Single catch rat trap



Multiple catch snap trap

4.4. Poison baiting

Use of rodenticides is common practice in local bodies as well as in premises. Although seven rodenticides are registered under the Insecticides Act, 1976, only zinc phosphide and bromadiolone are available in market. Aluminium phosphide is available with restricted legal provisions.

4.4.1. Rodenticides

Zinc phosphide

- It is an acute inorganic rodenticide.
- It is recommended for use at 2% in cereal baits using vegetable oil as binding medium.
- These baits release phosphine gas in the acidic medium of stomachs of rodents on eating the baits.
- It detoxifies rapidly in dead rats and baits and thus is relatively safer for use and economical.
- It gives an overall rodent control success of about 60%.
- It has no effective antidote.
- It is recommended to be used in open urban areas like parks, rail tracks etc.
- Extreme care needs to be taken to safeguard non-target species like dogs, cats in the habitations.

Bromadiolone

- It is a second generation anticoagulant
- It is recommended under IPM packages for rodent control in storage/domestic premises.
- It is used in cereal bait formulation with wax coating at 0.005% a.i., (ready-to-use formulation) and applied inside closed containers (bait stations) or applied inside burrows @ one piece/burrow.

- Bait shyness does not exist with this chemical
- Repeat application might be required based on residual rodent infestation.
- Aluminium phosphide
- It is a burrow fumigant can be used in public places and around the premises for effective control of burrow dwelling rodents i.e., bandicoots.
- Due to easy handling, application and immediate kill of the rats inside the burrows, the fumigant is preferred, in spite of lethal toxicity in accidental handling.
- The burrow fumigation inside the premises must be avoided due to hazard of accidental poisoning.

4.4.2. Bait delivary methods

The method of application of baits depend on the situation – open areas in the urban areas or inside the premises of various establishments as given below:

4.4.2.1. Open/Public areas

Packeting and Pocketing

i. Prepare the poison bait (bromadiolone 'C' at 0.005% a.i.) using bait base like broken grain adding binding medium – vegetable oil. Make them in to small packets of 20 g. using news papers.

Preparation of anticoagulant poison bait with broken grain at a community point

Placement of the bait deep inside individual rodent burrow in a public area

ii. Place each packet 3 cm. deep inside each active rodent burrow. This will prevent any accidental poisoning.

iii. Examine for residual rodent infestation, if any, after a fortnight.

iv. Treat the reopened burrows.

Permanent bait stations

Permanent bait station made of cement on rodent runway

i. Construct permanent bait stations made of cement structures should be constructed in public places like parks, shopping malls, drainage canals, road side culverts etc. The bottom opening should be only 3 cm. such small opening prevent entry of granivorous birds and other non target species.

ii. They afford protection to non target animals and children.

iii. Prepare the anticoagulant baits as in above step.

iv. Place 100 g of the bait inside the bait station from the top hole and keep a lid to it.

v. Examine these permanent bait stations once in 15 days and replenish the anticoagulant bait on complete consumption.

4.4.2.2. Inside the structures/Habitatiions/Shopping malls/Eateries etc.

Step 1. Select the rooms where infestation is reported.

Step 2. Fix 10 tracking points using fine powder at 10 x 10 cm.

on the runways of rodents or at the areas frequented by them.

Step 3. Observe the 10 tracks next day for rodent activity.

Step 4. Prepare Bromadiolone bais (0.005% a.i.) baits with broken cereal grain using vegetable oil as binding medium.

Step 5. The poison bait (about 100g.)

should be placed in suitable bait stations (discarded earthen pots, hollow bamboo shoot, metallic bait stations etc.) @ 2-5 bait stations in the premises based on level of infestation.

Simple mud made bait station

Metallic durable bait station

Bamboo shoot bait station

The poison bait should be maintained for 5-7 days with replenishment if required. Bromadiolone may also be used at 0.005% a.i. in baits distributed at number of places preferably in bait containers/stations.

Step 6. Repeat step 2 on 15th day.

Step 7. Observe the tracking points for rodent activity.

Step 8. Calculate the control success.

$$\text{Control success (\%)} = \frac{A - B}{A} \times 100$$

Where 'A' is pre-control infestation (per cent tracks touched) level and 'B' is post-control infestation level.

Note: Keep vitamin K_1 as stand by for meeting any exigency of accidental poisoning.

4.4.3. Integration of various methods

- Integrated Pest Management is a planned incorporation of various control methods into a pest management program.
- It requires understanding of pest biology, ecology and behaviour
- It also needs knowledge on buildings and structures, functioning of the structure, the occupants' life styles, landscaping work and types of intervention methods available.
- The perception that higher investments of money and time for IPM adoption made the end users to prefer conventional pest control.
- IPM exhibited cost effectiveness than conventional treatments on long term use.
- These studies have proven IPM to be viable, workable, ecological and profitable to pest control practitioners.
- Overall IPM was proven to be sustainable.

4.4.4. Quick action points for urban rodent management

i. *Seal the entry points* - Rodents tend to enter the premises where entrances aren't closely guarded. Look around basements and the foundations to check for any holes or cracks that provide access for rat/bandicoot entry. Foam or wire mesh barriers can be used to block the potential rodent entranceways on the foundation.

ii. *Check the roofs of public buildings* - A break or gap in the roof could be an entrance for rodents. Repairs should be made to fill in any gaps located while inspecting the roof.

iii. *Smart storage* - Don't leave any bags or containers containing food items open. Heavy-duty plastic or metal containers with sealed lids work best. Besides, store potential foods in similar containers.

iv. *Rodent guards* - Metal pipes or wire lines that run into the home from the exterior can be problematic facilitating rodent entry. Rodent guards are typically constructed out of plastic or metal and fit over the end of the pipe to prevent rodents from their entry inside. They are typically easy to install and are an inexpensive rodent prevention tool. Purchase the guards online or at any hardware store.

v. *Garbage/Trash cans* - The garbage can be a feast for non target animals like dogs, cats and will attract rats and bandicoots to the premises. The trash cans should be made from heavy-duty materials and have no damage like holes or cracks. Use lids with all your trashcans and make sure the lids fit tightly.

vi. *Maintain clean environs* - Always cleaning up potential food sources for rodents is a solid technique to prevent rodent invasions. Cooking utensils and dishes should be washed soon after they've been used. If you have an outdoor cooking area, it is especially important not to leave food or beverages outdoors. Grills should be cleaned regularly along with any barbecue cooking tools.

4.4.5. Recommended actions in Urban Rodent Pest Management

In view of the above and due to ever increasing reports on rodent related problems, there is need to think the problem in a wise and reasonable way as below:

i. Both consumers and implementing agencies are largely unaware of the gap between knowledge and practice. In order to reduce this gap, practical based capacity enhancement and consumer to consumer interaction programs are needed to the pest management professionals. Similarly, consumer awareness could be brought out through an 'assigned day' every year with exposure activities to general residents. Earlier India was having *Rat control week* every year in 1980s. Activity like "Rat Summit" as hosted New York corporation to the residents could be considered.

ii. Rodent-proofing is a proven and long lasting method over other methods such as traps, baits and poisoning, which are labour-intensive, messy and, at times, dangerous. Hence, priority exists to encourage such measures after proper inspection.

iii. The Professional Pest Management bodies, which serve as the public outreach arm needs to be encouraged and spread awareness about the health and property threats posed by rodents as being done by National Pest Management Association (NPMA) of USA.

iv. Piloting with different integrated techniques of rodent management in selected blocks should be done before initiating large scale measures to tackle a larger level population.

v. Legal framework needs to be strengthened and enforced to ensure effective practices for the control and prevention of rodents in human habitations. At the same time, regulatory powers for overseeing these programs also are essential. Although sanitation is improved due to Swaschh Bhaarat initiative, absence of rat control in municipal areas made Larger bandicoots to invade.

4.4.6. Audit for rodent incidence

Audit of Establishments dealing with Food/Pharma Products – items needs to be checked by Auditors include -

Date of the Statement: Supervisor of the visit:

S.No.	Observation	Enclosure Nos	Remarks
i.	There is a rodent control program at the facility		
ii.	The staff involved are appropriately qualified		
iii.	There are no rodent infestations present		
iv.	A comprehensive monitoring program is in place		
v.	Monitoring data are collected and analysed		
vi.	Appropriate rodent control is applied when necessary		
vii.	Risks from rodents and control measures are minimized		
viii.	The overall strategy is reviewed regularly.		

5. Timelines for implementation of the Plan

- Conduct monthly surveys to monitor the pest and vector situation in urban habitations of all public places viz., parks, open areas, drains, canals, roads, garbage dumps, office complexes.
- However, the periodicity can be decided based on the local situations. For rodent control operations summer months are desirable since low rodent infestation would be there at that time and rainfall flares up of bacterial diseases through flood waters.

6. Action Plan to Maintain low rodent population density

i. Before on set of monsoon, complete management actions

ii. Rodents' breeding starts with onset of monsoon and post monsoon months and rodent population will be very high and difficult to control.

iii. Use acute poison like zinc phosphide, aluminium phosphide in case of serious rodent infestations only. Legal provisions need to be considered while planning aluminium phosphide fumigation.

iv. Use anticoagulants or other structural modification (for prevention) during low rodent density situations.

v. Integrating the application of chemical inputs with structural modifications and clean premises/public places can bring maximum reduction of rodent populations.

vi. Use bait stations wherever feasible considering their safety.

7. Specific considerations for different sites of rodent infestation

Each rodent-infested site presents a different set of circumstances for extension professionals who are required to apply control measures.

Non target animal specificity

- Sites with rat and mouse infestations inside premises carries little risk of non-target exposure to animals like dogs, cats etc.
- Sites away from human habitation have more risk for non target animals
- Directly from consuming baits or
- Indirectly by eating the poisoned dead rodents.

Safety measures are, therefore, to be considered at planning level.

7.1. Domestic Premises and Public Awareness

Rodent control with poison baits in and around domestic premises poses problems with placement and protection of bait.

- Explain the residents in the locality about the risks involved in the use of rodenticides.
- Inform individual householder about bait placement locations and that they must not be moved or disturbed.
- Inform them on the treatment regime and the risks associated with the use of rodenticides.
- Leave details of the poison baits, the appearance of the bait, the number and position of baits laid and
- The actions needed if bait is disturbed or consumed accidentally and the inherent risks to non-targets.

- Create awareness on the importance of sound structural maintenance of the property (e.g. sealing gaps under doors and around service pipes).

7.2. Block treatments

It is difficult to bring effective rodent control in premises with multiple occupiers due to threat to public and non target species and reinvasion of rodents from treated sites or even from untreated premises.

- Wherever possible, undertake all management actions simultaneously in all premises in the selected site.
- Select next site after completing at one site to reduce the chances of surviving rodents to immigrate or reinvade the areas.

7.3. Commercial (non-food)/Electronic industry premises

The risk of infestation within commercial, non-food premises will be influenced by the work that takes place in them.

- The cables and wiring are vulnerable, often, for rat and mouse gnawing impacting performance of electronic items and industry.
- Thorough survey should be conducted to establish the areas that may be prone for rodent infestation.
- Rat movement takes place through cable and AC dusts spreading entire premises and special attention needs to be given to prevent their movement.
- Where catering facilities and food waste are on site these may be important areas to examine in detail.

7.4. Commercial (food) establishments

All the actions specified above are needed to be followed.

- In addition, owners of food premises needs to check for signs of pests periodically and have a pest control record system in place.
- Plan management measures based on this information.
- Where general standards of hygiene are of concern, the concerned person/s should be educated on needed actions.

7.5. Larger institutions

Large institutions like hospitals may have several locations prone for rodent infestation. Integrate different control methods, combined with close monitoring of the progress is essential.

- Identify restricted or areas with limited access at planning stage.
- Give focused attention on food preparation areas or kitchens.

- Waste disposal systems/garbage are rich source of food for rodents. Hence, make a thorough study on routes and methods of disposal of food wastes.
- Inspect food eatery areas since they are vulnerable for rodents.
- Examine service/AC ducts for evidence of rodent activity and their spread.
- For closed duct spaces, provide adequate trainning to the workers to work in confined spaces.
- Restrict access to vulnerable areas to prevent any accidental poisoning.

7.6. Public places (Parks, gardens and other open areas)

Protect the bait points/traps etc while dealing with rodent problems in open areas like parks, gardens, ponds etc by following measures:

- Place baits directly into active burrows, especially in areas where the public has restricted access.
- Burrow fumigation using aluminium phosphide could also be considered. Cover all treated holes, and check for reopened burrows when fumigation is made.
- For point treatments, regularly monitor the infestation.
- Using GPS, plot areas of treatments with baits or fumigated burrows and a notice explaining the risk of primary and secondary poisoning must be made.
- Position garbage bins with lids to prevent rodent entry.
- Correct use and maintenance of compost bins should be advised.

Similar considerations will apply in other open areas of public access, viz., railway environments, drainage/water canals and the banks of natural water courses, reservoirs, footpaths, and airports/air-fields.

7.7. Drains/Sewers

- Sewers or drains provide an ideal environment for rodents, especially Norway rats and bandicoots.
- A protocol is needed to be developed to ensure better coordination of rodent control in public drains/sewers.
- Train the extension professionals with specialized training to deal with application of rodenticide or fumigant.
- Provide an extension guidance document on the treatment of rat infestations should be provided to the teams.

7.8. Storage areas

- Stored grain/commodity storage will have more rodent infestation.
- Suitable weather and tamper-resistant bait boxes bait containers should be used.

- Alternatively, cement constructed permanent bait stations (as seen in the figure) may be used. Monitor such treatments frequently to replenish anticoagulant baits.
- Dispose of left over bait and any dead rodents by burying them in soil.

7.9. Airports

Particular attention is needed on monitoring rodent activity in airport areas. The harbourage in various locations of airports, as below, are conducive to rat activity in those areas.

- Presence of garbage dumps from slums around the airport boundaries afford food as well as shelter for the rats.
- Areas of long grass cultivated at airports to reduce bird-strikes of aircraft, may provide rat harbourage and becomes the rodent breeding hotspots.
- Areas around airport perimeter fences are subject to fly-tipping, thus providing harbourage and food sources for rats.

F. Data and Records Management

Record keepling

Forms and record keeping are essential part considering regulatory inspections and legal provisions.

Progress of Rodent Control

Block No.	Treatment area (Ha./Houses)			Infestation before control			Infestation after control			Control success (%)	
	Area 1	Area 2	Total	Live burrows per ha.	Tracks touched		Live burrows per ha.	Tracks touched		Live burrows	Tracking
					1	2		1	2		

G. References

(all relevant references both national and international to be given)

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H. Checklists

Checklist (check mark for completed tasks) – for each pest it needs to be

1. Date and time of visit

2. Inspected and applied following measures for management:

Date and Time	Area inspected	Type of measure applied	Input type and quantity applied	Follow up observations 7^{th} 14^{th} 21^{st} day

Chapter - 12

Ants in Human Habitations and their Management

Uday Menon

CHAPTER CONTENTS

Uday Menon

Uday Menon is an experienced Pest Management Professional for over 30 years dealing with all urban pests including fumigation. He is a Master Trainer for Australian Fumigation Accreditation Scheme (AFAS) , the Fumigation Training program of the Australian Government for their AFAS India Program and have conducted accreditation trainings in different parts of the country. He is an active member of Indian Pest Control Association (IPCA) and served as Secretary & Vice President. He is also a Trainer for IPCA for their various in-house training programs on General Pest Control and Vector control. Associated in the first National Work Shop on Ant Management in collaboration with Bio Control Research Laboratories at Bangalore

Ants in Human Habitations and their Management

A. Purpose and Applicability

The purpose of this Simple Operation Procedure (SOP) is to make strategy planning followed by planning management actions with respect to ants in the urban situations and to monitor their incidence at periodic intervals. This include their control in public places, different establishments and premises of residences ensuring public safety. The procedures outlined in this SOP are applicable to all urban areas as well as urbanizing/industrializing rural areas.

B. Operational Definitions

Ants

Ubiquitous insects found in community environments, indoors and outdoors having access to food and water.

Little black ant

Monomorium minimum

Fire ant

Solenopsis spp Odorous house ant

Tapinoma sessile

Pharaoh's ant

Monomorium pharaonis

C. Cautions, Health and Safety Warnings

- Keep warning sign boards in areas assigned for Bait placement
- Note safety considerations such as the location of pet animals and presence of small children.
- Take adequate care for personnel safety while –
  - i. preparing and handling chemicals & baits.
  - ii. checking the habitats
- Handle the snap and other types of traps, bait stations with care during rodent control measures.

- Precautions while using Chemicals & baits:
  - *Know-how of the operation should be told to the public always in local language followed by demonstrations by departments concerned.*
  - *Keep poisons away from the reach of children, pet animals, drugs and food.*
  - *Smoking, eating and drinking should be totally avoided while handling the poison.*
  - *Containers of the poisons should be opened in a well-ventilated room. Unused baits, containers and dead rodents should be buried deep.*
  - *Clean the hands, eyes and nose thoroughly after preparation of baits and chemicals*
  - *Ensure that the antidotes of poisons are available with the doctor for use in case of any accidental ingestion of poison.*

D. Equipment and Supplies

- The equipment required for Control Measures including Spray Pumps, Bait placement etc.
- The supplies include the inputs viz., baits, Chemicals etc

The equipment required to conduct a professional Ant Management include heavy duty flash light, a mechanic mirror and a flushing agent. Hand Magnifying lens, plastic vials.

The following steps shall be followed:

- Carry heavy duty flash light, a mechanic mirror a flushing agent during inspection & Treatment
- Follow Ant Trails and locate their Nests

The insecticide application shall be made as crack and crevice, spot or general.

The following is the spray fluid can be prepared as below

- Add water (1/2-1/3) volume of solution tank.
- Add pesticide according to label dilution rate.
- Replace pump assembly, tighten and shake vigorously for Uniform mixing open the assembly
- Add water up to the desired level replace pump assembly, tighten and shake vigorously for uniform mixing

The following is the spray procedure.

- Select appropriate spray nozzle.
- Pump until a tank pressure of 20 psi is reached (approximately 10 times pumping).
- Spray smoothly until the point of runoff (20 inches from surface) Upon completion of work,
- Rinse solution tank with ½ litre of water.
- Pump thrice spray into an empty container.
- Repeat the procedure 3 times.
- Keep reinstate for use the next day.

E. Procedural Steps

1. Know about Ants for their management

- Ants are some of the most ubiquitous insects found in community environments thriving in both indoors and outdoors having access to food and water.
- Ants outdoors are mostly beneficial, as they act as scavengers and decomposers of organic matter, predators of small insects and seed dispersers of certain plants.
- They can protect and encourage honeydew-producing insects such as mealy bugs, aphids and scales that are feed on landscape or indoor plants, and this often leads to increase in numbers of these pests.
- The body of an ant can be divided into three distinct regions: head, thorax, and abdomen which consists of the narrow constriction (waist or petiole) and the part beyond it (gaster).

- The waist can be made up of one or two small segments (nodes) and broadly grouped as one-node and two-node ants.
- A well-known feature of ants is their sociality living in colonies consisting of less than 100 individuals in small concealed spaces, to millions of individuals in large mounds.
- Functions within the colony are carried out by specific groups or 'casts" of adult individuals.
- Most ant colonies have fertile males called "drones", one or more fertile females called "queens" and large numbers of sterile, wingless females which function as "workers".
- Many ant species exhibit polymorphism with different appearances (sizes) and functions within the same caste.
- The worker caste may include "major" and "minor" workers with distinct functions, and "soldiers" that are specially equipped with larger mandibles for defense.
- Ant colonies usually multiply and spread by either or both of the processes called "swarming" and "budding".
- Only the drones and queens are capable of flight. During favorable times of the year, newly matured drones and queens will fly out ("swarming") or travel by foot on the ground ("budding"), away from their nest to mate and start new colonies.
- The sole function of the drones is to mate with the queens. After mating, the drones soon die, while the queens find nesting sites and start laying eggs.
- Ants have chewing mouthparts.
- While most ants are omnivorous and will consume a variety of food material, each species has certain food preferences such as sweets, starches, fats or meat, and this knowledge is useful in their management.
- In general, ants are considered a nuisance mostly because of their numbers, and will not cause significant damage if managed in a timely manner. However, some ants like carpenter ants can cause damage to wooden structures by hollowing out wood.
- Many species can inflict painful bites and stings, and this is a cause for concern.
- Some species such as Pharaoh ants are reported to transmit disease organisms such as Staphylococcus.

2. Life cycle of ants

- The ant life cycle consists of four stages: egg, larva, pupa and adult.
- Ant larvae are called "grubs", and they are wormlike and legless.
- They are tended by the workers through the pupal stage, till they emerge as adults and assume the specific duties of their caste.

3. Different Species of Ants and habits

Little black ant *(Monomorium minimum)*

Appearance

- This is very small (1/15 in. long)
- Shiny black body color.
- The workers about 1 to 2 mm long.
- Queens 4 to 5 mm long.
- A monomorphic species, with only one caste of worker, and polygyne

Lifecycle

- Little black ant colonies have multiple queens and may become very large.

Habits

- Nests are normally located outdoors, in the soil and in relatively open areas, or under objects.
- These ants will also nest in rotten wood, woodwork and the masonry of buildings.
- Most of their feeding is on plant secretions or honeydew of aphids and scale insects, but occasionally invade houses in search of food.
- Once inside, they feed on sweets, meats, breads, grease, vegetables and fruit.

Fire ant (*Solenopsis spp)*

Appearance

- Queens 5/8” long.
- Workers 1/8”-1/4” long.
- Coppery–brown on the head and body, with a darker abdomen.
- *Solenopsis* has a very distinctive two–segment antennal club, which is most visible in the front view of the female reproductive ant.

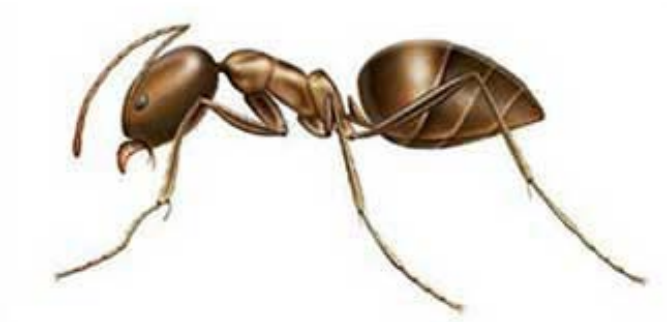
Lifecycle

- After swarming from the nest and mating, the queen searches for a suitable spot to lay her eggs. Once found, she can lay up to 125 eggs in late Spring.
- Larvae hatch within 8 to 10 days, and the pupal stage lasts for 9 to 16 days.
- Larvae feed on secretions from the queen’s salivary glands and broken down wing muscles until the first worker ants emerge. After this first batch of larvae moult into workers the queen’s role returns to egg laying – she can lay up to 1500 per day. Worker ants continue with larval care, nest building and food foraging.
- Fertile males are produced later in the season.

Habits

- Foraging workers diet consists of dead animals, including insects, earthworms, and vertebrates. Workers also collect honeydew and forage for sweet food, proteins, and fats.
- Nest locations can be a mound of up to 40 cm or next to objects found on the ground, e.g. logs.
- If aggravated, these react aggressively and can inflict a painful sting, resulting in a pustule some 48 hours later.
- These ants are a major agricultural and urban pest, destroying crops and invading residential areas both outdoors and indoors.

Argentine ant *(Linepithema spp)*



Appearance

- Light to dark brown in color
- Workers are 1/12 to 1/8 inches long
- One-segmented petiole
- 12-segmented antennae with no club

Lifecycle

- Many fertile queens are present in each nest.
- Mating usually takes place inside the nest, so winged forms are not usually found.
- Multiple queens are found in each nest.
- Formation of new colonies happen through a process called budding where some fertile queens and a cohort of workers become isolated from other colony members and establish a new colony.

Habits

- Nests are typically located in moist soil and under buildings, along sidewalks or beneath boards and plants.
- Argentine ants usually build the nest near sources of both water and food. Occasionally these ants may nest within a structure.
- Argentine ants prefer sweet foods, principally sugars, syrup, fruit juices, secretions of plants, and honeydew.

Odorous house ant *(Tapinoma sessile)*

Appearance

- Brown or black.
- 1/16 to 1/8 inch long.
- Antennae have 12 segments and are not terminated with a club.
- 6 legs.

Lifecycle

- Time to adult phase of development is 34-38 days.
- Typically live for several years.

Habits

- Feeding - eat most household foods, especially sugary food, eg sweets and fruits such as melon. Also eat pet food.
- Locations – attracted to moisture. In hot, dry environments nests can be found in house plants and even lids of toilets.
- Odour - produce a coconut smell when crushed.
- Colonies - range in size from 100-10,000.

Pharaoh's ant *(Monomorium pharaonis)*

Appearance

- Workers 1.5-2mm long, yellow-brown with brown abdomen.
- Males 3mm long, black, winged.
- Queens 3.5-6mm long, dark red in colour with wings.
- Black eyes, 2 small segments at the pedicel.

Life Cycle

- Multi-queen colonies.
- Swarming can take place at any time of the year.
- Winged adults seldom fly so rarely seen. Wings are soon lost after mating.

Habits

- Well–defined trails are laid which are often associated with heating systems. Feeds indoors on high protein foods — meat, fats, blood, dead insects, etc.
- Swarming characteristics — new colonies are often formed through nests that have been disturbed e.g., as a result of insecticide spray treatments.
- Each queen produces up to 3,500 eggs in its lifetime.
- Nest locations — deep seated in cavities in heated buildings. Often found in hospitals. Associated with humid conditions. Colonies can range from a few dozen to 300,000 individuals.

Carpenter ant *(Camponotus pennsylvanicus)*

Appearance

- Workers: 1/4” long.
- Queen: 1/2” long.
- Blackish color most common but can also be black and red.
- 6 legs.

Life Cycle

- It takes 3 - 6years to establish a large and stable colony.
- The life cycle of a carpenter ant is estimated to be 6 - 12 weeks from egg to adult.

Habits

- Locations - both moist and dry wood, but prefer moist, e.g. wood dampened by water leaks.
- Internally - excavate galleries in wood with a smooth appearance.
- Externally - sometimes hollow out sections of trees.
- Visibility - hunt for food mainly at night but also during the day in early spring / summer. Signs include sawdust, wet wood, or unusual noises coming from the walls.
- Feeding - primary food is honeydew, also eat plant secretions, fruit juices and insect remains. They do not eat wood. In homes they are attracted to sweet substances, fats, grease and meats.
- Contact - rarely come into contact with people, but if they do will try to escape. They cannot sting.

Crazy ant *(Paratrechina longicornis)*

Appearance

- Dark brown.
- 2.5 – 3.3mm.
- 6 legs.
- Antennae are with 12 segments and without club.

Lifecycle

- Multi-queen colonies.
- Colonies of crazy ants are moderate to very populous.
- On warm, humid evenings, large numbers of males gather outside nest and may swarm about excitedly.

Habits

- Nesting – crazy ants make their nests in a wide range of either dry or damp sites.
- Feeding habit – omnivorous and feed on seeds, dead invertebrates, plant secretions, fruit and a range of household scraps.
- Crazy ants are able to invade new habitats and out-compete other species of ant.

4. Inspection Procedure

i. Regular Inspection for Ants or Ant entry points is an important part of an Ant management program.

ii. Monitor for ants near attractive food sources or moist areas.

iii. Ants may invade kitchens, bathrooms, offices or bedrooms. Inspect under sinks, in cupboards, and along pipes and electrical wires.

iv. Lookout for Ant trails or foraging ants. Once Ant trails are spotted follow the ants to see where they are entering the building and to their nests if possible.

v. Look indoors and out doors for holes or cracks in foundations or walls that provide entry in to the buildings.

5. Ant Management

i. Ant problems occur in homes and structures primarily because food, water and favorable nesting sites are available there. Deprive the ants on these sites.

ii. Meticulous housekeeping eliminates significant ant problems by removing needed resources.

iii. Ant bait treatments are more effective if alternative food sources for the ants are eliminated as much as possible.

iv. Most ants prefer to nest in soil or wood outdoors, but homes offer many favorable nest sites for certain ants.

v. Cracks and holes in brick veneer, wall voids and structural wood close to heat and moisture sources are commonly used.

vi. Reduce water sources and nesting sites by caulking cracks and crevices, fixing leaks and replacing wet or rotten wood.

vii. Pay particular attention to ant colonies infesting potted plants or fire wood brought indoors.

viii. Insecticides registered for ant control are formulated as liquid sprays, dusts, fogs and baits. Many are generally labeled to control "ants," although some are specifically registered for particular ant species.

ix. The most effective ant control is to find the nest and treat it with insecticide.

x. An alternative is to use the workers to carry an insecticidal bait back to other colony members.

xi. In the home, extensive, undirected insecticide treatments, such as ant trail treatments or total-release aerosol fogs, are usually unsatisfactory because they kill only a few workers and often do not greatly affect the colony, the source of workers.

xii. Using surface applications on ant trails actually can make Pharaoh ant colonies divide and make the infestation worse!

xiii. Worker ants will often lead you back to the nest.

xiv. Another good technique is to use small bait stations to trick the ants into revealing their nest locations.

xv. Use soft drink or pill-bottle caps baited with small amounts of peanut butter, mint apple jelly, bacon grease or other attractive materials, which will attract the ants. Watch them as they locate the food and take some of it back to the nest. They may even establish an odor trail for other workers to use to find the food, so an ant column may develop.

xvi. Although these steps take time and effort, they eliminate undirected, ineffective insecticide spraying indoors and make ant elimination by nest treatment quick and efficient.

xvii. Treat indoor nests with an insecticide registered for this use.

xviii. Dust formulations are preferred for treating nests indoors because they do not stain and generally give longer residual control than sprays.

xix. The approved chemicals for ant management are as under:

Insecticide	Type of Application	Remarks
Imidacloprid 0.05%	Baiting	Applied as a Gel on Horizontal surfaces.
Beta Cyfluthrin (10.5%) + Imidacloprid (21%)	Spray	For treatment of Ant Colonies

F. References

Kelly, M. 2009. Indoor Insect Pests Hand Book, KD Publications, UK, pp 143 to 146.

Mallis, A. 2011. Ants. In: Hand Book of Pest Control, Mallis Handbook Company, (10th Ed),737-804.

G. Checklists

Checklist (check mark for completed tasks) – for each pest it needs to be

1. Date and time of visit
2. Inspected and applied following measures for management:

Date and Time	Area inspected	Type of measure applied	Input type and quantity applied	Follow up observations 7th 14th 21st day

Chapter - 13

House Hold Pesticides and their Utility in Human Habitations

C.V. Rao

CHAPTER CONTENTS

Mr. C.V. Rao

Mr. C.V. Rao, a Pesticide Quality Control and Residue Analysis Specialist possesses 33 years of pesticide management experience at National Institute of Plant Health management, Ministry of Agriculture, Govt of India. Organized training programs in Pesticide Formulation Analysis, a mandatory requirement by State Department analysts. Coordinated National workshops of Pesticide Analysts, Organisation and Management of PTLs for Senior level officers of State Departments of Agriculture. Associated with the National workshops on Approved Uses of Pesticides for State Departments of Agriculture, ICAR Scientists and University Professors. Involved in establishment of Laboratory for Bio product analysis for Central Insecticides Laboratory (CIL)] and Laboratory for Monitoring of Pesticide Residues Center under the National Project and Proficiency Testing center for pesticides quality control and Resdiues at PMD, NIPHM, Hyderabad.

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House Hold Pesticides and their Utility in Human Habitations

A. Purpose and Applicability

This module is information on pesticides recommended and used to manage pests in human habitations. It presents classification of pesticides based on pest target groups, class of chemicals. Pesticides are substances or mixtures of substances intended for controlling, preventing, destroying, repelling, or attracting any biological organism deemed to be a pest or disease causing organism (vector). Insecticides, herbicides, defoliants, desiccants, fungicides, nematicides, avicides, and rodenticides are some of the many kinds of pesticides. In the perspective of public health, they include vector control pesticides, household pesticides, and professional pest control pesticides. Information on these aspects along with provisions of Insecticides Act are provided.

B. Operational Definitions

Pests

Organisms which cause structural and financial losses to structures and commodities.

Vectors

Organisms which transmit pathogens to human and livestock in human habitations

Pesticides

Substances which bring kill of pests and vectors.

Pesticide Formulations

Mixture of pesticides which bring optimal pest control

C. Cautions, Health and Safety Warnings

- There are no "safe" pesticides. Know about the safe and judicious use of pesticides.
- They can contaminate land, the air, food crops, water ways and seriously harm or kill native animals, pets and domestic animals.
- They are toxic, and exposure to pesticides can cause a number of health effects and linked to serious illnesses and diseases from respiratory problems to cancer affecting often the nervous system.
- They are equally toxic to a host of other organisms including birds, fish, beneficial insects, and non-target plants.
- Household pests include insects such as flies, cockroaches and mosquitoes, or rodents like mice or rats.

- Household pesticides have open sales from supermarkets or hardware stores, and are designed for householders to use around their home or garden.
- In local bodies these domestic pesticides are applied by public health employees having specialized training in safety precautions and directions for use.
- Their risk with rodenticides can be minimized by use of protected bait boxes, and as always, usage in strict compliance with the pesticide label.
- An additional risk is the contamination of drinking-water, food or soil.

D. Classification of Domestic Pesticides

There are various **groups of chemicals** used in the House hold pest control which include rodents and termites. Based on their application to control the house hold pests they may be listed as follows;

S.No.	Group	Used against	Examples
1	Acaricide	Mites, ticks	Dicofol, permethrin
2	Anticoagulant	Rodents	Bromadiolone
3	Insecticide	Insects	Malathion, chlorpyrifos, Temephos
4	Repellent	Repels vertebrates or arthropods	dimethyl toluamide, or DEET.
5	Rodenticide	Rodents	Zinc phosphide
6	Termiticide	termites	Imidachloprid, Fipronil, Chlorphyrifos

Larvicides

- Detection of large numbers of immature mosquitoes in areas where source reduction or biological control is not feasible may require larvicide treatment to prevent the emergence of adult mosquitoes.
- Use of larvicides is less controversial than use of adulticides, although use of larvicides may lead to public concern about their effects on non targeted beneficial aquatic arthropods and vertebrates.

Adulticides

- Adulticide applications, particularly aerial applications and thermal fogging, are quite visible and contribute to public apprehension.
- The insecticide is diluted with petroleum oil and vaporized with heat into a dense, highly visible fog of very small uniform droplets, which allows tracking the plume downwind to target areas.
- Although the fog reduces visibility, it penetrates vegetation better than a ULV application. Small electric or propane thermal foggers are available for consumer use in retail stores.
- Adult mosquitoes are easily controlled with insecticides applied at extremely low rates.

Rodenticides

- Use of acute rodenticide like zinc phosphide is discouraged for use in human habitations in view of its risk to non target or accidental toxicity.
- Anticoagulant rodenticides may be typically classified as first or second generation.
  i. A first generation rodenticide requires higher concentrations (usually between 0.005 and 0.1%) and consecutive intake over multiple days so a lethal dose may bio-accumulate.
  ii. Second generation rodenticides are applied in lower concentrations in baits (usually in order 0.001-0.005%) and are lethal after a single ingestion of bait. These are also effective against rodents that are resistant to first generation anticoagulants.
- Warfarin was very successful as a rodenticide when it was first introduced because rodents did not exhibit bait shyness because of the extended period of action of the coumarins. However, physiological resistance to coumarins has been reported in rats later. This has led to discovery of second generation anticoagulants (e.g., brodifacoum, bromadiolone) killing rodents in 4–7 days after a single feeding. These materials can be used where rodents are encountered that are resistant to conventional anticoagulants.

Chemical repellents

- Chemical repellants are used in public health applications prevent bloodsucking insects such as mosquitoes, black flies, and ticks from biting humans, livestock, or pets.
- The most widely used chemical used in repellent formulations to protect people is dimethyl toluamide, or DEET.
- This brings down disease transmission rates from vectors. Citronella and its oil for mosquitoes exhibited limited success.

- Mechanical repellents, such as high frequency emitters, marketed for insects or other pests are generally unproven and ineffective.

Termiticides

The termicides killing the termites belong to different chemical group of pesticides. Chlorpyrifos 20%EC is from Organo phosphate group, imidachloprid is from neo nicotinoid group whereas the fipronil is carbamate group.

Classification based on the chemical group

S.No.	Chemical Group	Examples	Used against
	Organo chlorine	Dicofol,	mites
	Organophosphates	malathion, chlorphyrifos	insects
	Carbamates	propoxur , Fipronil	insects
	Pyrethroids	Permethrin, cypermethrin	insects
	Coumarins	Bromadiolone	rodents
	Metal phosphide	Zinc phosphide	rodents
	Neo nicotinoids	Imidachloprid	Insects and termites

Organochlorine Pesticides

- This group consists of, the polychlorinated derivatives of cyclohexane (Lindane), polychlorinated biphenyls (DDT, dicofol) and polychlorinated cyclodiene (Endosulfan).
- They possess low volatility, low water solubility, high solubility in oils, fats,lipids etc.,
- These molecules are not prone to environmental degradation and are highly persistant molecules in the environment. (ex. dicofol).

Organo phosphorous pesticides

- These are the esters of derivatives of phosphoric acid, thiophosphoric acid and dithio phosphoric acids which are called phosphates, thiophosphates and dithiophosphates respectively.
- These compounds are available as liquids or semi solids and posses significant vapour pressure and comparatively volatile. Some compounds have slight solubility in water (MCP and Phosphamidon are soluble in water).
- Sunlight brings about modification of the toxicity of these molecules either way.

- They exhibit acute extreme toxicity to slight toxicity. They inhibit cholinesterase enzyme and accumulation of acetyl choline takes place in the organism as result in disruption of nerve function centrally and peripherally that leads to respiratory failure and death by asphyxia. (ex. chlorpyrifos, ethion).

Carbamates

The Carbamates are esters of either carbamic acids or thiocarbamic acids. The Organo carbamate (OCs) compounds exhibit moderate to extreme toxicity. And they do not display chronic toxicity. Propoxur belongs to this group and is in high toxicity 2nd group as per the classification. These compounds inhibits the cholinesterase but they differ in their action from Organo phosphate(OP) compounds – the inhibition of OC compounds is reversible unlike OPs. On inhibition of cholinesterase, disruption of nerve function takes place centrally and peripherally leading to respiratory failure and death by asphyxia.

Pyrethroids

Pyrethroids are synthetically produced molecules that are chemically similar to pyrethrins. The Pyrethroids are present as volatile and non volatile solids or semisolids. They are insoluble in water. Pyrethroids are not persistent. At rates applied for vector control, they break down quickly in sunlight, and are rarely present after just a few days. Pyrethroids are now among the most common public health pesticides used. Examples: permethrin, cypermethrin and deltamethrin.

Coumarins

Coumarins are aromatic organic compounds belong to benzopyron group and lactone structure. They are colorless crystalline solids with a sweet odor resembling the scent of vanilla and a bitter taste. They are found in many plants, where it may serve as a chemical defense against predators. These are used as rodenticides. Death occurs after a period of several days to two weeks, usually from internal hemorrhaging. The second generation coumarin bromadiolone is a very popular rodenticide.

Biorationals

Biorationals area group of pesticides that are considered relatively non-toxic to humans and are also environmentally safe. There are two group of pesticides.

a) **Biochemical pesticides:** They are hormones, enzymes, pheromones, and natural insect and plant regulators e.g: methoprene, Diflubenzuron (insect growth regulators),

b) **Microbial bio pesticides:** They are viruses, bacteria, fungi, protozoa, and nematodes. Microbial pesticides kill arthropods either by toxins released by microbial organisms, or by infection by the organisms. Two common pesticides that fit within this group include the bacterial toxin produced by Bti, and the live bacteria, *Bacillus sphaericus* (Bs). Products containing both of these bacteria are used against mosquito larvae, with Bti being effective in killing black fly larvae as well. Most microbial pesticides are more selective than biochemical pesticides. e.g: *Bacillus thuringiensis israelensis* (Bti).

The pesticides are applied as stomach, contact or systemic poisons to control the pests.

Stomach toxicants

Stomach toxicants enter an insect's body through the mouth and digestive tract, where they are absorbed into the insect's body. Stomach poisons are acquired during feeding. In vector control, this category includes bacteria, or their toxins, applied to the water where filter-feeding mosquito or black fly larvae will consume the poison. These microbial insecticides kill by destroying the midgut (or stomach) of the larvae. Ants, cockroaches, and other pest insects with chewing mouthparts can be controlled by incorporation of insecticides into baits of various types

Rodents are also often controlled for using ingested anticoagulants. They die from internal bleeding, the result of loss of the blood clotting ability and damage to the capillaries.

Contact toxicants

Generally enter the pest or plant's body either by exposure to water treated with the chemical or direct contact with an aerosol (e.g., adult mosquitoes flying into an insecticidal "fog"), or by exposure to some treated surface, such as leaves. Like most insecticides, these poisons act upon the nerve and respiratory centers of arthropods. Most adult mosquito control products are contact toxicants.

Fumigants are volatile compounds that enter the bodies of insects in a gaseous phase.

Systemic toxicants are absorbed by plants, pets, or livestock and are disseminated throughout the organism via the vascular system. When a pest organism feeds on the plant or animal, they ingest the toxicant. Some toxicants are quickly lethal to the pest; others work to prevent the pest from maturing. Application in vector control is typically used for tick and flea control on pets, as well as dog heartworm prevention.

E. Toxicity and colour codes

i. A chemical substance that exerts an injurious effect in the majority of cases when it comes into contact with living organisms is termed a poison or toxin. This phenomenon which results is toxicity.

ii. Toxicity is inherent quality of the chemical to harm living organism and cannot be changed without changing the chemical to another form.

iii. The toxic effect on an organism is related to the amount of exposure. The toxic effect of exposure depends on

-the route of exposure;

-the total dose

-the time course of exposure

iv. There are two types of toxicity -

1. Acute toxicity

- An acute toxicity may be defined as poisoning or damage that occurs on account of single dose or single short time exposure of an organism to the chemical or toxicant.
- Acute effects occur within minutes, hours or days (mostly in single day). The magnitude of the effect depends on the innate toxicity of the substance, duration of exposure and the method of application or exposure to a particular organism

2. Chronic toxicity

- There is no standard measure like LD_{50} or LC_{50} for chronic toxicity studies. Long term and short term toxicological studies on different animals exposed to non-lethal levels of toxicant by different routes are conducted.
- The effect of toxicant on different organs of animals is studied for some of the chronic effect like Carcinogenicity (cancer causing ability); Mutagenicity (ability to induce genetic aberration); Teratogenicity (ability to cause birth deformity in the off springs of pregnant animals exposed to toxicant; Oncogenecity (ability to produce tumor) etc. On the basis of such studies "No observable adverse effect level" "NOAEL"s of toxicant is determined on different test animals.

3. Delayed Toxicity

- Delayed toxicity may occur many years after exposure to a chemical and is most often only discovered in retrospective epidemiological studies (studies done after the fact).
- Some chemicals that produce delayed toxicity are fipronil and asbestos. Epidemiological studies are crucial to the detection of further occurrences of delayed toxicity.

It is scientifically accepted that very low levels of pesticides can be tolerated by mammals which is called accepted daily intake 'ADI'. ADI is defined as maximum daily intake of toxicant expressed in mg. of active ingredient per kg body weight throughout one's life that is considered to be safe on the basis of toxicological data information available date.

4. Determination of the cautionary word and Colour coding

The cautionary word is required to appear on the front panel of all pesticide labels, are furnished in the following table;

Toxicity Categories for Pesticides as approved by the CIBRC, Government of India:

Classification of the Insecticides	oral route acute toxicity LD 50 mg/kg.	dermal route dermal toxicity LD 50 mg/kg.	Colour of identification band on the label	Symbol
1	2	3	4	5
1. Extremely toxic	1-50	1-200	Bright red	
2. Highly toxic	51-500	201-2000	Bright yellow	
3. Moderately toxic	501-5000	2001-20000	Bright blue	
4. Slightly toxic	More than 5000	More than 20000	Bright green	

F. Pesticide formulations used in Domestic Pest Control

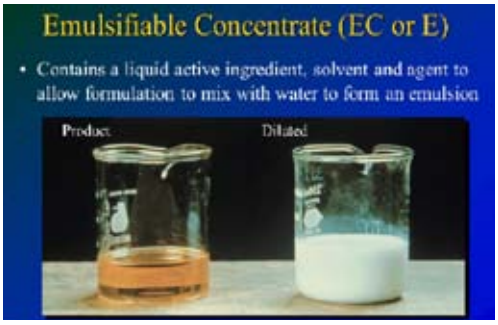
i. The pesticides are converted in to formulation to improve safety, ease of handling, storage, ease of use, and effectiveness of pesticides. Some of the most commonly used formulations in household pest control are, EC, SC (Flowable), ULV, WP, Granules, Fumigants, Ready to use liquid spray, Aerosols, Cakes/baits., Chalks, vaporisable liquids etc.,

ii. All the formulations will contains some inert material/filler material as diluent. The pesticide is mixed with the diluent to a desired level and then added some adjuvants to bring about the desired physico chemical properties and stabilisers to the product besides some colouring dye.

iii. Advantages of Pesticide Formulations:

- Facilitates easy handling
- Enables the farmer to dilute water insoluble pesticides in water
- Helps in achieving more uniform application
- Reduced toxic hazards
- Improved efficacy and selectivity
- Enhanced storage stability

1. Emulsifiable concentrate (EC): EC is a clear liquid homogeneous formulation of active ingredient(s) which form emulsion after dilution with water. It is a solution of a.i. and surfactant in water immiscible solvent(s), which on addition of water forms usually an oil in water emulsion (spontaneously or with agitation). Ever increasing cost of the petrol based solvents coupled with toxicological and phyto-compatibility constraints, besides environmental safety have led to a search for alternate products to replace ECs. Slowly newer formulations like EW and SC formulations are replacing them

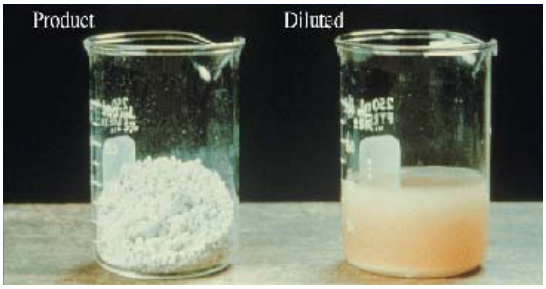


2. Suspension concentrate (SC): Wet flowable or suspension concentrate is the designation for a stable suspension of active ingredient(s) in an aqueous continuous phase, intended for dilution with water before use. A SC formulation contains finely divided solid particles in a liquid dispersing medium, usually water. The proportion of the solid usually ranges from 5 to 60% which may be a single a.i.

or a mixture of several active ingredients with or without a carrier.

They are becoming much more important because of increasing solvent costs and environmental restrictions on pesticide auxiliary materials. This formulation disperses spontaneously when poured in water having good suspension stability.

3. Wettable powder (WP): Pesticide in dry form with surfactant, often mixed or coated on a fine solid carrier for dispersion in water to form a suspension which is called as wettable powder formulation. Wettable powders are finely divided solids, typically mineral clays, to which an active ingredient is sorbed. The particles do not dissolve in water. They settle out quickly unless constantly agitated to keep them suspended. Therefore, these Wettable powders are added wetting and dispersing agents as part of the formulation. Such formulation when mixed with water form a suspension which is stable for a reasonable time.



Wettable powder and its suspension

4. Granule (GR): There are many types of granular formulations are available to day. Few formulations are described below;

Different kinds of pesticide granules

(i) Extruded granules: The granules are prepared by adding the active ingredient to a suitable filler materials, ground and made in to a dough and drawn in to strings, tried and cut to size and sieved to get desired particle size. The entire granule contains the active ingredient uniformly. The macro and micro granules as well as WG granules are prepared in this procedure.

(ii) Coated granules: The granules are prepared by impregnation of the active ingredient as per the required concentration over an inert blank granules or silica / quartz grains (binder may be required), dried and packed after sieving. Some auxiliary chemicals also required to enhance the stability of the formulations throughout its shelf life and dyes for alarming. In this type of granules active ingredient is available only on the surface of the granules.

(iii) Encapsulated granules: The coated granules prepared as above are further encapsulated with an inert material so as to protect the operators/farmer workers from the toxic effects particularly from those chemicals whose dermal toxicity is very high.

4. Baits: Baits are prepared taking active ingredient in required concentration and mixed with food/feed and other auxiliary substances to attract the pests. They are easy to use. Readily control pests moving into or out of an area.

Bait

5. Chalks: These are prepared by taking inert material like talc and admixed with the recommended amount of pesticide and a dough is prepared which is then put in to the moulds and dried.

Pesticide Chalk

6. Aerosol (AE): An aerosol is a suspension of solid or liquid particles with a diameter less than 50 μ, in air or gas. This is a self-contained sprayable product in which the propellant force is supplied by a liquefied gas. An aerosol is just not any specific product, but the whole package comprising of container with a valve, a liquefied gas propellant, solvent, a.i. and other auxiliaries packaged under pressure.

The mist is formed when an aerosol is discharged and the propellant changes from liquid to gas at the atmospheric pressure which makes the pesticide along with the solvent disperses in to the atmosphere This kind of formulation is widely used for household pest control and application in cracks and crevices.

Aerosol

7. ULV formulations: Ultra-low-volume concentrates have almost 100% active ingredient. They are designed to be used "as is" or diluted with only small quantities

of specified solvents. These special purpose formulations are most suitable for outdoor applications, such as in agricultural, forestry, ornamental, and mosquito control programs. ULV products are applied as very fine droplets at very low rates per unit area

(or volume). e.g. deltamethrin 1.25% ULV, Malathion 96% ULV

Application of ULV formulation

G. Pesticide formulation recommended for domestic Pest control

1. Insecticides and their formulations approved by the registration committee for rodent control in field and house/godown under the insecticides act, 1968.

Sl No.		
1.	Bromadiolone	0.005% RB, 0.25%CB
2.	Coumatetralyl	0.0375% Bait
3.	Warfarin	0.5% (HH),0.025%w/w
4.	Zinc Phosphide	Technical, 2%RB
5.	Barium carbonate	10-20% Tech. mixed with bait

2. Insecticides approved by the registration committee to control termites in agricultural crops under the insecticides act, 1968.

Sl. No.			
1	Chlorpyriphos	20 EC	A) Non cropped area: 1) Building (Pre & Post construction treatment @1%a.i.) 2) Forestry @1%a.i.
2.	Imidacloprid	17.8% SL	0.075% a.i. concentration. for Pre and Post construction.
4.	Fipronil	2.92% EC	0.25% a.i concentration for Pre and Post construction.

3. Insecticides approved for mosquito control under public health programme.

Sl. No.	Name of Insecticide and formulation	Stage of the mosquito		Dosage	
				Active Ingredient	Formulation
1.	Alpha Cypermethrin 5% WP	Public health use-out door	Adult	25-40 mg/m^2	0.5-0.8 g in 20 ml water/m^2
		In houses – in door	Adult	25-40 mg/m^2	0.5-0.8 g in 20 ml water/m^2
2.	Bifenthrin 10% WP	Indoor spray	Adult	25 mg/m^2	0.250 g in 20 ml water/m^2
3.	Chlorpyrifos Methyl 40% EC	Public health use -in human dwellings	Adult	500 mg/m^2	1.25 ml in 50 ml water/m^2
4.	Cyfluthrin 10% WP	Public health use	Adult	25 mg/m^2	0.25 g in 20 ml water/m^2
		In houses by spray	Adult	20 mg/m^2	0.20 g in 50 ml water/m^2
	Cyfluthrin 5% EW	In houses by spray	Adult	0.02 g/m^2	0.4 ml in 50 ml water/m^2
		Impregnation of bed nets	Adult	50 mg/m^2	1 ml/m^2
5.	Deltamethrin 1.25% ULV	Outdoor application Thermal fogging	Adult	0.5 g/ha	50 ml in 10 litre diesel oil/ ha
		Outdoor application ULV application	Adult	0.5 g/ha	50 ml in 0.5 litre diesel oil/ ha
		Indoor application (To be used by pest control operators, municipalities, Govt./ semi Govt. institutions/ agencies, army etc.)	Adult	2.0 g/1000 m^3	200 ml in 250 ml diesel oil/1000 m^3

Sl. No.	Name of Insecticide and formulation	Stage of the mosquito		Dosage	
				Active Ingredient	Formulation
	Deltamethrin 2.5% WP	For public health purpose	Adult	12.5 - 25 mg/ m^2	500-1000 mg in 30 – 50 ml water/m^2
	Deltamethrin 2.5% Flow	Impregnation of polyesters, nylon and cotton bed nets	Adult	25 mg/m^2	1 ml/m^2 bed net
		In houses, factories, offices, market places, hospitals, hotels, cattle sheds etc.	Adult	25 mg/m^2	1 ml in 100 ml water/m^2
	Deltamethrin (0.0 018% w/w)	For public health purpose		55 mg/m^2 {for a period of 3 years u/s 9(3)}	
	Deltamethrin 25% Tablet	Impregnation of polyester, nylon and cotton bed nets	Adult	25 mg per m^2 bed net	1 tablet (1 g) or ½ Tablet (2 g) / 10 m^2
6.	DDT 50% WP	In houses by spray	Adult	1-2 g/m^2	2-4 g/m^2
7.	Diflubenzuron 25% WP	Clear surface water	Larvae	25-50 g /ha	100-200 g/ha
		Polluted surface water	Larvae	50-100 g /ha	200-400 g/ha
		Sewage pits, soakpits, latrines, septic tanks	Larvae	1 mg/litre	4 mg/lit water
	Diflubenzuron 2% GR	Water bodies, Cess pits, Drains & disused wells & pots.	Larvae	1.25-3.0	

Sl. No.	Name of Insecticide and formulation	Stage of the mosquito		Dosage	
				Active Ingredient	Formulation
8.	Fenthion 2% G	Banks of lakes, ponds, ditches, drains, marshes, swamps, stagnant water, septic tanks, rice fields	Larvae	100 gm for surface up to 10 cm depth and 500 gm for surface up to 50 cm depth/ha	5 kg for surface up to 10 cm depth and 25 kg for surface up to 50 cm depth/ ha
9.	Lambdacyhalo-thrin 10% WP	Public health use -outdoor	Adult	15-30 mg /m^2	150-300 mg in 20 ml water/m^2
		In houses by spray	Adult	20 mg/m^2	200 mg in 20 ml water/m^2
11.	Malathion 25% WP	In houses by spray (To be used by Govt. Departments for public health under National Malaria Eradication Programme)		2.0 gm/m^2	8.0 g in 100 ml water/m^2
12.	Primiphos methyl 50% EC	Mosquitoes breeding surface		12.5 g/ha	25 ml/ha in 225 litre water
	Primiphos methyl 1% spray	In houses by spray	Adult	0.5 g/100 m^3	50 ml/100 m^3
13.	Propoxur 20% EC	In houses by spray (To be used by Government, Semi-Government Departments only)	Adult	200 g in 40 litre water	1 litre in 40 litre water

Sl. No.	Name of Insecticide and formulation	Stage of the mosquito		Dosage	
				Active Ingredient	Formulation
14.	Temephos 50% EC	Open water, Swamps, Marshes with low organic contents	Larvae	27.5-56.25 g/ ha	55-112.5 ml/ha
		Heavily polluted water with high organic content or vegetative cover	Larvae	27.5-56.25 g/ ha	55-112.5 ml/ha
				Consult local authorities (higher dose will be required)	
		Small area treatment	Larvae	0.1 g/m^2	1 tsp in 1 gallon water/25m^2 (equivalent to 0.2 ml in 150 ml water/m^2)
		Lakes, Ponds, Swamps, Drains, Ditches and other mosquitoes breeding area	Larvae	20 – 64.5 g/ha	40 – 129 ml/ha
	Temephos 1% SG	Standing water, Shallow ponds, Lakes, Pools and Woodland	Larvae	50-100 g/ha	5 – 10 kg/ha
		Tidal waters, Swamps, Marshes	Larvae	100-200 g/ha	10 – 20 kg/ha
		Drains, Cesspits	Larvae	200-500 g/ha	20 – 50 kg/ha

4. Bio pesticides approved for mosquito control under public health programme.

Sl. No.	Name of bio pesticide and formulation	Habitat	Mosquito species and stage	Dosage
1.	Serotype H-14 (AS)	Paddy fields, Ponds, Pools		
		Drains, Cesspits, Casuarina pits, Disused wells		
		Tree holes, Disused tyres		
2.	*Bacillus Thuringiensis* var. *Israelensis* Serotype H-14 12 AS	Clean water, Cement tanks	*Anopheles* larvae	1-2 lit/ha
		Polluted water, Cesspits, Cement tanks, Stagnant and flowing drains	*Culex* larvae	2-4 lit/ha
3.	*Bacillus Sphaericus* 1593 M serotype H-5a 5b 1.3 FC	Drains, Cesspits, Cesspools, Paddy fields, Ponds	*Anopheles* and *Culex* larvae	112 lit in 1120 lit water/ha
		Cesuarian pits, Unused wells, Unused overhead tanks, Domestic wells (not for drinking purpose)	*Anopheles* and *Culex* larvae	112 lit in 1120 ltr water/ha
4.	*Bacillus Thuringiensis* var. *Israelensis* strain 164, Serotype H-14 (WP)	Water surface of any habitat	*Anopheles* and *Culex* larvae	0.5 g/m^2
5.	*Bacillus Thuringiensis* sub sp. *Israelensis* 5% WP, serotype H-14	River bed pool, Cement tanks, Pokhars, Small kaccha or cement tanks with low walls, Pits and ditches, Paddy fields, Semi polluted pits, Ornamental fountains, Flood prone polluted cesspits and ditches, Drains with polluted stagnant or flowing very slowly	*Anopheles* and *Culex* larvae	0.5 g/m^2
		Septic tanks	*Anopheles* and *Culex* larvae	1.0 g/m^2

5. Insecticides approved by the registration committee to control household pests in houses under the insecticides act, 1968.

(Last updated on 20th October 2015)

S.No.	Name of the Pesticide	Formulation
	Allethrin	0.2% Coil, 0.5% Coil, 4% Mat, 3.6% Liquid Vaporizer, 0.5% Aerosol
	Alphacypermethrin	0.5% chalk, 0.1% RTU, 5% WP
	Beta Cyfluthrin	2.45% SC
	Bifenthrin	0.05% Mosquito Coil
	Cyfluthrin	5% EW, 10% WP
	Cyfluthrin 0.025% + Transfluthrin 0.04% water based Aerosol	Aerosol
	Cypermethrin	3% Smoke generator, 1% chalk, 0.1% Aqueous
	Cypermethrin 0.11% + Pyrethrin 0.2% Aerosol	Aerosol
	Cyphenothrin	5% EC
	Cyphenothrin 0.3% + d-allethrin 0.2% Aerosol	Aerosol
	Deltamethrin	0.5% chalk, 1.25% ULV, 2.5% Flow, 0.5% tablet bait, 1% RTU
	Deltamethrin 0.02% + Allethrin 0.13% Aerosol	
	Deltamethrin 0.05% + Allethrin 0.04% LV	
	Deltamethrin 2.5% + Allethrin 2.0% Liquid Concentrate	(to be used only by pest control operators, Government establishments, Government agencies for large scale disinfections)
	Diazinon	25% Micro Encapsulation
	Diazinon 0.5% + Pyrethrum 0.1% Spray	
	Diflubenzuron	2% GR, 2% Tablet, 25% WP

S.No.	Name of the Pesticide	Formulation
	d-trans allethrin	2% Mat, 0.1% Coil
	Fenitrothion	2% Spray, 20% OL
	Fenthion	2% Spray
	Fipronil	0.05% Gel
	Forchlorfenuzon (CPPU)	0.1% Liquid
	Imidacloprid	2.15% Gel
	Imiprothrin 0.1% + Cyphenothrin 0.13% Aerosol	
	Lambda cyhalothrin	10% WP, 0.5% Chalk, 2.43% CS (Impregnated Bed Nets for vector control)
	Lindane 0.05% + Pyrethrin 0.05% Spray	
	Malathion	2% Spray, 5% Spray
	Malathion 1% + Pyrethrum 0.05% Spray	
	Metofluthrin	0.005% M.coil (6 Hrs.)
	Permethrin	5% SG
	Pirimiphosmethyl	1% Spray
	Prallethrin	0.05% Coil, 0.04% Coil, 0.5% Mat, 0.8% Mat, 1% red Mat, 1.2% Mat, 1.6% liquid Vaporizer, 0.8% Liquid Vaporizer, 19% VP, 2.4% LV
	Propetamphos	1% Spray
	Propoxur	20% EC, 1% Spray, 2% Aerosol, 2% Bait
	Propoxur 0.5% + Cyfluthrin 0.025% Spray	
	Propoxur 0.75% + Cyfluthrin 0.025% Aerosol	
	Propoxur 1% + Cyfluthrin 0.025% Aerosol	

S.No.	Name of the Pesticide	Formulation
	Pyrethrin 0.02% + Lindane 0.02% + Piperonyl butoxide 0.5% Spray	
	Pyrethrin 0.02% + Lindane 0.5% + Piperonyl butoxide 0.02% Spray	
	Pyrethrin 0.02% + Malathion 0.05% + Piperonyl butoxide 0.5% Aerosol	
	Pyrethrin 0.05% + Malathion 1%	
	Pyrethrin 0.05% + Piperonyl butoxide 0.50% Spray	
	Pyrethrum	0.2% Aerosol
	S-Bioallethrin	2.4% Mat
	Transfluthrin	0.88% Liquid, 20% MV Gel(30 days mat tray), 1.6% LV, 1.2 % LV

6. Storage of Pesticides

a. Always store pesticides in their original, labelled container with the label clearly visible.

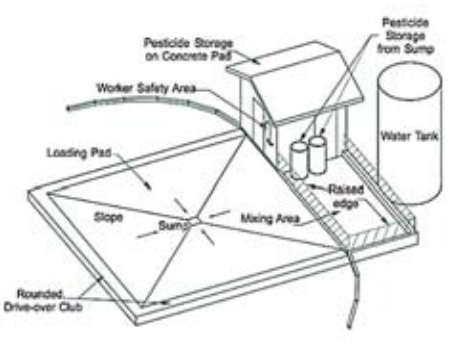
b. Always store pesticides in tightly sealed containers and check containers periodically for leakage, corrosion breaks, tears, etc.

c. Always be certain that pesticide storage areas are well-ventilated to prevent the accumulation of toxic fumes.

d. Always store different types of pesticides in different areas, to prevent cross contamination and the possibility of applying a product inadvertently.

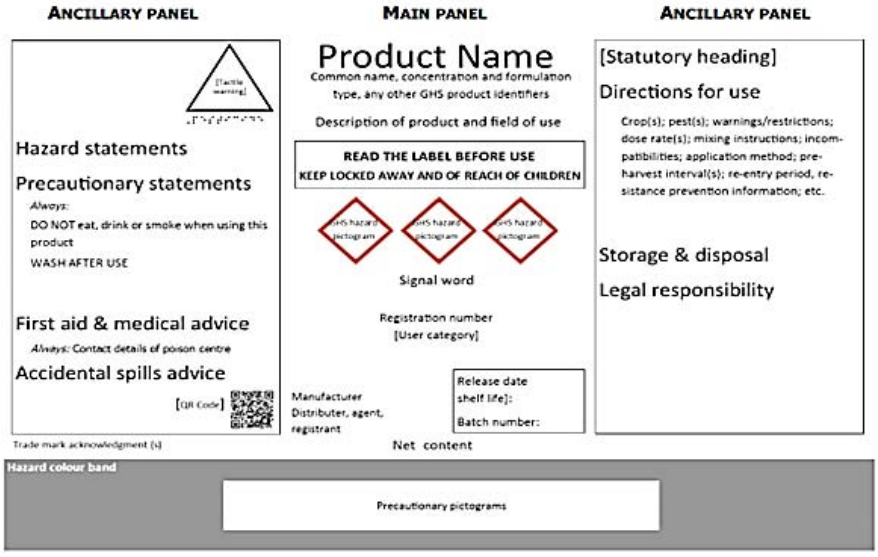
e. Never store pesticides near food, feed, or seed.

I. Agencies or programs that store significant amounts of pesticide should have a designated pesticide storage facility.



7. Pesticide labels and labelling

The term label refers to the printed material attached to a pesticide container or a wrapper of a retail pesticide package. The term labelling refers to all of the printed instructions that come with a pesticide. This definition includes the label on the product, the brochures and flyers provided by the manufacturer, and other information, such as handouts, from the dealer. The Label and Leaflet provide are required information about the pesticide, type of formulation, use and safety precautions. Symptoms of poisoning and first aid . Disposal of used containers etc., Read the Label information on application and safety aspects before spray.



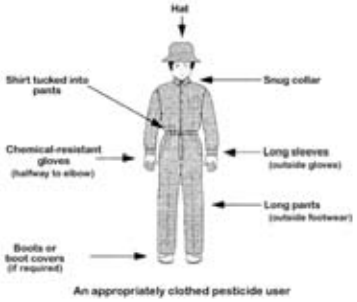
A typical Pesticide Label

Apart from the toxicity information, some more additional information is provided in the form of safety pictorials on the pesticide containers, which may be followed.

H. Mixing and loading pesticides

Many pesticide accidents occur when the chemicals are being mixed for use. A few common sense rules can make mixing and loading safer, thereby helping you to avoid the leading cause of pesticide-related illnesses:

1. Before handling a pesticide, READ THE LABEL.
2. Based on label recommendations, put on protective clothing and use other necessary protective equipment. Also from reading the label, follow instructions on what special equipment is necessary.



An appropriately clothed pesticide user

3. Mix the pesticides outdoors, in a place where there is good light and ventilation. If you must mix or load pesticides indoors or at night, make sure you have good ventilation and lighting.

4. Stand upwind of the pesticide to avoid contaminating yourself.
5. Use a sharp knife to open paper bags; do not tear them or the label.
6. Measure accurately; use only the amount you need to apply at the rate specified on the label.
7. When removing the concentrated material from the container, keep the container below your waist if possible to prevent the possibility of splashing or spilling any pesticide into your face and eyes.
8. If you splash or spill a pesticide while mixing or loading, stop immediately! Remove contaminated clothing; and wash thoroughly with detergent and water. Speed is essential if you or your clothing is contaminated. Clean up the spill.

I. Applying pesticides

1. Careful attention to a few simple guidelines during pesticide application will greatly increase your chances of effectively controlling the pest. At the same time, attention to these details will make the job much safer for you, other people, pets, livestock, and the surrounding environment.


2. Check the application equipment. Look for leaking hoses or connections, plugged or worn nozzles, and examine the seals on the filter openings to make sure they will prevent spillage of the chemicals.
3. Calibrate your equipment before use. Make certain that your equipment is adjusted according to the manufacturer's specifications and meets label requirements for the product being applied.
4. Before the pesticide application starts, clear all livestock, pets and people from the area to be treated. Although it would be the ideal situation, most ULV labels do not require this. Always check the label for any specific restrictions.
5. Apply the pesticide at the recommended rate. Do not exceed the maximum application rate specified on the label or the written recommendation.
6. Apply pesticides only at the correct time and under acceptable weather conditions –

check the label for specific limitations. Avoid applying pesticides when temperatures are extremely high or low. Be especially careful when temperatures exceed 85ºF or are below 50ºF.

8. Use extreme care to prevent the pesticide from contaminating unintended target sites (e.g., streams, ponds, lakes or other bodies of water).

10. Do not contaminate food or feed through careless application methods.

J. Equipment Cleaning

After completing the application of any pesticide, immediately clean the mixing, loading, and application equipment as per the procedures for cleaning and decontamination.

K. Personal clean-up and Disposal

After you have completed the pesticide application, disposed of excess material, and cleaned the application equipment, you should thoroughly wash all your protective equipment. Remove your work clothes and place them in an area separate from other laundry items or properly dispose of them if they are disposable coverall, Now take a shower. Wash yourself completely with soap and water.

Pesticides as hazardous waste: The left over, unused and time barred pesticides should be disposed off scientifically in an environment friendly manner through an hazardous waste management agency authorised/approved by the State Pollution Control Board.

Pesticide container disposal

Always dispose of pesticide containers in a manner specified on the label. Many pesticide containers can be recycled, either as a part of a regular recycling program, if approved on the label, or by returning to the chemical supplier. Before disposing of any empty pesticide container, it must be rinsed thrice at least with water equivalent to 1/4th volume of the container each time.

L. Symptoms of poisoning, first Aid and Antidotes

Pesticide poisoning can mimic the signs and symptoms of other common diseases. The nature and intensity of insecticidal toxicity depends upon the chemical structure of the insecticide and their mode of its action, level of exposure and the concentration of the insecticide. Pesticide poisoning can affect the body in two ways: it can cause a local reaction when a pesticide comes into contact with exposed parts of the skin or eye, or it can be absorbed into the body and cause a systemic reaction.

Symptoms severity of pesticide poisoning

Mild Poisoning	Moderate Poisoning	Severe Poisoning
Fatigue	Unable to walk	Unconsciousness
Headache	Weakness	Severe restriction of eye pupil
Dizziness	Chest discomfort	Muscle twitching
Blurred vision	Constriction of eye pupil	Secretions from nose and mouth
Excessive sweating and salivation	Greater severity of signs of mild poisoning	Difficulty breathing
Nausea and vomiting	With continued exposure, coma and death	Coma and death

First Aid

Procedures for first aid vary according to the type of exposure. In all cases, a person with knowledge of the incident should accompany the victim to the medical facility to inform qualified medical personnel about the nature the of accident, the material being used, the first aid given, and the victim's symptoms following exposure up to the time of his arrival at the medical facility.

First aid measures according to the type of exposure are given below.

i. Pesticide on the skin - Remove contaminated clothing and shoes. Wash skin and hair with soap and plenty of water.

ii. Pesticide in the eyes - Flush the eyes with running water for 15 minutes. Use a low-pressure water source.

iii. Pesticide inhaled - Remove victim to fresh air and have him lie down. Loosen his clothing and keep him warm and quiet. Apply mouth-to-mouth resuscitation if breathing stops.

iv. Pesticide swallowed - Induce vomiting only if specified on the pesticide label. Apply cardiopulmonary resuscitation if breathing and heart beat stops.

Then the person to the nearby medical attendant and hospital.

M. References

Major uses of pesticides, http://ppqs.gov.in/divisions/cib-rc/about-cibrc

Registered pesticides http://ppqs.gov.in/divisions/cib-rc/about-cibrc

Registered pesticide formulations http://ppqs.gov.in/divisions/cib-rc/about-cibrc

Insecticides Act 1968 and Rules 1971 http://krishi.bih.nic.in/Acts-Rules/Insecticides_Act_1968.pdf

N. Checklist

Chapter - 14

Importance of Safety in Pest Management Measures in Human Habitations

Dr. Anil Mazgaonkar
and
Dr. Sarang Savalekar

CHAPTER CONTENTS

Dr. Anil Mazgoankar

Dr. Anil Mazgoankar is a researcher and expert in pest management in human habitations. Worked at various teaching and research positions with the Konkan Krishi Vidyapeeth for a decade. Working in the Pest Management Industry from 1993, first as an employee and later as an entrepreneur. Specialized in termite ecology, studied on species diversity of Termites and utilization of termites for soil improvement in the coastal zone of Maharashtra. Continues taking up various teaching assignments in colleges and with the Pest Management Association programs. Serving as Vice President for Pest Management Association and taking part in organizing various In-House training programs to Technicians and Supervisors.

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Dr. Sarang Savalekar

Dr. Sarang Savalekar has rich experience in pest management in structures and in human habitations for over 28 years. He has good and successful research based contributions for termite management in new and old structures and also on integrated management of termite pests in both pre and post building construction scenario. He is involved in developing training programs and curricula in structural pest management for Technicians and organized several In-House training programs. He is presently President of Pest Management Association, Pune and actively engaged in betterment of pest management industry.

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Importance of Safety in Pest Management Measures in Human Habitations

A. Purpose and Applicability

This module is to understand safety precautions while using domestic pesticides. There are simple measures by which non target human being can prevent the deleterious effects often associated with various pesticide application measures. This SOP is meant to give caution on such deleterious effects and make the users to utilize the pesticide application safe.

B. Operational definitions

Pesticide

A chemical substance which kills a pest or vector on being exposed to it.

Colour code

Classification of a pesticide based on its toxicity to indicate its relative safety. It often depends on the toxicity of the substance in terms of LD50 based on oral toxicity trials.

Personal protective equipment

The implements or equipment which afford protection to the person who operates the pesticide

Routs of exposure

The entry of a pesticide to the body of a human being – inhaling, eating, dermal etc.

Fight aid

The actions needed to give relief to a persons who accidentally is exposed to the pesticide environment.

Antidote

Substances which can be administered to a person with accidental toxicity before taken for medical treatment

C. Cautions, Health and Safety warnings

1. Categorization of pesticides

Based on colour code

Categorisation of pesticides

Depiction				
Colour of lower triangle	Bright red	Bright yellow	Bright blue	Bright green
Toxicity class	Extremely toxic	Highly toxic	Moderately toxic	Slightly toxic
Oral LD_{50} value (mg/kg	<50	51-500	501-5000	>5000
Signal words (Upper half)	POISON (In red)	POISON (In red)	DANGER	CAUTION
Warning words (Outside the diamond)	Keep out of reach of children. If swallowed or symptoms of poisoning occur, call doctor.	Keep out of the reach of children.	Keep out of the reach of children.	---

2. Care to be adopted while planning spraying

i. Use the least toxic pesticide available for effective control of insect, fungus or plant, as the case may be.

ii. Ensure only the recommended rate of pesticide is used.

iii. Wear protective clothing and equipment as described on the label.

iv. Prepare only enough chemical for immediate use.

v. Keep a record of each use and the results.

vi. Ensure equipment works properly and does not leak.

vii. Cover feed and water containers near areas where livestock are grazing;

viii. Don't eat, drink or smoke while pouring, mixing or spraying.

ix. Don't pour concentrated pesticide into tanks above shoulder height.

x. Avoid working alone if you are using a highly toxic pesticide; or have some form of mobile communication.

3. Care to be taken while undertaking Spraying Operations

i. Spray so that other workers or persons are not exposed.

ii. Other workers and persons must not enter the area where a pesticide is being sprayed.

iii. Be aware of wind direction. Wind can cause the pesticide to drift to areas not chosen for spraying.

iv. If possible, spray early in the morning or in late afternoon. High humidity will lessen the chance of drifting.

v. All workers must be notified in advance of where spraying is to occur.

vi. All workers must have immediate access to water, soap, and towels for routine washing and emergency decontamination.

vii. Anyone exposed to a pesticide must be taken to a medical facility. Tell medical personnel the type of pesticide being used.

viii. Spray with minimal drift and preferably in low wind conditions.

ix. Never spray in high wind conditions.

x. Use mechanical suction to transfer pesticides to spray tank.

xi. A vortex system can be used to mix pesticide concentrate with water before filling the spray tank.

xii. Prevent nozzles blocking by using correct filters and pesticide formulation. Ensure water and equipment are clean.

xiii. Clear blocked nozzles by using a soft bristle brush or compressed air. Never suck or blow nozzles to clear them

4. PPE: Personal Protective Equipment

- Helmet or cap or hat.
- Safety goggles.
- Mask
- Gloves
- Apron or Uniform
- Safety shoes
- Ear plugs





Work Clothes for Spraying:


5. Modes of Exposure to Pesticides

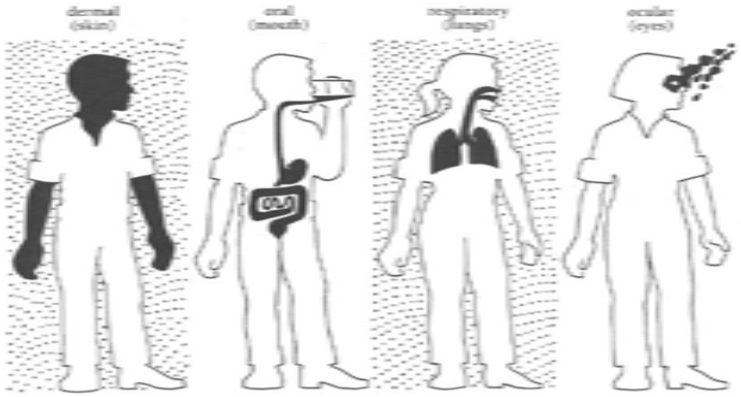
i. Dermal - any covered or uncovered skin

ii. Eyes-direct splash or contact withhands

iii. Inhalation – carried in with air

iv. Oral – taken into mouth or on lips

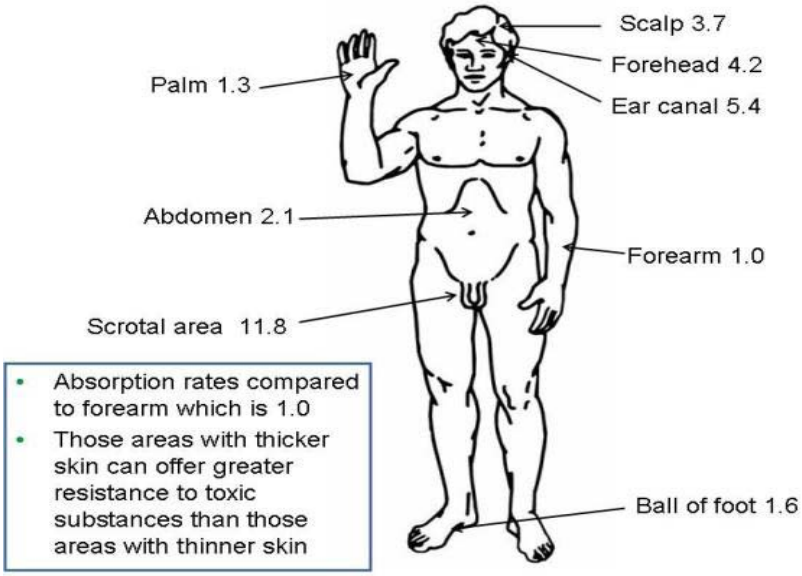
Modes of Entry of Pesticides



a. Dermal Exposure:

The majority of all pesticide exposures are dermal. The most common route is through the hands and forearms.

Absorption rates:



It can be protected by:

i. Helmet & Goggle, Mask

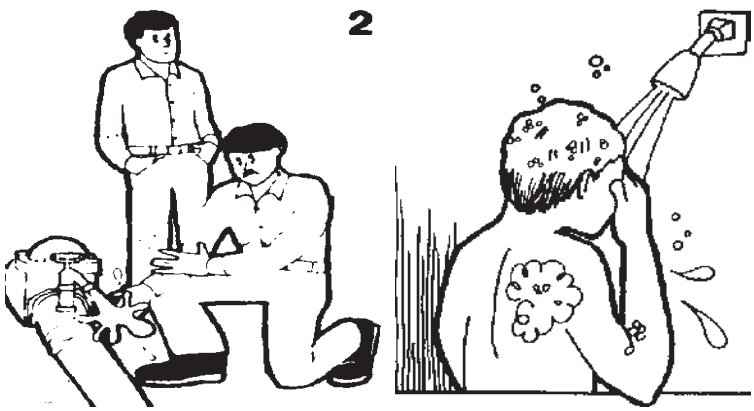
ii. Gloves, Uniform/ Apron

iii. Safety Shoes

Dermal Exposure: Can occur from

- Wearing inadequate personal protective equipment while handling pesticides
- Not washing hands after handling pesticides or their containers
- Splashing or spraying pesticides on unprotected skin
- Wearing pesticide-contaminated clothing (including PPE)
- Applying pesticides in windy weather
- Touching pesticide-treated surfaces

In case of Dermal Exposure wash with plenty of soap and water



b. Eye Exposure: Common when

- Mixing pesticides
- Whenever the potential for splashing exists
- Applying pesticides in windy weather
- Rubbing eyes or forehead with contaminated gloves or hands

Rinse affected Eyes with plenty of water: Hold eyelids open

- Wash immediately with a gentle stream of water.
- Continue washing for 15 mins or more.
- Do not use Chemicals or Drugs in the wash water

c. Respiratory exposure

In case of inhalation poisoning remove from the site after wearing protective gear:

i. Loosen Tight clothing

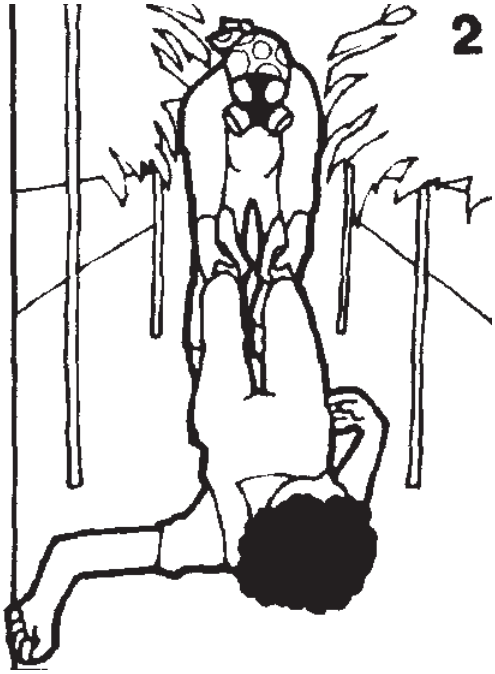
ii. Remove to fresh air

iii. Perform Artificial Respiration if necessary

iv. If toxic material is present in victims mouth or respiratory path use chest compression

v. Keep warm and quiet

vi. Keep chin up so air passage will be free for breathing



d. Oral Exposure:

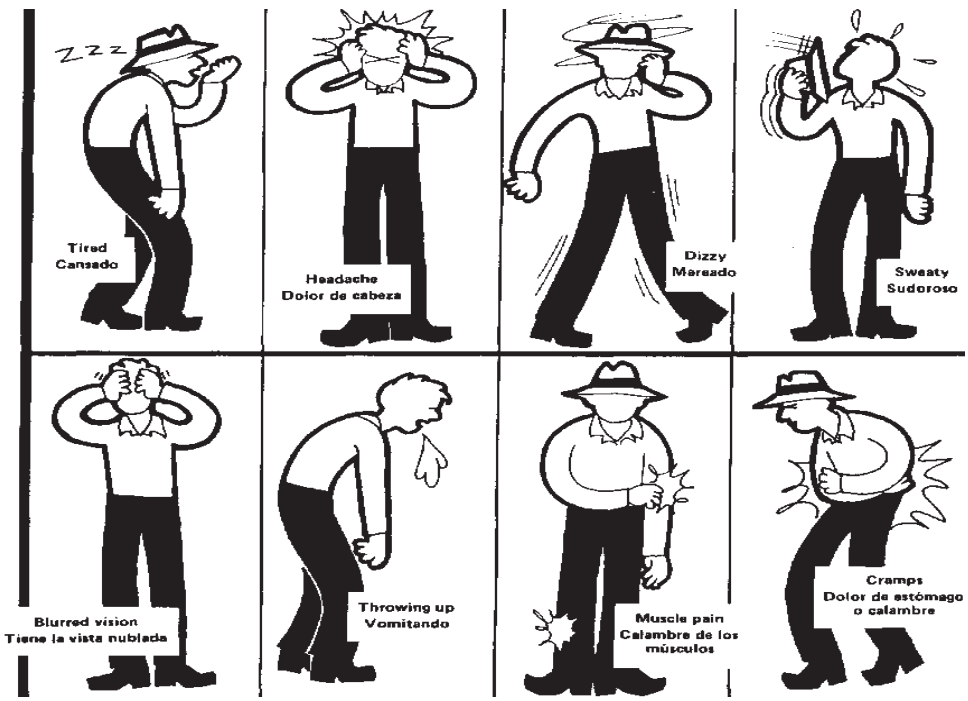
- Ingestion through the mouth
- Not washing hands before eating, drinking, smoking, or chewing
- Putting contaminated items and hands in or near mouth - such as food or Cigarettes
- Splashing into mouth through carelessness or accident

D. First Aid

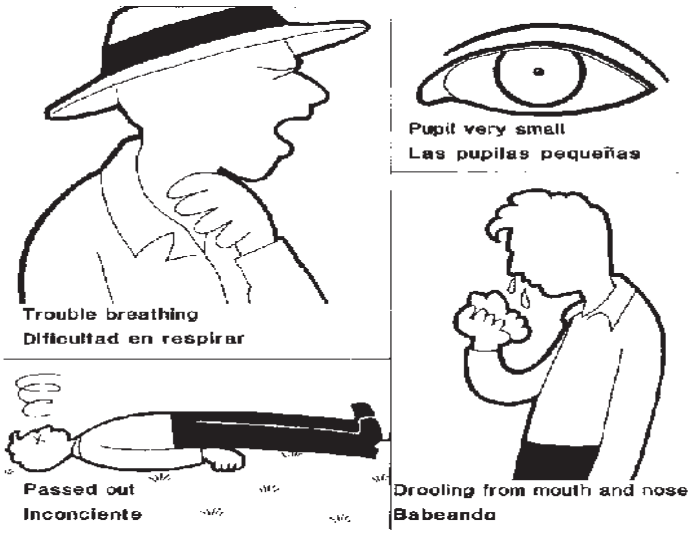
Swallowed poisons:

- Call for doctor immediately
- If non corrosive substance is swallowed MSDS may recommend to induce vomiting.
- To induce vomiting place the blunt end of the spoon or your finger at the back of the throat or use an emetic of two tablespoons of salt in a glass of warm water.
- When retching and vomiting begin place the patient face down with head lowered thus preventing the vomitus from entering lungs and causing further damage. Do not let patient lie on the back
- Never induce vomiting if the patient has swallowed petroleum products or a corrosive poison or if a patient is unconscious or experiencing convulsions.

Symptoms of mild poisoning:



Symptoms of Severe Poisoning:



Take the Pesticide container when you go to a Doctor:

E. Safety of the Environment

i. Our environment is the world in which we live and it is our duty to protect it.

ii. As said earlier all pesticides are poisonous. Some are extremely toxic to fish, bees and aquatic organisms.

iii. We should use pesticides to kill only the target pests.

iv. Never ever throw empty containers.

v. Each empty container should be triple rinsed, the water used and the container puntured and buried.

vi. Water after rinsing spray equipment should never be allowed to flow into natural

water bodies

Do not carry pesticide containers home Do not burn pesticide Containers:

Disposal of Empty Containers:

i. Empty insecticide sachets and packaging should be collected and returned to the supervisor.

ii. Do not use the empty sachets and packaging for any other purpose

iii. Never re-use empty insecticide containers.

iv. Ensure they are burned, away from houses.

F. Handling Pesticides

i. Keep pesticides in their original containers and safely out of reach of children and pets.

ii. Be especially careful when handling the concentrated form of any pesticide, as the concentrated form is the most toxic form.

iii. Prepare spray materials in a well-ventilated area.

If an insecticide kills an insect will it kill me also?

i. The insecticide is meant to kill an insect it acts on its system.

ii. The strength of an insecticide is called Toxicity and it is mgs/kg body wt.

iii. The weight of a cockroach is say 100 mg a dog weighs 8 kgs you weigh 40 kgs ie (4000000 mgs).

iv. So the recommended pesticides only are relatively safe to you and me if we use the correct concentration to kill the target pest

Are all Pesticides Poisonous? What about Ayurvedic or Herbal?

i. Remember ALL pesticides ARE poisonous.

ii. Even Salt and Sugar are poisons you know they are used as preservatives because they are poisonous to bacteria and fungi and in large quantity can be poisonous to us too.

iii. Ordinary Nail Polish Remover is more poisonous than most of the pesticides we use.

End of the Day:

If any of the Insecticide remains at the end of the day's work it must not be poured into rivers, drinking water sources or pools. It should be only be poured into pits dug especially for the purpose away from sources of drinking water.

G. Clean Up

i. Thoroughly clean all spraying and protective equipment, where run-off will not create a hazard or contaminate the environment.

ii. Wash work clothing separately from domestic clothing, or use disposable clothing.

iii. Wash yourself well after a spray operation.

iv. After handling pesticides, wash hands with soap and water before eating, drinking, going to the toilet or smoking.

H. Checklist

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