

## General Methods of Mosquito Control

It is obvious that some species of mosquitoes can carry disease which shown in the table of part I. In some regions, it become a serious nuisance, so it is necessary to have the methods of mosquito control.

There are two main methods :-

- Larvicidal Method
- Adulticidal Method

Mosquito control is applied against the aquatic forms by means of drainage, filling, and the use oil and other larvicidal agents. These procedures may be grouped under the term "larvicidal" methods. Other methods, which may be called "adulticidal" methods, are direct against the mature winged mosquito.

### Larvicidal Methods

#### (1) Mechanical Methods

1. Drainage
2. Pumping
3. Diversion of water
4. Improvement and Maintenance of Streams
5. Filling



6. Miscellaneous

Drainage

Drainage for mosquito control differs in some of its details from ordinary drainage. Storm-water drainage, for instance, requires immediate carrying away of large volumes of water, while drainage of water for mosquito control needs only to be so designed that the water will be carried off within the time necessary to produce mosquitoes. Ordinary drainage of agricultural land is concerned only with keeping the land sufficiently dry to produce crops, and little or no damage is done by small amounts of water retained in the ditches on the other hand, such small accumulations are more favorable for mosquito breeding than larger amounts. Hence, antimosquito drainage must be so arranged that no water is allowed to stand for any length of time in the drainage ditches. The methods of mosquito control in drainage are as follows :-

(a) Ditching (open ditch)

The first step in drainage is to make a lay out of the system of ditches, and then the ditches should be dug. Ditches should have clean sides sloped as steeply as the

earth or other materials will permit. The bottom should be as narrow as to confine the stream. Wide ditches are undesirable as they permit pools of water to stand and mosquitoes. Where a very wide ditch is necessary, this danger may be eliminated by constructing a small ditch in the bottom of the large ditch. Sharp bends should be avoided when making changes of direction, and branch ditches should join the main ditch at acute angles or with a curve.

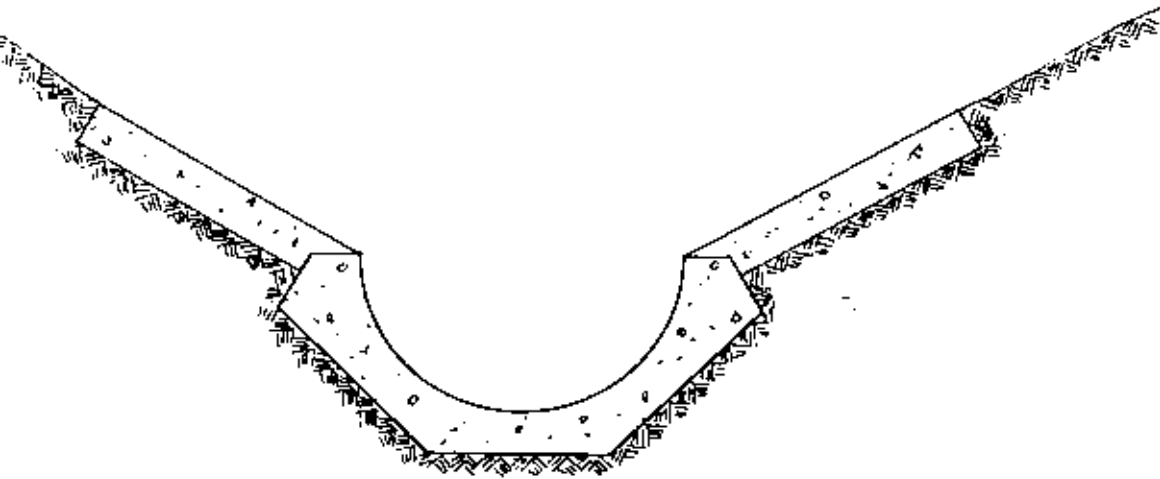
The grade of an unlined ditch should be great enough to give a cleaning velocity but not so great that erosion will occur. A grade of 0.05 foot per 100 feet is the minimum for an unlined ditch, while 0.6 to 0.8 foot per 100 feet is the maximum.

Side slopes of earth ditches are usually 1 horizontal to 1 vertical in firm loam or sand clay. In soft loose soil it should be 1.5 horizontal to 1 vertical.

Where a lined ditch is necessary for the purpose to avoid excessive erosion, this can be done by laying stone or concrete on the bottom of that ditch. See Fig. A

#### (b) Subsurface Drainage

Subsurface drainage is advantageous in swampy areas



*Cross section of a lined ditch*

*Fig. A*

where open ditches quickly become choked with vegetation or trampled by cattle. It also eliminates possible breeding in the ditches themselves and reduces maintenance costs. The pipes used in subsurface drainage may be cement, clay or asbestos pipes which varies from 3 inches in diameter upward. Under average soil conditions the laterals may be spaced 100 feet apart and the pipe laid at a depth of 2 to 4 feet. <sup>Why?</sup> The pipe, which is of the plain-ended, porous variety, is laid with close joints which may be covered with straw or sacks to prevent entrance of sand. The usual fall given is not less than 2 inches to 100 feet. *for what diam.?*

A simple and less expensive drain can be made by using logs. It is important that they be covered with leaves, straw, or small brush. This type of drains should slope from 0.2 to 1.0 foot per 100 feet of length. See Fig. B

#### (c) Vertical Drainage

This method can be used for pools and swamps, where there is an impervious stratum. It sometimes happens that beneath the impervious stratum there is one that is very open and porous, as sand or gravel; or fissured, as limestone.

If surface drainage in this case is impracticable or too costly, vertical drainage can be obtained. This requires one or more shafts or wells through the impervious stratum to the porous or pervious stratum. Conducting ditches may be required to carry the water to the shafts. Such shafts or wells may be lined with tile pipe or sheeted with timber to prevent caving. Shafts of large diameter are sometimes filled with large stones. In the case of small shafts a drain head is often placed at the top. This is in effect a wooden box with screened entrances for the water and also has a screened opening over the end of the shaft. This will serve to keep out coarse sediment and floating materials.

See Fig. C

#### (d) Street Drainage

In the more densely populated areas of cities and towns the surface water is discharged directly onto footpaths and finds its way into the street drainage system. This usually consists of a pipe or culvert situated beneath the footpath, or at the side of the street. Waste water from houses is also discharged to this system. The sewage will flow to the canal system, the river or the treatment

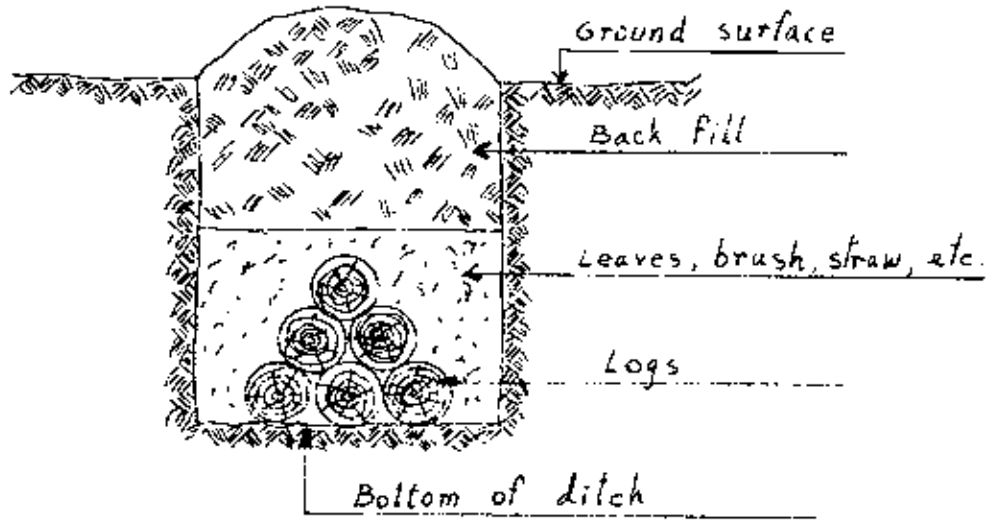


Fig. B Log drain

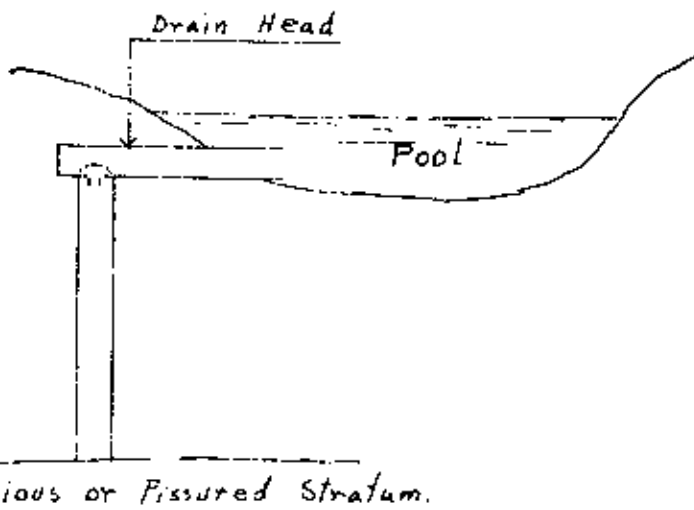


Fig. C Vertical drain

plant.

Mosquito control in cities and towns will be greatly facilitated by proper attention to street drainage. Culverts are frequently silted up at the lower end and consequently hold water if not cleared. Storm-water catch basin, particularly of the trap type, may be mosquito breeders. There is no doubt that an improvement and maintenance of the canals and waterways in the city should be done with the consideration of mosquito control in view. All ditches of unpaved streets should be brought to grade, cleaned, and freed of weeds. The culverts should to be laid at a gradient which water will be carried off within the time necessary to produce mosquitoes.

#### Pumping

It is obvious that elimination of water sources will prevent the production of mosquitoes. The impounding of waters may be eliminated by using the method of pumping. Pumping can be used when considered the followings:

1. The level of drainage area is lower than outside water level.
2. When a drainage area, especially in peat or



muck soil, has shrunk or subsided below the adjacent water level.

3. The annual cost of pumping is less than the construction and maintenance cost of open ditch drainage.

Some areas are frequently flooded during a time. If it cannot be drained, it can sometimes be adequately kept from breeding mosquitoes by pumping.

#### Diversion of Water

Diversion of water is frequently used to control the mosquitoes. Water impounded in reservoirs for irrigation may be drained to the agricultural lands through the system of irrigation ditches. In the same way, if we want to drain the water from a source, we may diverge that water by digging of ditches from the water source. When the water flows on the surface of ditches, some of the water sinks into the ground, and some evaporates. That is a method of drainage by diversion of water.

#### Improvement and Maintenance of Streams

It is a fact that mosquitoes do not breed in swiftly running water. However, does not eliminate the running stream as a mosquito producer as there will frequently be

found deep pools, obstructions, or vegetation which will sufficiently check the current of the stream to allow breeding in such favorable places. Streams may be improved by clearing of vegetation and other obstructions. Deep holes may be eliminated by filling or rechanneling. New channels may be dug or blasted to straightening the streams. Before this is done, an engineer should run levels to make sure that enough slope is available. In dry season, it will be found that no water remains except in isolated pools. These should be connected by ditches. Clearing and maintaining of streams will materially aid minnows and other larvae-eating fish to keep down mosquito production.

#### Filling

Areas that cannot be drained can sometimes be economically and adequately kept from breeding mosquitoes by filling.

There are two methods of filling:-

1. Dumping
2. Sanitary Fill

#### Dumping

This may be done with shovels if the hole is small,

with scrapers if the hole is larger and if there is earth available. In some cases it is possible to fill low areas with rubbish, but care should be taken that some containers are covered with earth, ashes or sawdust so that they will not hold water and breed mosquitoes.

#### Sanitary Fill

This method is also used as a means of disposal for all classes of refuse. It differs from ordinary dumping in that the material is adequately covered with earth at the end of the working day. Low areas in the cities may be filled with this method to eliminate the mosquito breeders.

#### Miscellaneous

1. Screening or mosquito proofing cisterns, wells and water containers. This method use screen or other materials for preventing the water container from breeding place of mosquitoes.

2. Remove or destructive of unnecessary artificial water container. These containers are always the breeding place for mosquitoes because the water may remain. These are tin cans, tubs and barrels.

3. Removal of protective vegetation or floatage.

These vegetables are grasses, weeds and high grasses, and it will be the place for resting of mosquitoes and also will be the place of larvae living.

4. Repair of leaks or defect in water supply plumbing or drainage system. The leak of water may result in pool of water which is suitable for mosquito breeding. If the sewer is clogged, the result is also the breeding place. Thus water supply pipes and sewers should be investigated for repairing.

5. Tree surgery. The tree hole is the breeding place of some species. It is necessary to eliminate these breeding places. The holes should be filled with mortar. If there are larvae in the holes, the best way for killing them is using of larvicides, such as DDT or cresylic acid.

(2) Toxic Substance Methods

In this method, the toxic substances may be divided into two groups. They are:-

1. Petroleum derivative oils
2. Larvicides

### Petroleum Derivative Oils

It is used as the toxic substance to kill larvae because of knowing its nature. The nature of larvae and pupae of the common varieties of mosquitoes are the air breathers and must come to the water surface to renew their air supply by using their breathing tube. When oil is used, it forms a film over the water surface and closes the breathing of the larvae. When the larvae return to the surface, some of oil will enter into the breathing tube. The oils have a poisoning effect rather than mere clogging or choking, and it causes death. Oil which is used as toxic substances may be as the followings:-

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#### 1. Direct refinery product

The products from petroleum by refinery are gasoline, kerosene, diesel oil and stove oil and other materials, such as hydro carbon and benzene derivatives. The effect of kerosene is very rapid destroyer of mosquito larvae. If they are exposed to kerosene, they will die in about fifteen minutes. The mosquito larvae will also die in short period if they are contacted with gasoline. The two have the advantage of good spreading ability. The disadvantages are

its higher cost, quick evaporation from surface of water in hot weather, and lack of color which make it difficult for the oiler to be certain that he has adequately covered the surface of the water.

Diesel oil and stove oil vary in toxic power and spreading ability. Proper spreading can be obtained by diluting the heavy oil with sufficient amount of kerosene or small amount of spreader.

2. Treated oil for increased toxicity or increase spreading capacity.

In this case, the oil is added with aromatic compound which increase the spreading capacity and toxicity. Sometimes the spirit gum and some of product of sulphonation of petroleum are useful addition to oils for increase of spread. The chemicals with hydroxyl (OH) ions, such as phenols, cresols, and xylenols, were most effective in increasing oil spread. The addition of phenols and higher alcohols is based on a fallacy, as the water-soluble compounds of materials escape from the oil into solution in the water, thus causing a break up of the oil film.

### 3. Reclaimed waste oils

This method is used the waste oils, such as waste crank case oil. The waste oil should be strained to remove grit and should be settled for several weeks to remove heavy residues. The remainder must be added with some lighter petroleum oil in order to give it good spreading characteristics and to remove its volatile fraction.

### Larvicides

Larvicides is the chemical agent for killing larvae and pupae. The larvicides may be divided into two classes, they are:-

1. Stomach poisons, which must be ingested by the larvae.
2. Contact poisons, which penetrates the body wall, or the respiratory system.

The larvicidal materials, such as paris green, calcium arsenite, and cuprous arsenite are stomach poisons, while oils and pyrethrin are contact poisons. Such material as DDT acts both contact and stomach poisons. These will be explained in the following.



### 1. Cresylic acid

Cresylic acid is toxic to both larvae and pupae. For use as larvicide, the creselic acid must be emulsified with soap. The original Panama larvicide was made with a rosin soap as the emulsifying agent; 200 pounds of powdered rosin with 30 pounds of caustic soda were added to 150 gallons of crude carbolic (cresylic) acid, with heat and stirring. Whale oil soap, or other cheap soap may be used as emulsifiers. The preparation is best done by manufacturing chemists who have proper equipment. The larvicide is applied in the proportion of 1 part to 30,000 parts of water. It will be said that dilution shall be 100 percent effective in killing the larvae and pupae within a period of 2 hours. It may be used with oil for quick killing larvae and pupae, in the case of very windy condition. It also can be used to eliminate mosquito in tree hole.

### 2. Pyrethrum

Pyrethrum is the dried flower of *Chrysanthemum cineraraefolium*. Its essential principle is termed pyrethrin, which is very toxic to many forms of insect life, especially mosquitoes in both the larval and adult



stages. It has been extensively used as insecticide. It is the least toxic to manals of all insecticides commonly in use. The most extensively used extract has been one containing 2.5 per cent pyrethrins which produces a finished spray of approximately 0.1 percent toxic principle when diluted with 19 parts of kerosene. This material prepared an emulsion of kerosene extract (extracted from 1 pound of pyrethrum flower per gallon of petroleum solvent) emulsified with water and soap (66 percent kerosene extract with 34 percent of water containing 3 percent to 5 percent of soap). This stock emulsion was diluted 1 to 10 with water for field spray. Use 55 gallons per acre for killing mosquito larvae.

### 3. Paris green

It is one of the most successful of all larvicides, when used against surface-feeding larvae. The chemical name is copper aceto-arsenite ( $\text{Cu H As O}_3 + \text{Cu C}_2 \text{ H}_3 \text{ O}_2$ ). It can be used as dust to the water surface by machine blower or by hand or by aeroplane. The Paris green is diluted with road dust, hydrated lime, finely powdered char coal, finely powder talc or other inert finely

powdered materials. It effects as stomach poison by small particles being ingested with larval food. This poison is mixed with the diluent in the ratio of 1 part of paris green to 99 percent of diluent (by weight).

Paris green may be applied in liquid form as a spray by using concentrated ammonia as the solvent, then added to large volume of water produced a colloidal solution of toxicity to mosquito larvae. The ratio of the solution is 20 grams of paris green to 100 C.C of concentrated ammonia, and using this solution with five drops in a litre of water as larvicide to spray.

#### 4. Dichloro-Diphenyl-Trichloroethane (DDT)

This material is very powerful culicicide. It is prepared by heating an anhydrous mixture of chloral and chlorobenzene with concentrated sulfuric acid. The product occurs as melted needles which melt at 105° C. It was originally known as Gerasol. It is an almost odorless, white, crystalline powder having a tendency to form lump. It is not soluble in water but it is soluble in kerosene and vegetable oil, and highly soluble in organic solvent as benzene, trichloroethylene, xylene, and acetone.

The solvents are inflammable and explosive. This solvent can be used in the form of emulsion, DDT oil solution, or dust. In the form of emulsion, it may be made if 25 percent DDT, 10 percent triton X - 100, and 65 percent xylene or other solvent and add to water and stirring for long time. Using one volume of concentrated is mixed with four volumes of water to produce 5 percent emulsion of DDT for larvicide. DDT oil solution is the form of DDT and solvents as diesel oil, kerosene, or fuel oil. The rate of using DDT oil depends on the requirement of that area, generally use 1 percent solution when use with pressure spray equipment as larvicide. In the form of dust DDT is used in the same way as Paris green. It is applied as a 10 percent DDT in talc, or other inert dust at the rate of 0.1 to 0.2 pounds DDT per acre, using one pound of dust mixture.

#### 5. Phenothiazine

Phenothiazine, the chemical name is thiodiphenylamine or  $(C_6H_5)_2SNH$ . It can be used for control of mosquito breeding in artificial containers. It is a pale yellow green powder, and is not soluble in water. It is stable

when kept dry, but oxidize slowly when exposed to air and moisture. In using against mosquito, it is not toxic to warm blooded animals and to plants, but it will kill fish.

For use as larvicide, it is mixed with a wetting agents such as sodium lauryl sulfate, or other dry powdered emulsifier. For control larvæ use 10 percent of wetting agent and 90 percent of phenothiazine. The small amount of mixture will suffice to keep water free from mosquito larvæ for several months. However, it is necessary to test water before using this material because under different condition have some difference in toxicity of phenothiazine.

#### 6. Miscellaneous poisons

These poisons are borax (sodium borate), nicotine sulfate, calcium arsenite dust mixed with chalk, white arsenic and copper sulfate, chloropicrin, calcium cyanamide and rice bran. These agents are used as larvicides by taking in the water.

(3) Naturalistic Methods



It is the fact that nature may be the builder and destroyer. From this reason, nature will be used for control of mosquitoes. Nature, in this case may be meant the living things, such as birds, fishes, or dragonflies. Dragonflies, birds prey upon the winged mosquitoes. Dragonflies larvae, fish and other aquatic insects feed upon the larvae and pupae of the mosquito. Besides the living things, the non-living things may be used as destroyer, such as the changing of nature or other cases which will be explained in the following paragraph.

Naturalistic methods are divided into three methods:-

1. By chemical
2. By physical
3. By biological

The naturalistic methods which mentioned in this part are the methods of mosquito control in larvae stage and pupae stage.

By Chemical(1) Changing salt (NaCl) content of water

This case means the changing of salinity of water in swamp area, especially in salt area. In fresh water, it will be changed by increasing the Salinity of water. Thus the mosquitoes will not lay egg in that place. A few years afterward, the water in that area is allowed to freshen. It will reduce the mosquitoes. It is suitable for salt marsh area or places near salt water area.

(2) Pollution

This method is using the foul water of high organic content to control the mosquitoes. It will be the way to prevent some area from breeding of mosquitoes. The place is deliberated by polluting the breeding water with decomposable organic matter. Cut vegetables of various types packed into the breeding pools or swamps, so that it rots and fouls the water. This condition will prevent the Anopheles mosquitoes in breeding because the Anopheles like to lay eggs in clean water. But some species of mosquitoes like to lay eggs in foul water, such as Culex quinquefasciatus which found in Bangkok in great number.

In using the herbage, it should be packed into water until it extends above and cover the surface. In India uses cactus to prevent breeding of Anopheles.

In some places which have the stagnant water, it may be changed to foul water with decomped organic matter. This place will not be the breeding place of some species of mosquitoes.

#### By Physical

There are many conditions which will be used to control the mosquito. These conditions are explained in the following paragraphs.

#### (1) Drying by agricultural use or by special planting

The ground may be dried by the agricultural use because the plants use the water for its growing and then it will cause the ground drying. Some special plants when they are planted, they make that place like the mat, which is valuable in reducing the breeding of mosquitoes. The special plants are floating mat, floating leaf, such as lotus, alligator weed, water lily, musk grasses, duck weed.



(2) Natural fill (Siltin)

The sedimentation of silt may reduce the breeding places of mosquitoes because the places will be shallowed. This case will happen in the place where the water did not flow or slowly flow, such as water in front of dams or dykes. The sedimentation of silt or other small particles will occur and will cause the bottom of that water source being shallow. In swamp area or marsh area or other place like this may be controlled in the same way as explained above by closing the passing way of the water that will cause the shallow area. This is a method of mosquito control by nature.

(3) Setting water in motion

This method is made by using the water in motion, it may be made by wind or other case like this. This condition will make the water surface in the condition of wave or moving that will prevent the mosquitoes to lay eggs. This will reduce the number of mosquitoes.



(4) Intermittent drying

This method is provided by drying the ground at once time and then have water at once time. This case have water over that area about five days. In this period, the eggs hatch into larvae. Then the water is drained until drying, the larvae will die before it become the winged mosquito.

(5) Fluctuating water level

It is the method of changing the water level all time. Such as increase the water level above the normal level and then decrease the water level below the normal level and make it alternately. If the condition is completed, the eggs of mosquitoes can not hatch into larvae because they strand on the ground or shallow places in that area after drainage. This method will also protect the floating matters and make them stranding.

(6) Flushing

This is the method of using large volume of water in overflowing the area and then discharge until drying. This method is made alternately. By this method, the larvae are swept downstream or are destroyed by stranding.

Flushing device can be installed at interval along the breeding length so as to reduce suddenly a large quantity of water accumulated behind dam. Flushing devices consist of dam, or weir across the stream and discharge gate or a apparatus which can rapidly discharge the large volume of water.

(7) Controlled reflooding and redraining

This method is employed in the control of mosquitoes. It makes by flooding the marshes for several days until the eggs hatch into larvae, and then draining the marsh rapidly before the larvae develop into adult mosquitoes. This area is allowed to remain unwater for one month and then flooding is repeated. This is suitable for control of salt-marsh mosquito. This method is also suitable for the place where the tide water do not occur frequently. The period for complete flooding and draining is about seven to ten days.

(8) Surface, especially by wind

In this method the water source which may be breeding place must be clear and free from obstructions, such as vegetables, grasses, or other plants. It can be made by

hand with knife, shovel and rake to clear the bank of the river; canal, or impounded water. Thus, the wind will blow through that area and mosquitoes cannot lay its egg, because of lacking plants, vegetables or other plants. The water surface becomes the wave which prevents the mosquito laying. It will be another method of mosquito control.

(9) Shading to exclude sunlight

Mosquito control in some water sources can be done by cutting trees and plants to exclude sunlight shining to the water surface and the neighboured area, and it will be useful for the mosquitoes in sheltering. When trees or plants cannot be the shelter of mosquito, the mosquitoes cannot lay its eggs and will reduce the number of mosquitoes.

(10) Clearing to expose sunlight

This method can be used for the water sources which have some floating matters, vegetables, grasses and other kinds of plants. This can be prevent breeding of mosquitoes by clearing the water. We know that plants are the shelter of mosquitoes and also be the shelter of larvae by perching on the roots of plants. When these plants are removed, the Sun shines to that area and will cause the water being hot.

Then the larvae may die and the mosquitoes cannot rest.

It will reduce the number of mosquitoes.

(11) Muddying

The place will be made to be marsh and remain the water at one period and then the water will dry. The mosquitoes may lay eggs and will be the larvae when there are water, and they will be die if the water dried.

(12) Constant level flooding

By considerable that place is desirable and necessary to keep marsh flooded at all time, The mosquito abatement can be maintained if the following requirements are met:-

1. The water level is maintained at constant elevation.
2. The marsh is kept will stocked with larvicides fish.
3. The fish have access to all parts of the marsh.
4. The water is kept in circulation.

The water can be enclosed with dyke and furnishing a sufficient supply of water. Pond can be kept fresh water from a stream by diversion or pumping. Pond on tide water can obtain circulation by holding the water height at about

mean tide elevation by means of weirs at inlet and outlet. The gates may operate with automatic device or by hand. The water will have the constant level, and the activities of the fish should prevent the development of mosquitoes.

#### By Biological

It is the method of using of biological knowledge to control the mosquitoes. These methods will be explained as follows:-

##### (1) Natural enemies

The mosquito, like most animals and insects, has its natural enemies. Dragon flies, birds, and bats prey upon the winged mosquito. Dragon-fly larvae and other aquatic insects feed upon the larvae and pupae of the mosquito. All of the natural enemies, only fish appear to be useful in mosquito control.

Mosquito control by means of fish is the cheapest method that has been discovered so far. However, it have their limitations under natural conditions. The fish which mentioned in this part are fighting fish, gold fish, catfish, and the others. The most important fish are several species

of minnows. The top-water minnow, whose scientific name is *Gambusia affinis* are the fish of more widely use. It gets its name of "top-water minnow" from its habit of surface feeding, which makes it especially effective against.

Anopheles larvae. It grows to a maximum length of approximately 2 inches. It is very hardy and is able to live well in brackish water, fresh water, or water with some pollution. One specimen has been observed to eat 165 mosquito larvae in one day. It has an important thing to be considered, some fish are not suitable for all parts of the country, so the local fish or some kinds of fish will be chosen to use in mosquito control.

(2) Elimination or Destruction of aquatic food supplied

Some chemical agents such as copper sulfate will be used for destruction of food supplied. This chemical agent will kill all vegetation aquatic and also poison to the organic food supply of mosquito larvae. That is a method of elimination the mosquitoes. The dosage require to kill the organism is about two pounds per million gallons of water. The dosage which is larger than this should be avoided because of killing fish.



## Adulticidal Methods

Adult mosquito control were employed to avoid the nuisance of mosquitoes and preventing disease. The control works can be divided into three manners.

1. Mechanical Methods
2. Toxic Substance Methods
3. Naturalistic Methods

### (1) Mechanical Methods

These methods are used to prevent and destroy the adult mosquitoes by means of mechanical equipments. The methods are as follows:-

#### Screening

Screening is one of the methods of mosquito control in biting and eradication of mosquito transmitted disease and protecting the dweller against the discomfort of mosquito. In using screen, the four fundamental idea must be kept in mind. They are:-

- (1) The kind and size of screen must be suited to the exposure or climate condition.

(2) The screen must be protected or reinforced where necessary against mechanical breakage due to ordinary usage.

(3) All apertures must be closed so as to prevent access by insects.

(4) Ventilation with screening must be good so that the habitants will not prefer in warm weather to remain outdoors in the evening or at night.

Most screening is made of iron wire, generally galvanized. Wire of other metals, such as bronze and copper may be used, and they have longer life. The life of screening depends upon the climatic conditions and usage. Now, noncorrosive screening is used widely and longer-lived than metal. The plastic strands are thicker than metal wire. The wire cloth of 12-mesh material having 12 openings to the inch each way, is too large an opening and will allow a very large percentage of mosquitoes to find entrance to the room. Wire of 16-mesh gives good protection against mosquitoes, but it will allow some smaller of the Culex to enter. Screens which are already in place may be improved by giving the wire one or more coats of special screen paint. Screen is also used to cover



impounded water, such as pools, jars, wells and barrels, for preventing it laying eggs.

The most efficient method of screening window is to cover the whole outside of the window by fastening the screen wire to the outside frame of the window by means of the strip of wood. This complete covers the window with no opportunity for the shrinkage of screen frames to allow the entrance of mosquitoes. The next best screen is the type that has a frame which fits into the frame of the window on the outside, suspended at the top and fastened with a hook at the bottom. Screening is widely used to control the mosquitoes, because it is effective in preventing of mosquitoes.

#### Mosquito net or bed net

In this case, it means the screen made of wire cloth for covering the bed. It is used for sleeping outdoor or indoor when there is no screen. Bed net should be of sufficient size to hang well away from the bed, so that no part of body touch the net during sleep. The net is reinforced with cloth at edges and corners and strongly sewed, and the skirt is long enough to fall on the ground

or floor with several inches to spare, or to be adequately tucked in under the mattress. For sleeping, a bed net will give sufficient space for comfort about nine feet long, and five feet wide, with sides about five and one-half feet high. Mosquito net material should be a stiff bobbinet with effective aperture not over 0.05 inch. This equipment will also use for control of mosquito.

#### Deterrents

This case means the using things that mosquitoes fear and cannot bite the human or cannot stay in that place. These things are fan and punkahs which is used by blowing with hand or using electric fan blowing. This method is used for temporary control.

Another kind of deterrent, that is simple method. By using the wind blow through the place or house which will prevent mosquitoes from biting and nuisance. This method is used because of the habit of mosquito which will like to rest and bite in the calm place without wind. Thus it will reduce the mosquito brood because it cannot lays eggs, and cannot breed.

### Trapping

The trapping mosquito is worked by using the equipment and bait. The equipment using light as the bait is called mosquito light trap and is the New Jersey type. The figure is shown in Fig.D. In using, this equipment is hanged above the ground from five to six feet and is in the place without wind or has no windy, or in the place which does not interfere by other light.

Another type of trap has been used by using animal as the bait. The animals are donkey, cattle, horses and other animals. The animal is kept in pen with large screened window on the sides so arranged that mosquitoes are diverted to slit in the screen wire or louvered area situated below the screened area which allow them to enter. After feeding, the mosquitoes are unable to escape and can be captured on the following morning.

### Hand catching and killing

Hand catching can be accomplished with a killing tube. The killing tube can be made from a test tube or similar container fitted with a cork stopper. Wads of

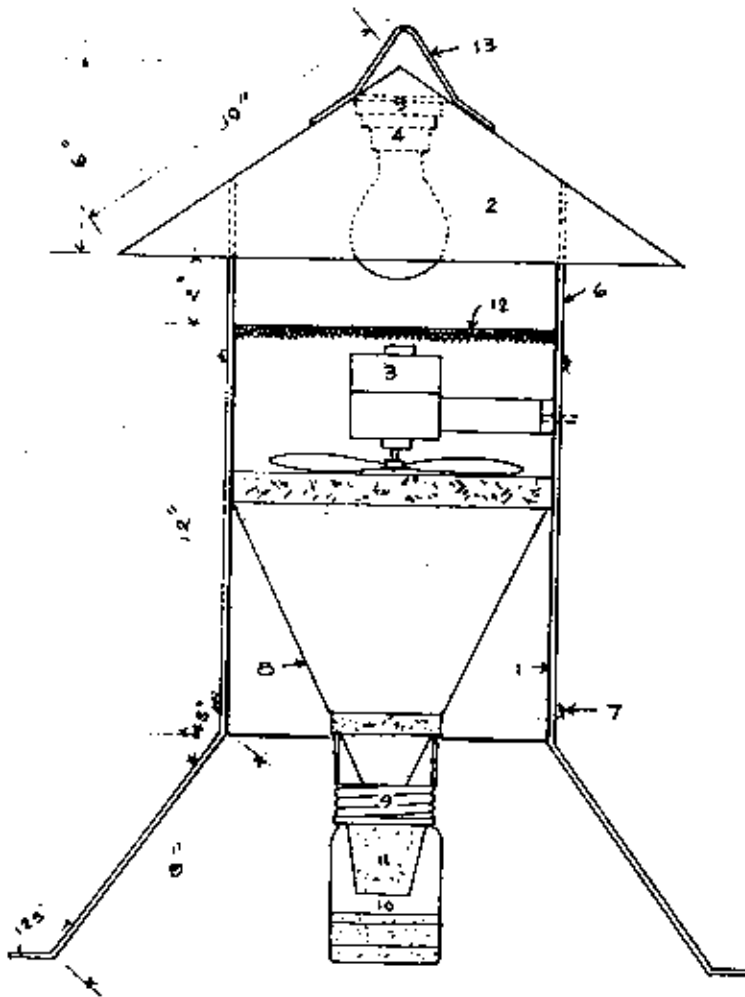


Fig. D

New Jersey Light Trap

Mosquito Light Trap ( New Jersey Mosquito Trap )

This device that shows on the previous page by numbers, those numbers are :-

1. Galvanized iron cylinder, 22 gauge; 9 inches inside diameter ( cut away to show interior ).
  2. Roof of galvanized iron.
  3. Motor and 8-inch fan.
  4. Porcelain receptacle for light bulb.
  5. Sponge rubber to absorb vibration.
  6. Three supporting ribs of ban iron ( 1/8 in. by 1 in.)
  7. Screws and nuts for assembling trap.
  8. Screen funnel of 16 mesh bronze wire.
  9. Mason jar cap.
  10. Jar with cyanide for killing insects.
  11. Perforated paper cup.
  12. Galvanized screen 3/8 inch mesh.
  13. Loop for carrying or hanging trap.
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cotton saturated in chloroform and placed in the bottom of tube under wadding cut from blotting paper kill the specimens. When using the tube is placed under or over the resting mosquito and the chloroform cause it to fall into tube. Besides this, the mosquito can be captured by swing net or hand killing.

#### Removal of houses or village to sites beyond flight range

It is the method of removal the houses or dwelling far from the breeding place. The flight of mosquito is in the range of one mile from the place, but all of them usually fly near breeding, except the salt marsh-mosquito that will travel long distance. This method is impractical for mosquito control but it only avoid the annoyance of mosquitoes. This method give a little result.

#### (2) Toxic Substance Methods

In mosquito control of adult stage by using toxic matters, there are two methods of applying which will explain in the following paragraph. These control methods are made by spraying, fumigation, and using some chemical repellent. Before using by these methods, the

toxic material must be studied and must be considered that they have an effect to mosquito or not. It can kill the mosquitoes or cannot kill, and will also kill another insects or not. In the case of mosquito if it does not die it will build the resistance to the toxic materials. Thus the toxic material is useless in afterward. In using, it is necessary to consider the advantage or disadvantage. These toxic materials are DDT oil solution, pyrethrum solution, benzene hexachloride, chlordane, dieldrin, lindane, malathion and parathion. The latter two names are use for housefly control and is approved for use in dairy farms. In using these toxic materials they are worked by using these methods.

### Spray

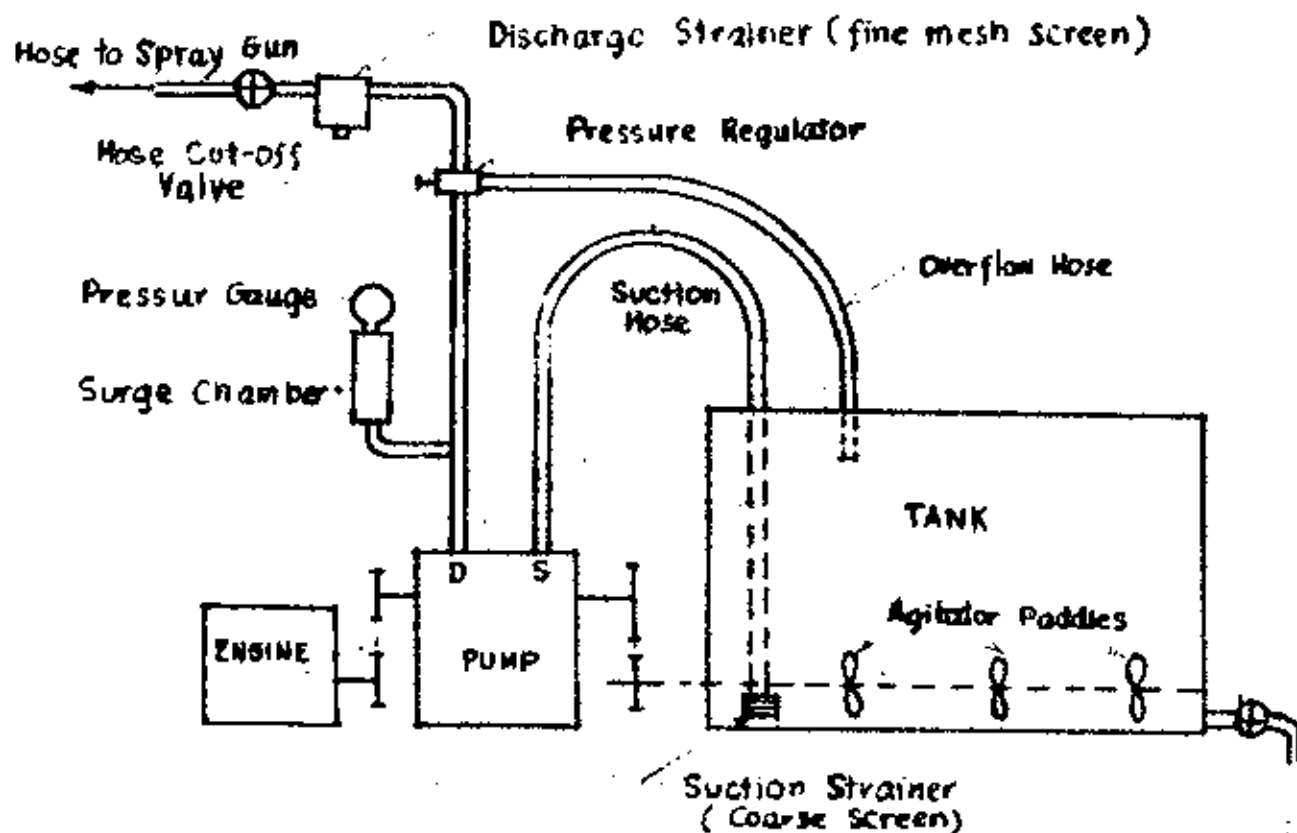
By spraying, system of atomizing nozzle, the insecticide is in the form of atom to the wall, ceiling or resting place of mosquitoes. The toxic material is formed in minute crystal on the surface of wall or etc. It will poison to the mosquitoes which rest upon the wall or other place which have the poison of toxic material. It is the habit of mosquitoes that will rest on the wall after biting. In one spraying it will remain the poison for several days.

The equipment for spraying may be hand sprayer or power sprayer. Hand spraying equipment is knapsack sprayers type. This equipment is pumped by pump mechanism and fill in the container; the other type has the pump set in the container and is operated by lever extending over one shoulder. Power spraying is operated by man, the gasoline engine drive the plunger pump, and spray on the place. The man does not pump the equipment, the engine serves in place of man, man is only operator. Diagrammatic sketch of power sprayer is shown in Fig.E.

### Fumigants

It means the using gaseous poisons to kill mosquitoes. In using the toxic matters, such as DDT, or mixing of another kind of toxic matters with DDT, such as DDT with oil solution, with BHC, is sprayed in forme of fume or gas over the area of mosquitoes. The other chemical using in fumigant are hydrogen cyanide, sulfur dioxide, nicotine, para-dichloro-benzene, etc. This method is applied by mean of sprayer or aeroplane in form of gas or fume. In using aeroplane will give the good result because it can cover more area than other method but it has the disadvantage in killing some useful insects.





DIAGRAMMATIC SKETCH OF POWER SPRAYER

Fig. E



### Chemical repellents

They are the chemical for dispelling mosquitoes. Some of these chemicals are effective and some are not effective or have a little effect. All of these chemicals does not give the full result, they give only a short time for three to fives hours. Most of them were mixtures of oil of citronella with various added in gredients such as camphor, eucalyptus oil tar, oil of cedar, or carbohic acid.

Some chemical repellents can be applied to the skin. This is Dimethyl phthalate which is effective against Anopheles species, and 2 - ethyl - 3 hexanedinol (612) is the most effective against Culex. Indalone is quite effective against salt-marsh Aedes species. These materials are liquids which are applied to the exposed skin surfaces, and to those parts of the clothing. Dimethyl phthalate and 612 are effective for as long as four hours under sweating conditions, and for about twice as long if not sweating profusely. Some of the repellents is used by burning and make it smoke. Chemical repellent may be applied as spraying, such as pyrethrum - kerosene emulsion. It is used fifty gallons per acre of one to ten dilution.

This method is used for preventing the annoyance of mosquitoes. It is not the direct control.

(3) Naturalistic Methods

Nature may be the constructor of insects animals, and trees or plants, but it may be the destroyer in the same time. Nature can be applied as the direct destroyer or indirect destroyer. In mosquito control, the nature may be used as destroyer. The destroyer may be direct or indirect part which will explain about the different method in the following paragraph. This method is divided into three kinds, they are:

- By chemical characteristic
- By physical characteristic
- By biological characteristic

Chemical characteristic

By using some chemical substance have in the nature. The chemical substance may be sulfur or carbon. These substance when it is burned, it give the poison-smoke. This smoke will effect to the insect and it will die. These materials are used in limited area for best result.

However these materials are only temporary control and use for preventing annoyance.

### Physical Characteristic

#### Clearing, destruction or removal shelter

This means to get rid of obstructor by destroying or removal. The obstructor may be small plants grasses grown along the swamp, or pond or drainage. These plants are the shelter of mosquitoes, it would be cut or use some poison chemical for killing. In calm place without wind blowing, such as space between wall and cupboard or inside corner of house, these are the shelter of mosquitoes. These places should be clear without web and expose to wind. That will prevent the resting of mosquitoes.

#### Creation of plant barriers to flight

This method is used by planting the tree which obstruct the flight and these plant will also are the resting. Then it is the simple method in killing by using toxic agent, such as DDT or other kind of insecticides. In other way, the big plant will control the small plant in growing because it cannot get enough the light for synthesis of carbohydrate and will cause. the small plant

die. Thus it also be the method of control.

#### Rendering dwelling

It is the translation of house from annoyance of mosquitoes, Such as in the bed room, it is used the mosquito net covering bed, or using window screen or door screen, or airconditioning room. Sometimes, it expose to wind. It is also the method of arrangement the house in the suitable form for preventing breeding place. The vicinity should be cleared with out small plants, swamps, pools and marshes. Water should be drained into a sewer or into an septic tank. Water barrel, rain barrel should be closed. Septic tank effluent should never be allowed to run upon the ground surface but should be disposed by passing sand bed. The tank should have a mosquito proof cover. Water troughs for cattle, horses should be completely emptied and cleaned. Ornament pool and fountains must be watched if the aquatic plant growing in them. These plants should be cut. This arrangement will use in mosquito control.

### Biological Characteristic

This is the method of control by using the living as the destroyer, changer, or use the condition of climatic as destroyer. These are briefly explained in the following paragraphs.

#### Natural enemies

The natural enemies of mosquitoes are dragonflies, birds, and bats. These enemies feed on mosquitoes at different time. Adult dragonflies are adept at capturing mosquitoes on the wing just before and at sunset. Dragonflies do not fly at night, when night-flying mosquitoes are on the wing. Bat are insectivorous and feed on mosquitoes at night, but are not effective enough to be large factor in control. Birds of dusk eating are also feed on mosquitoes.

#### Deviation by animal

This method is used the animal as the bait. It deviates biting from human to animal. It has certain amount of usefulness in reducing the tendency to attack by mosquitoes. This method is placed the barns or quarters of any domestic animals such as horses and cattle between the houses and the known mosquito breeding areas. There will

be a tendency for the mosquitoes in migrating to fill up on these animals. Thus, it will reduce the attacking of mosquitoes to human, this is another method of mosquito control.