

## Public Health Section

### D.D.T.—AN IDEAL INSECTICIDE AND LARVICIDE

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RECENT award of the Nobel Prize for medicine to the Swiss scientist Dr. Paul Muller for his discovery of D.D.T. is an event of great importance. It was after many years of research devoted to synthetic insecticides, with the hope of replacing the vegetable insecticides by substances capable of being manufactured as required and capable also of modification to meet particular requirements, that Dr. Paul Muller of the firm J. R. Geigy A. G. of Switzerland discovered D.D.T. The early patents protecting its use as an insecticide date from March 1940.

#### Ideal insecticide

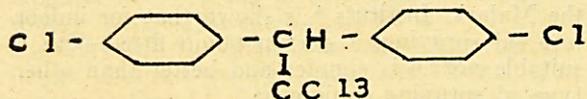
During the period of research the following qualities were aimed at for an ideal insecticide :—

1. Toxicity to insects of many types combined with safety when in contact with mammals and plants.
2. Stability in order that it may continue to kill for the longest possible period.
3. Power to persist in presence of sunlight, rain, growing plants and soil, etc.
4. Lack of stain.
5. No offensive smell.
6. Ease of manufacture.
7. No harmful effects on fabrics, metal and furniture.
8. Low cost.
9. Adaptability to many methods and purposes.
10. Pleasant aromatic smell and certain degree of repellent action.

Tested by these criteria, D.D.T. (dichlorodiphenyl-trichlorethane) is closer to the ideal than any other known insecticide. Only quality lacking is no. 10.

#### Chemical composition

As above stated D.D.T. stands for dichlorodiphenyl-trichlorethane. It may be expressed as



#### General properties of D.D.T.

D.D.T. can be used as a solution in some organic solvent or again after making solution in

that solvent it can be emulsified with water. Also as a dust it has been used. There are many possibilities of its dissolving in many solvents and then being emulsified by a number of different agents. Sometimes it can, after being dissolved in an almost non-volatile mineral oil, be emulsified and then sprayed on water. It will then float on water. As an alternative it may be dissolved in some much more volatile material and then used as a spray after being emulsified. In that case, after the solvent has evaporated, dry D.D.T. and traces of emulsifier are left behind. In this way it can be effectively used on the surface of the wall.

D.D.T. is known to be quite compatible with extracts of pyrethrum. The use of pyrethrum as an insecticide has been mentioned in an article published by me in March 1938 issue of the *Indian Medical Gazette* on antimalarial measures in railway area at Delhi. On account of its pleasant aromatic smell and certain degree of repellent action it exercises on certain insects, pine oil has been used as an adjuvant when using pyrethrum as an insecticide.

Approximate solubility of D.D.T. at 27° to 30°C. is given below :—

| Solvent                          | Grammes of D.D.T. per 100 ml. |
|----------------------------------|-------------------------------|
| Cyclo hexanone                   | 100 to 120                    |
| Ortho dichlorbenzene ..          | 63 to 71                      |
| Acetone ..                       | 50 to 55                      |
| Carbon tetrachloride ..          | 46 to 48                      |
| Methyl salicylate ..             | 39 to 41                      |
| Ether ..                         | 27 to 28                      |
| Pine oil (Hercules 'Yarmor 302') | 15                            |
| Cotton seed oil ..               | 9                             |
| Kerosene, crude ..               | 8                             |
| Kerosene, refined ..             | 4                             |

D.D.T. tends to be more soluble in the less highly refined oils.

Solubility in water is very low. D.D.T. is heavy and its addition to crude oil might produce a solution so heavy that it would sink in water. D.D.T. is so highly insecticidal that the solution in water cannot be considered to be harmless to such insects as mosquito larvæ.

In the year 1945 the Railway Board set up an 'ad hoc' committee of research under the chairmanship of the C.M.O., N. W. Railway. The committee tried to incorporate D.D.T. in paint with efficient action. A third class bogie was painted with such paint as an experiment, but the experiment was believed to be a failure, as particles of D.D.T. were no longer available for ingestion by mosquitoes. The committee, further, established that not all samples of

D.D.T. are satisfactory. Present-day commercial samples vary somewhat widely in their purity, depending on the process used in manufacture and on whether the material has been recrystallized. Much that is at present available has a purity of 60 to 70 per cent. The principal impurity (the ortho para compound) has been isolated and shown to be only slightly insecticidal. It has also been established that for accurate work one should either use chemically pure samples or state the amount of the pure para compound in the material which was used.

From the list given above of the solubility of D.D.T. it will be seen that D.D.T. dissolves better in crude kerosene than in refined kerosene.

Most effective D.D.T. is known to be obtained from the United States of America and other samples are known to be 60 per cent less effective. D.D.T. in oil is more effective than D.D.T. in dust. 100 per cent solution is obtained in cyclo hexanone but at present the price is hardly justified. According to Campbell and West (1944) American production had reached three lakh pounds per month when their paper was published in September 1944.

D.D.T. is stable in the presence of light, ultra violet, water vapour and boiling water. It is without effect on metals, fabrics, leather and dyestuffs. In view of its use, however, with organic solvents or emulsion, such a spray may do harm to paints and varnishes.

D.D.T. acts as a contact poison and its action on insects is generally slow probably due to its very low solubility in watery fluids.

#### *Special applications*

Uses of D.D.T. as an insecticide and larvicide against mosquitoes and those particular types of insects which are important to our society are given below :—

##### (A) *Mosquitoes*

(i) As a larvicide it will produce a less dramatic improvement and, unless care is taken to ensure that it is properly developed, it will meet the fate of paris green which has been recently discredited in many large areas. Application from the ground reduces the amount of oil needed from 20 gallons to half a gallon per acre. It might be said that the use of paris green similarly reduces the weight and cost of larvicide used. The labour of application remains much the same. Supervision is more difficult and consequently employment of more highly skilled labour is essential. There is physical difficulty in the application of such small quantities evenly over large water areas and the types of apparatus now in use are not quite suitable. Little reduction in cost or increase in efficiency will result if it is used as a mere substitute but this could be achieved if it was no

longer considered necessary to ensure application to every part of the breeding area or if somehow a prolonged larvicidal effect could be obtained. Prolonged effect in small water areas following the introduction of balls made of a plaster of paris sawdust mixture incorporating the larvicide has been needed.

The use of aeroplane for the distribution of D.D.T. in oil was originally regarded as a larvicidal measure. There is evidence that it is very effective specially on large bodies of water but it is found that some of the oily spray contaminates surfaces and kills many of the adult mosquitoes. Moreover, it does not only kill day-biting mosquitoes which might contact the spray particles while in flight but it also kills night-biters (*Anopheles*), which, presumably, pick up D.D.T. from surfaces on which they alight during the night after the spraying.

(ii) *Adult mosquitoes*.—Most sprays for use against mosquitoes or flies now rely on D.D.T. to kill the insects. Some pyrethrum extract may be added if a quick knock-down is desired. For spraying of passenger aeroplanes these sprays are now being used.

The effects of residual spraying against adult mosquitoes have been so good that it seems possible that this may prove to be the best method of using D.D.T. for routine malaria control in civil population. The main use of D.D.T. has been as a residual insecticide and of necessity practical work has been running alongside or even ahead of experimental work.

D.D.T. has been applied for this effect in the form of kerosene solutions, emulsions and as a dry dust. The results appear to be much the same but are less satisfactory with the dust. As a preliminary precaution, the oil used as a solvent should be tested to ensure that it is not repellent, a practical possibility which has been at one time a serious source of trouble.

It is considered that theoretically thorough spraying once every three months should suffice, but in practice under service conditions to derive maximum comfort and protection, monthly re-spraying is recommended.

Trials to ascertain the comparative efficacy of various preparations of D.D.T. as indoor residual sprays were carried out by the Malaria Institute of Delhi in seven villages in the Delhi rural areas. This work continued temporarily due to extensive flooding of the rural areas and on account of disturbances that took place in Delhi in 1947, and this work is being continued this year. Experience of work carried out by the Malaria Institute has shown that for indoor residual spraying, a stirrup pump fitted with a suitable nozzle is simpler and better than other type of spraying equipment.

##### (B) *House flies*

There is little published information on which one could precisely evaluate D.D.T. as a spray

against adult house flies. The following combinations have been known to be effective against adult flies :—

|                      |               |               |
|----------------------|---------------|---------------|
| D.D.T. 0.10 per cent | + Pyrethrine  | 0.03 per cent |
| D.D.T. 0.05 per cent | + Pyrethrine  | 0.05 per cent |
| D.D.T. 0.10 per cent | + Thanite     | 2.0 per cent  |
| D.D.T. 0.10 per cent | + Lethane 384 | 2.0 per cent  |

The above mixtures give a very high knock-down in 10 minutes or less, as well as a kill of 90 to 100 per cent. Used alone D.D.T. will give no knock-down but 80 per cent kill.

Residual films will probably prove even more valuable in fly control than sprays. The adult flies are susceptible to traces of dry D.D.T. in the surface on which it settles. There is also evidence available from different parts of the world that one application of the above mixture will keep a cowshed clear of flies for the duration of a European or North American summer. The method is applicable to restaurants, markets, latrines, screens and to almost any surface on which flies settle. A very minute dose is effective on glass, probably on account of the fact that D.D.T. crystals are readily detachable and all on the actual surface. It is, therefore, quite possible to put an invisible film on the inner surface of a window, and be free of the buzzing of flies for weeks.

D.D.T. in the form of a residual film is quite effective and this may, therefore, prove very valuable in tropical slaughter-houses, in the markets and so forth. It may also be sprayed on animals to kill the flies which contact them.

#### (C) Head and body lice

The essential point in dealing with an outbreak of lice on a large number of human beings is to use some insecticide which has a lasting effect. The Geigy Company in Switzerland were the first to discover D.D.T. for the control of head and body lice. They have been advertising from the later part of 1942.

D.D.T. dust experiments have been made. A cloth sleeve is slipped over the arm or leg of an experimental subject, lice and powder introduced into it and the ends fixed to the skin above and below with adhesive tape, results were examined after 24 or 48 hours : if all lice were dead, more were introduced and the experiment continued (sleeve and powder remaining in position) till insecticidal action of D.D.T. became very weak. D.D.T. showed itself very potent and much more lasting than other materials and further tests were carried out in which men's underclothes were dusted and then infested with several hundred lice. 10 per cent D.D.T. dust is now widely used. The effect lasts for 2 or 3 weeks and may kill lice after that, assuming that the person does not wash his garments. For men in winter clothes 1½ ounces per treatment suffice.

Very wide use of D.D.T. dust in the control of the epidemic of typhus in Naples early in 1944 was made. The method of application of the dust was by hand-blowers, dust being puffed up the sleeves and trousers' legs, down necks

and into the waists of shirts and trousers. This method is very quick and seems to have been proved effective.

An even more effective way of using D.D.T. in the control of lice is by impregnating garments which then become insecticidal and capable of killing lice even after wear for several weeks and several washes in hot soap and water. An addition of one or two per cent by weight of D.D.T. is all that appears necessary. This can be added to fabrics (cotton or wool) either from solutions in volatile solvents or from emulsions. The emulsions may be particularly valuable for they only require diluting to a particular figure after which a few garments can be 'louse-proofed' in a bucket.

Emulsions have been used to impregnate the hair of the head. A dose of 0.2 gramme of D.D.T. is quite enough for a week for this purpose.

#### (D) Bed bugs

Dry dust 5 to 10 per cent have been used successfully. In the circumstances which generally prevail in houses, dust is more likely to be removed than a spray deposit and therefore less likely to give a satisfactory lasting effect. The exact dose to be put down cannot be precisely defined. The more one puts down, the longer it will last. About 100 mg. per square foot is likely to be satisfactory and will kill any bugs which may be brought in for about three months. 5 per cent of D.D.T. in kerosene or 7 ounces per gallon may be used.

#### (E) Other domestic insects

Cockroaches appear to be somewhat resistant to D.D.T. Against fleas 5 per cent D.D.T. powder is effective.

Generally speaking, some ticks require high dose by the methods of application which have been used up to now. Further work on ticks may prove D.D.T. useful in prevention of tick-borne diseases, particularly tick-borne relapsing fever.

As to the clothes moths there is no detailed information available but it is generally believed that impregnated garments are moth-proof and remain so for a long time.

Most of the observations in the above article are based upon the use of D.D.T. in railway areas and hospitals at Ferozepore and Delhi. The writer was fortunate to get liberal supplies of D.D.T. through the courtesy of the military medical authorities in Ferozepore and Malaria Institute in Delhi. It was as early as the year 1944 that he started using D.D.T. in Ferozepore railway areas and this must be the first occasion when D.D.T. was ever used in any railway or civil area.

My thanks are due to Dr. S. S. Kent, Chief Medical Officer, E. I. Railway, Calcutta, for his permission to send this article for publication.

#### REFERENCE

CAMPBELL, G. A., and J. Oil Col. Chem. Assoc., WEST, T. F. (1944). 27, 241.