FIELD EVALUATION OF MOSQUITO CONTROL IN SEWAGE OXIDATION PONDS USING PLASTER OF PARIS IMPREGNATED BRIQUETTES

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ABSTRACT. During the summer of 1970 a survey was made of the mosquitoes in the oxidation ponds of Douglas, Arizona which are physically located in Agua Prieta, Sonora, Mexico.

An experiment was undertaken to evaluate the longevity and effectiveness of three different insecticide-impregnated plaster of paris briquettes containing Abate, fenthion, and Gardona as mosquito larvicides. Dosages applied in the experiment were calculated on a w/w basis or 5 percent of the toxicant in the total amount of briquettes.

On August 11, 1970, 21 sites were selected for treatment to control mosquito larvae in oxidation ponds. Four sites remained untreated as controls. Treatments were carried out by hand casting the plaster of paris briquettes into the ponds at the rate of one briquette per 4–6 linear feet. Larval population samples were made pre-treatment and post-treatment, 8 hours, 24 hours, 48 hours, and at weekly intervals thereafter.

The test demonstrated that fenthion and Gardona provided the most effective and longest control while Abate was effective for 48 hours but later showed no significant mosquito control.

INTRODUCTION

Field studies have shown that the breeding of mosquitoes in waste disposal lagoons and/or oxidation ponds creates a potential danger to all the inhabitants within a particular population area. An increase in the number of oxidation ponds and waste lagoons along with recent reports of encephalitis has demonstrated the need for adequate mosquito control measures.

Since the beginning of the widespread usage of insecticides, there has been much consideration given to the concept of using insecticidal briquettes for controlling mosquito larvae. The potential use of such briquettes as a long-term control measure against mosquitoes breeding in artificial containers, tree-holes, woodland pools, roadside ditches, irrigated pastures, and intermittent pools appears highly feasible. Their shape and weight would facilitate distribution and penetration of vegetation both from the ground and from the air. Upon penetrating the surface of a pond, the water would leach a continuous amount of insecticide which would be adequate for controlling mosquito larvae until disintegration of the briquette.

Barnes, Webb, and Savage in laboratory experiments (1967) demonstrated excellent control of *Culex pipiens quinquefasciatus* Say larvae using casting plaster and other briquette media impregnated with Abate (o.o.o′,o′-tetramethyl o,o′-thiodi p-phenylene phosphorothioate). W. W. Barnes and A. B. Webb, (1968) also conducted field tests to evaluate the effectiveness of similar Abate briquettes against *Aedes canadensis canadensis* Theobald larvae in woodland pools. It was shown that 4–18 days were required for a toxic level of Abate to build up in pools before control of the larvae could be realized. Again the briquettes were made up first, then the Abate was added either topically by a pipette or by soaking the briquettes in an acetone-Abate solution.

B. M. Glancey *et al.* (1968) conducted tests in Thailand with *Aedes aegypti* (L.) breeding in concrete water jars. Abate was demonstrated to be an effective residual larvicide formulated as concrete pellets.

H. A. Schultz and A. B. Webb (1969) tested the use of pesticide-impregnated

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rubber pellets as a carrier for mosquito larvicides by using Abate in three different formulations. Tests indicated that further studies would have to be conducted to determine the toxic concentration needed for field use.

The incorporation of pesticide in plastic has been discussed by G. D. Brooks and H. F. Schoof (1964) using dichlorvos in a resin strip. These tests indicated that effective control against *Aedes aegypti* in cisterns was possible for up to 6 weeks. Thus far, the amount of vapor from dichlorvos escaping into the air and causing larval kill through fumigation effects has not been established.

J. T. Whitlaw and E. S. Evans (1968) combined technical Abate with polyvinyl chloride (PVC) as a carrier for mosquito larvicides and demonstrated long-term residual control of *Culex pipiens quinquefasciatus* Say. Wilkinson *et al.* (1971) demonstrated that fenthion formulated in polyvinyl chloride and Dursban incorporated in polyethylene and in charcoal gave effective control against *Culex restuans* Theobald for 20–26 weeks in polyethylene-lined field pools.

The concept of using briquettes containing mosquito larvicides to attain long residual action has been closely associated with the use of chlorinated hydrocarbon insecticides which have long residual properties. The questionable tolerance of persistent chlorinated hydrocarbon pesticide residues in the environment has resulted in the curtailment of application of this category of compounds in many areas of the world.

The low concentrations required for effective control and rapid detoxification, with a minimum residue, are the major factors for wide acceptance of organophosphorus pesticides in pest control. An important shortcoming of many organophosphates is the accelerated degradation in alkali media.

This study was undertaken to determine the efficacy of three different "slow release" formulations for mosquito control in oxidation ponds.

MATERIALS AND METHODS

This study was conducted at the sewage-treatment plant in Douglas, Arizona. Raw sewage flows southward from the city of Douglas in an underground pipeline into the plant at an average rate of 44,000 gallons per hour. The effluent from the primary treatment plant discharges into ten oxidation ponds or lagoons located in Agua Prieta, Sonora, Mexico. The ponds are connected in series with 6–8 concrete and wood drain boxes (18″ x 18″ x 30″) at the end of each pond, whose purpose is to control the water depth of each pond and regulate flow.

The ponds were built by the International Boundary and Water Commission in December, 1960, and have dimensions of 150′ x 500′ with an average depth of 4 feet. During this study the ponds received treated sewage which had an average BOD of 44 p.p.m., the PH varied from 6.8–8.2 and the average water temperature was 85.3° F. The effluent of the ponds discharged into an open concrete drainage ditch which led to a corrugated pipe approximately 100 feet long. The overhanging pipe extended into Mexico and eventually emptied onto open pastures 200 yards south of the pond area.

Larvae were collected from the oxidation ponds with an enamel dipper which had a 450 ml capacity. Larval counts at each test site were calculated by taking the mean of the larvae obtained from three dips.

Effectiveness and longevity of the insecticidal briquettes were determined by population density prior to treatment and at intervals subsequent to treatments.

Three formulations of plaster of paris briquettes containing fenthion, Abate, and Gardona were evaluated in this test. Technical grade fenthion (93 percent) in a 5 percent w/w concentration, technical grade Gardona (94 percent) in a 5 percent w/w concentration, and Abate in a 43 percent EC or a 4.3 percent w/w concentration were used.

The briquettes were constructed by:

mixing the plaster of paris with an acetone solution of the pesticide; evaporation of the acetone within 24 hours; and subsequent mixing with water (2:1). The wet plaster was then poured into plastic ice cube trays until firm. The hardened briquettes were later removed from the trays and stored in a hood for a 48 hour curing period. Control briquettes were similarly made but without the pesticide. The briquettes weighed 57.39 g and measured 4.5 x 3 x 3 cm.

The briquettes were later hand cast into the water at the selected sites (Figure 1) at the rate of one briquette per 4–6 linear feet.

The rate of Gardona release from briquettes later recovered in the field was determined by gas-liquid chromatography.

RESULTS AND DISCUSSION

Species Composition of the Ponds. Mosquito larvae collected from the oxidation ponds were identified as *Culex tarsalis* Coquillett and *Culex pipiens quinquefasciatus* Say. The most abundant mosquito in the ponds was *Culex tarsalis* until the latter part of August when the activity of *Culex pipiens quinquefasciatus* increased with lower temperatures and a higher relative humidity. *Culex pipiens quinquefasciatus* was more prevalent in treated sites than non-treated sites.

Mosquito egg rafts, larvae, and pupae were recovered from nonflowing drain boxes and those areas where bermuda grass was prevalent.

The oxidation ponds studied contained emergent and overhanging vegetation. They were frequently anaerobic and ideally suited for excessive mosquito, midge, and other dipterous production. Other aquatic insects were in abundance, specifically: diving beetles, damselflies, water scorpions, back swimmers, and water boatmen. The dominant weed on the banks of the oxidation ponds was horse nettle (*Solanum elaeagnifolium*). Bermuda grass (*Cynodon dactylon* (L.) pers.) made up practically all of the overhanging and emerging vegetation.

Although these ponds were exposed to an abundant mosquito population, mosquito breeding was concentrated in and around certain overflow structures where the water flow was not excessive and those areas where overhanging and emerging vegetation was present.

Previous investigations by Smith and Evans (1967) had shown that the presence of emergent and/or overhanging vegetation is the most important factor leading to mosquito production in oxidation lagoons. The results of this study confirm those findings and include additional factors such as presence of parasites and predators, types of waste, and dissolved oxygen content which has a direct relationship to available food. Anaerobicity seemed to have little or no effect on the mosquito production in the ponds. The mosquito larval counts are given in Table 1. Since they remained fairly constant from the second week after treatment until termination of the study, the intermediate counts are not shown. The 48-hour observation period for Abate sites suggests that the emulsifiable formulation gave an early kill but later showed no significant mosquito control.

This was probably due to the location of these sites within the test area. They were closer to the treatment plant and therefore received a higher amount of particulate matter which possibly covered the briquettes and limited dispersion of the toxicant. In addition, there was a stronger water flow which had an influence on the control failure at the Abate sites.

Fenthion and Gardona gave immediate control within the 48-hour period and each continued to maintain control of mosquito breeding during the summer and early fall months. During the latter part of the study most of the larval dips at the Gardona and fenthion treated sites consisted of first through third instars, indicating that either the larvae reached only this stage and succumbed or there was inhibited development of the larvae. The controls and the Abate sites showed normal development and progression to the

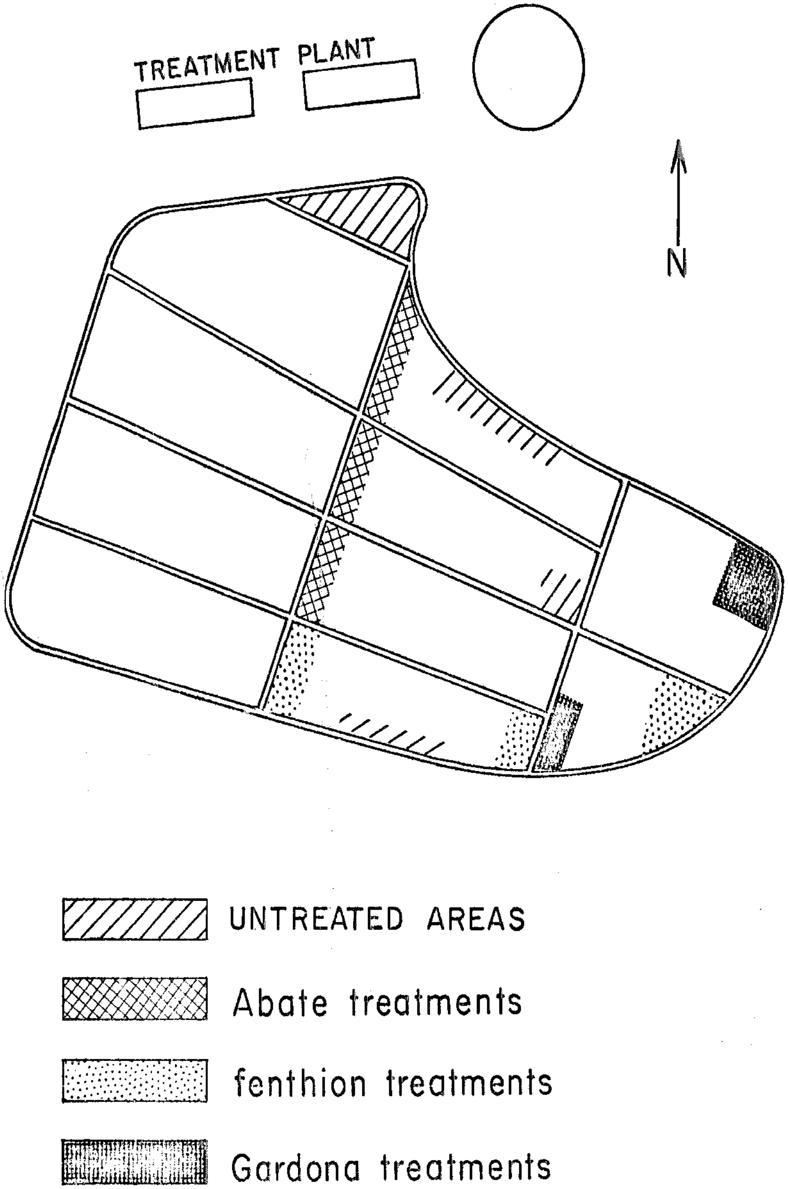

FIG. 1.—A schematic diagram of the oxidation ponds showing the locations of the treated and untreated areas.

TABLE 1.—Mosquito control with fenthion, Abate, and Gardona applied as insecticidal briquettes to oxidation ponds in Agua Prieta, Sonora, Mexico

Site No.	Material	Pre Treat	Average number of larvae/dip counts made after treatment: 1 day	2 days	16 days	51 days
*1	Gardona	5	1	1	20	5
2	Gardona	3	0	0	0	0
3	fenthion	7	0	0	0	0
*4	fenthion	7	0	0	0	0
5	fenthion	5	0	0	2	0
*6	Gardona	9	3	0	0	0
7	Gardona	3	2	2	5	0
8	Gardona	9	5	4	4	0
9	Abate	>100	1	10	>100	>100
10	Abate	>25	5	5	>25	>25
*11	Abate	>50	2	5	>50	>50
12	Abate	>50	8	10	>100	>50
*13	Abate	>25	5	7	>50	>25
14	Abate	>100	10	10	>100	>100
*15	fenthion	>100	0	0	10	3
16	fenthion	>50	0	0	5	2
17	fenthion	>25	5	5	5	0
18	control-1	>100	>100	>100	>100	>100
19	control-2	>50	>50	>50	>100	>100
20	control-3	>50	>50	>50	>100	>100
21	control-4	>100	>100	>100	>100	>100

* Drain gat-treated site.

fourth instar and pupal stage. A statistical comparison of the populations using the Kruskal-Wallis one way analysis of variance by ranks showed that fenthion and Gardona were significant at the .01 level. Abate showed no significance using the same statistical test.

Field test data suggest that adequate dosages were not present, no matter which insecticide was used, when high water flow rates were present. It was also noted that rapid erosion caused a dilution of the toxicant. Inadequate concentrations or none at all were released in those areas where the briquettes were completely encased in sludge and/or scum. This situation became obvious when some of the briquettes were recovered after the experiment was terminated.

Pre- and post-treatment observations at all treated sites were made of various non-target organisms e.g., damselflies, beetles, copepods, etc. and no gross, persistent, deleterious effects were detected. Several water samples were taken of the oxidation pond effluent and bioassays were conducted with 50 third and fourth instar larvae of *Culex tarsalis* and no mortality was observed within a 24-hour period.

It would appear from the data obtained that mosquito larvae can be controlled with this type of formulation of fenthion and Gardona under the described conditions without apparent danger to non-target organisms. This experiment was to have been continued; however, action by the Mexican authorities to drain the ponds imposed a mandatory project termination 51 days after treatment.

When the ponds dried up in January, 1971, five of the original briquettes were recovered and taken back to the laboratory for analysis. After exposing them to a moderate flow of tap water for 5 minutes, extracts were taken and analyzed by the gas chromatograph. These results are shown in Figure 2. Two briquettes were recovered from slow water movement and had less erosion than those recovered from fast water movement. Figure 2 shows a straight line relationship between release rate and briquette weight.

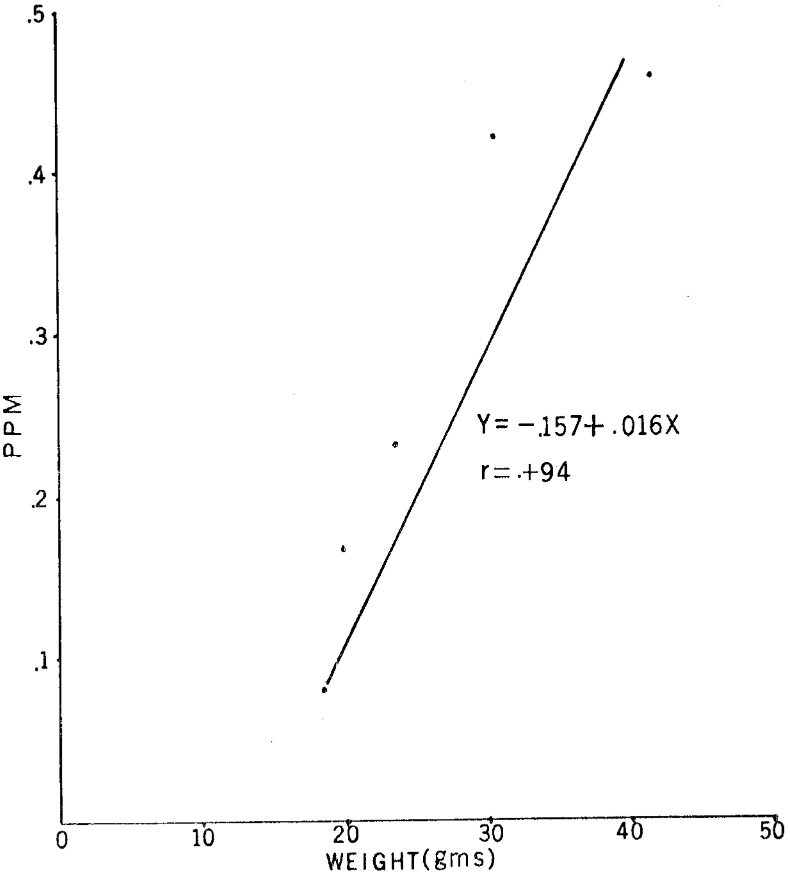

FIG. 2.—Release rates of recovered Gardona briquettes after exposure in the field for a period of 157 days.

The release rate mechanism appears to be quite complex, since the amount of toxicant in the water at any time after application depends on several factors, including (1) solubility in water, (2) the concentration of the toxicant in the briquette medium, (3) the rate of application, (4) agitation of water, and (5) amount and nature of absorbents.

The field data suggest that in order to obtain good dispersal of the larvicide in the ponds, it is mandatory that these briquettes be scattered uniformly over the surface so that after they sink to the bottom there is not too great a distance between them. It is suggested that smaller briquettes, in the form of pellets be used for this purpose in later tests.

SUMMARY AND DISCUSSION

Both Gardona and fenthion impregnated in plaster of paris briquettes and hand cast into oxidation ponds gave a significant reduction in the number of mosquitoes observed in these ponds. During this experiment, the reductions in larval and pupal populations at the Gardona and fenthion-treated ponds lasted throughout the breeding season. Abate did not appear to be as effective as Gardona and fenthion under the same conditions of high organic pollution and heavy vegetation. It appeared that other factors such as dilution and erosion due to greater water flow rates caused an immediate loss of the toxicant at the Abate-treated sites. This hypothesis is realistic, but future tests with plaster of paris briquettes must be conducted to determine the dilution factors associated with various flow rates.

In the last few years it has been shown that Dursban and Abate are very effective in mosquito larval control. It appears that Gardona and fenthion are also good mosquito larvicides and could be recommended as effective residual larvicides when incorporated in a briquette medium.

Slow-release larvicides are a useful tool for controlling mosquito and other aquatic dipterous pests. Studies are being conducted to determine the feasibility of incorporating insecticides into various synthetic porous polymers as is presently being done with herbicides for aquatic weed control. It is quite possible, under certain conditions, to obtain larval control for an entire season with a single application. The saving in labor costs for application of insecticides is considerable, greater precision in application is possible, and there is a greater safety factor in the handling and applying of the chemicals.

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