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POLYMER FORMULATIONS OF MOSQUITO LARVICIDES

IV. LARVICIDAL EFFECTIVENESS OF POLYETHYLENE AND POLYVINYL CHLORIDE FORMULATIONS OF CHLORPYRIFOS DURING AN 18-MONTH FIELD TEST [1]

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ABSTRACT. The long-term effectiveness of three polymer formulations of chlorpyrifos [0,0-diethyl o-(3,5,6-trichloro-2-pyridyl) phosphorothioate] was evaluated in artificial field pools at Edgewood Arsenal, Maryland. The formulations, designated M-3409, PVC-10, and M-3570, differed in percent composition, polymer carrier, specific gravity, and pellet size. Each was applied to the pools at a dosage of 5.0 ppm in May 1970 and chlorpyrifos residues maintained in the treated water were monitored monthly through October 1971. Single applications of the formulations resulted in the following 18-month average chlorpyrifos residues: 14.7 ppb for the M-3409; 1.5 ppb for the PVC-10; and 2.5 ppb for the M-3570. During 18 months in the pools, the formulations released the following percentages of the chlorpyrifos originally contained therein: 91.6 percent for the M-3409; 16.7 percent for the PVC-10; and 28.8 percent for the M-3570. Although each formulation was effective for at least an 18-month period covering two breeding seasons, the large amount of formulation (kg/hectare) required at the 5.0 ppm dosage may make them impractical for large-scale field use.

Studies by Miller, *et al* (1973), evaluated the larvicidal effectiveness of three polymer formulations of chlorpyrifos [0,0-diethyl o-(3,5,6-trichloro-2-pyridyl) phosphorothioate] applied to four types of artificial field pools. Each of the formulations (designated: M-3409, PVC-10, and M-3570) was determined to be effective for 6 months based on weekly in-pool bioassay with laboratory-reared mosquito larvae and weekly gas chromatographic residue analysis of the treated water. In the present study, the same artificial pools were monitored monthly for an additional 12 months by gas chromatographic residue analysis to determine if the three polymer formulations would be effective for a total period of 18 months, covering two mosquito breeding seasons.

METHODS AND MATERIALS. During the first 6 months of this study (May–October 1970), the artificial pools, polymer formulations of chlorpyrifos, and dosage levels were as reported by Miller, *et al.* (1973). During the last 12 months of the study (November 1970–October 1971), all shades

[1] The opinions contained herein are those of the authors and should not be construed as official or reflecting the views of the Department of the Army. Mention of proprietary products is for the purpose of identification only and does not imply endorsement by the Department of the Army. Address reprint requests to: Commander, USAEHA, Aberdeen Proving Ground, Maryland 21010.

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were removed from the pools, leaving only unshaded pools either with or without soil. Residue analyses of the treated water had originally been conducted weekly (May–October 1970). For the purpose of comparison, these weekly residue determinations were summarized on a monthly basis to correspond to the monthly residue analyses conducted during the latter part of the study (November 1970–October 1971). All water samples taken during the 18-month period, whether collected on a weekly or monthly basis, were subjected to hexane extraction and gas chromatographic residue analysis as described by Miller, *et al.* (1973). The minimum detectable quantity measured in the water during the entire study was 0.1 ppb chlorpyrifos. Average monthly residue levels for each formulation were calculated without distinction as to specific type of artificial pool.

In order to complement the continuing residue analysis, a single in-pool bioassay (Miller, *et al.* 1973) using 4th instar laboratory-reared larvae of *Culex pipiens quinquefasciatus* Say was conducted at 14 months posttreatment (July 1971).

After the 18-month posttreatment water samples were collected for residue analysis, all pools were drained. Samples of pellets of each polymer formulation were collected, returned to the laboratory, rinsed with distilled water, and allowed to air dry. The pellet samples were grouped according to type of formulation (i.e., M-3409, PVC-10, M-3570) without regard to the specific type of pool they were tested in. The field-collected pellet samples, along with corresponding pellet samples which were stored under refrigeration for 18 months in the laboratory, were forwarded to the Dow Chemical Company, Midland, Michigan. The pellets were extracted and subjected to infrared analysis by Dow Chemical Company to determine the percent chlorpyrifos remaining.

Residue levels of treated pools were considered inadequate for control if they were lower than 0.9 ppb, the established LC_{90} for the 4th instar larvae of *C. p. quinquefasciatus*. Residue levels were considered excessive if above 18.0 ppb, which is above the recommended (Anonymous, 1970) maximum dose of 0.056 kg chlorpyrifos per hectare.

RESULTS. Water volumes (Figure 1) varied considerably during the 18-month test period, ranging from the original volume of 254 liters to a maximum of 446 liters (September 1971). The pools contained ice during December 1970, and January and February 1971. During February 1971, water volumes were actually as low as 167–176 liters, since the pools contained 249–250 liters of ice. During the 18-month test period, each of the polymer formulations maintained average monthly chlorpyrifos residues equal to or greater than 0.9 ppb, except for the PVC-10 formulation during December 1970 (Figure 1).

Average maximum residues were: 21.4 for the M-3409 formulation in December 1970 and May 1971; 2.7 ppb for the PVC-10 formulation in January and March 1971; and 4.7 ppb for the M-3570 formulation in January 1971. Average minimum residues were: 8.2 ppb for the M-3409 formulation in October 1971; 0.4 ppb for the PVC-10 formulation in December 1970; and 1.1 ppb for the M-3570 formulation in December 1970. Average residues for the 18-month test period were 14.7 ppb for the M-3409 formulation, 1.5 ppb for the PVC-10 formulation, and 2.5 ppb for the M-3570 formulation.

Pellet samples analyzed for percent composition after 18 months in the pools showed that the formulations released the following percentages of the chlorpyrifos originally formulated: 91.6 percent released from the M-3409 formulation; 16.7 percent released from the PVC-10 formulation; and 28.8 percent released from the M-3570 formulation.

The in-pool bioassay conducted in July 1971 (14 months after treatment) resulted in average mortalities of 100 percent in pools treated with the M-3409 formulation, 65 percent in pools treated with PVC-10 formulation, and 95 percent in pools treated with the M-3570 formulation.

DISCUSSION. Each of the polymer

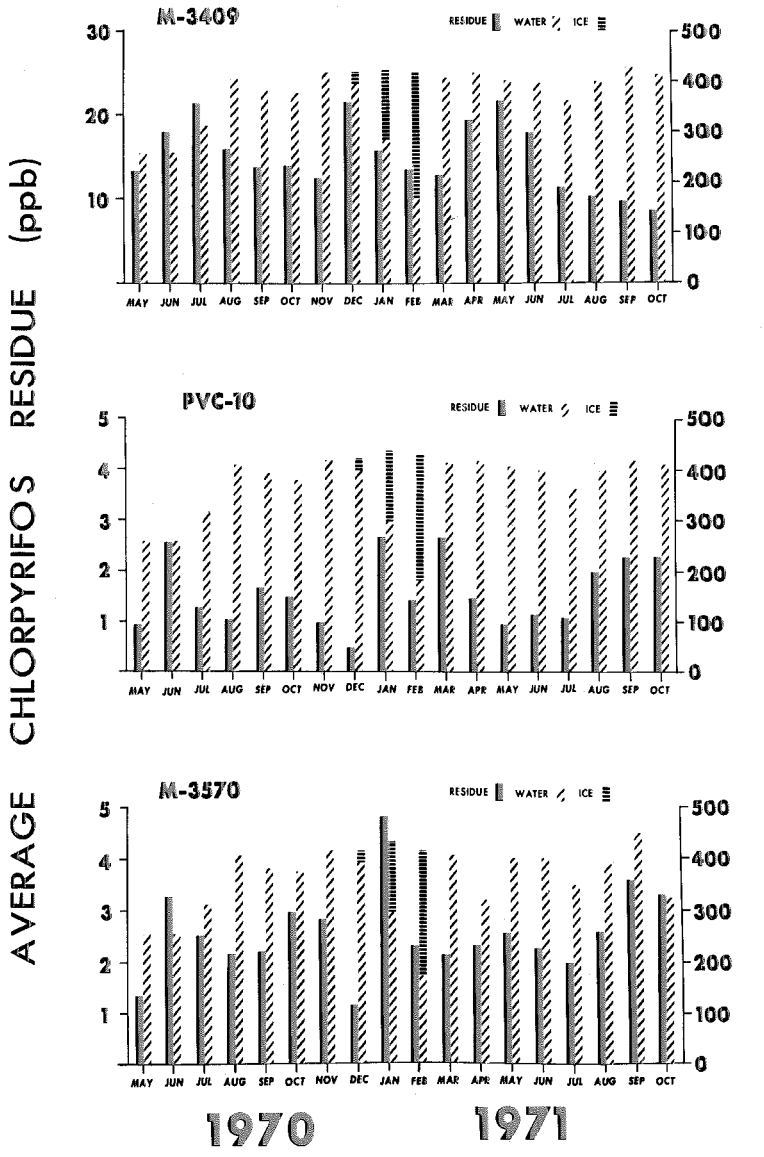

Fig. 1.—Average monthly residue levels and pool volumes observed in field pools treated with M-3409 (top), PVC-10 (middle), and M-3570 (bottom) formulations of chlorpyrifos.

formulations provided 18 months of control. The fact that the PVC-10 formulation produced residues below 0.9 ppb during December 1970 is not considered important because mosquito breeding does not occur at that time of the year in Maryland.

This study did not include an evaluation of the formulations at various dosages. All were applied at 5.0 ppm. The kg/hectare equivalent to this dosage is: 153 kg for the M-3409 formulation; 152 kg for the PVC-10 formulation; and 131 kg for the M-3507 formulation. This dosage appears to be approximately correct for the PVC-10 and M-3570 formulations, since they maintained 18-month average residues of 1.5 ppb and 2.5 ppb, respectively. For the M-3409 formulation, a dosage of 5.0 ppm appears to be too high, as this formulation maintained an 18-month average residue of 14.7 ppb, or approximately ten times that required.

The study having been terminated at 18 months posttreatment, it is not possible to determine how long each of the formulations may have continued to maintain toxic residues. However, the relative amounts of chlorpyrifos released by the formulations during 18 months in the field were proportional to the average residues maintained in the water. The M-3409 formulation released almost all of the chlorpyrifos (91.6 percent) and it is doubtful that this formulation would have remained effective for many more months. If the dosage of this formulation were reduced to achieve more desirable residue levels, the release rate would still remain relatively constant and the formulation could not be expected to be effective for more than about 18 months. Even though this formulation would probably be effective at dosages <5.0 ppm, it has a specific gravity <1 and could be undesirable from the standpoint of the ease with which it may be translocated on the surface of environmental waters. The PVC-10 and M-3570 formulations released much smaller percentages (16.7 and 28.8 percent respectively) while maintaining residues only slightly above the desired level (0.9 ppb). Therefore, it is likely that each of these formulations would have been effective for considerably longer than the 18 months demonstrated in the present studies.

CONCLUSIONS. Single applications of each of the polymer formulations, at a dosage of 5.0 ppm, maintained average monthly chlorpyrifos residues at or above mosquito larvicidal levels (0.9 ppb) for at least 18 months. During 18 months in the field, the formulations released the following percentages of the original chlorpyrifos formulated: 91.6 percent for the M-3409 formulation; 16.7 percent for the PVC-10 formulation; and 28.8 percent for the M-3570 formulation. The large amount of each formulation required on a hectare basis may make them impractical for large-scale field use, even though each was effective for at least 18 months.

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