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Concentrations of propoxur in air following repeated indoor applications*

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The insecticide propoxur was applied as 2 non-overlapping bands approximately 1 m wide to the interior of houses in El Salvador once every 35 days for a period of 9 months. Air samples were collected from the interior of the houses once every seventh day during the entire period. In the study area, air temperatures remain relatively constant, while rainfall varies seasonally. It was found that volatilization of propoxur, as determined by the amounts detectable in air, represented release of the chemical from the treated surface and that the volatilization process was most influenced by the amount of moisture present in the air. Higher air concentrations of propoxur occurred during periods of high relative humidity than in periods of low relative humidity. The principles involved in this process and its bearing on the value of propoxur in malaria control programmes are discussed.

The development of resistance to DDT in *Anopheles* mosquitos has focused attention on the need for alternate insecticides for use in malaria control programmes. Propoxur is one of the compounds that has shown considerable promise in mosquito control. Laboratory tests have shown the chemical to be effective against *Anopheles albimanus* (4), *A. stephensi* (5), and *A. quadrimaculatus* (2). In operational field trials, it has been found capable of controlling *A. stephensi*, *A. gambiae*, *A. funestus*, *A. albimanus*, *A. dthali*, and *A. quadrimaculatus* for periods of 2–4 months (3, 9). In addition to its proved contact toxicity, propoxur has been reported to have an airborne fumigant toxicity that often extends a considerable distance from the treated surface (6, 9). However, little information is available on the persistence and concentration of the insecticide in the air following application, or on the extent to which environmental factors exert an influence. This paper reports the results of an investigation directed at providing further information on propoxur's fumigant properties.

MATERIALS AND METHODS

Air sampling and chemical analysis

The method used for the collection and analysis of propoxur residues in air was that of Miller et al. (8). This method involves drawing air at a known flow rate through a glass impinger charged with a trapping solution of dilute sodium hydroxide. Using this trapping medium, the insecticide is converted to its corresponding phenol and easily extracted into benzene. A chloroacetate derivative is then formed by the addition of chloroacetic anhydride in the presence of trace amounts of pyridine. This derivative is readily amenable to quantitative analysis by electron capture gas chromatography with detector sensitivity of 50 pg.

Recovery from fortified samples was 90% with sampling periods up to 60 min. All data reported herein are based on a 60-min sampling period at an air flow rate of 2.8 l/min, and have been corrected by the percentage recovery factor. The air sampling units were positioned approximately 15 cm from the treated surfaces and were always placed in the same location when repeat samples were collected.

Field investigations

Large-scale field trials on the efficacy of propoxur have been carried out in El Salvador under the auspices of the Pan American Health Organization (PAHO). Lassen et al. have described this pro-

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gramme and summarized some preliminary findings (7).

In the field study, a water-dispersible powder formulation of the insecticide was applied once every 35 days in 2 non-overlapping swaths approximately 1 m wide to the interior of houses near the junction of the roof and the wall, using conventional house-spraying techniques at a target dose of 2 g/m². The tests were carried out in the Department of La Paz along the El Salvador littoral. The houses in the area are primarily of pole wall and thatched roof construction. Air samples were collected from the interior of 3 typical houses the day before application, the day after first application, and every seventh day thereafter, through 9 spray cycles. The data reported herein are the mean values of the samples taken. At the time of sampling, the air temperature and relative humidity were determined and recorded.

RESULTS

The day after spraying began, the concentration of propoxur in the air was recorded at 7 ng/l (Fig. 1). This concentration decreased sharply to zero by the fourteenth day and no insecticide was detectable until the start of the second cycle. Unfortunately, samples could not be collected the day following the second application, but samples taken over the remainder of this cycle showed a greater degree of persistence, albeit at low concentrations.

During the second cycle the rainy season began. The day following the third application, air concentrations of the insecticide reached 34 ng/l, which represented approximately a 5-fold increase over any amount previously encountered. High concentrations were consistently found the day following each application made during the wet season from June to early October (Fig. 1). With the onset of the dry season, concentrations again decreased to low levels, as the results for the eighth and ninth cycles show. The insecticide persisted in the air at high concentrations for longer periods in the wet season than in the dry season.

During the entire sampling period the temperature remained relatively stable (27.8–31.2°C), whereas the relative humidity ranged from a low of 35% in

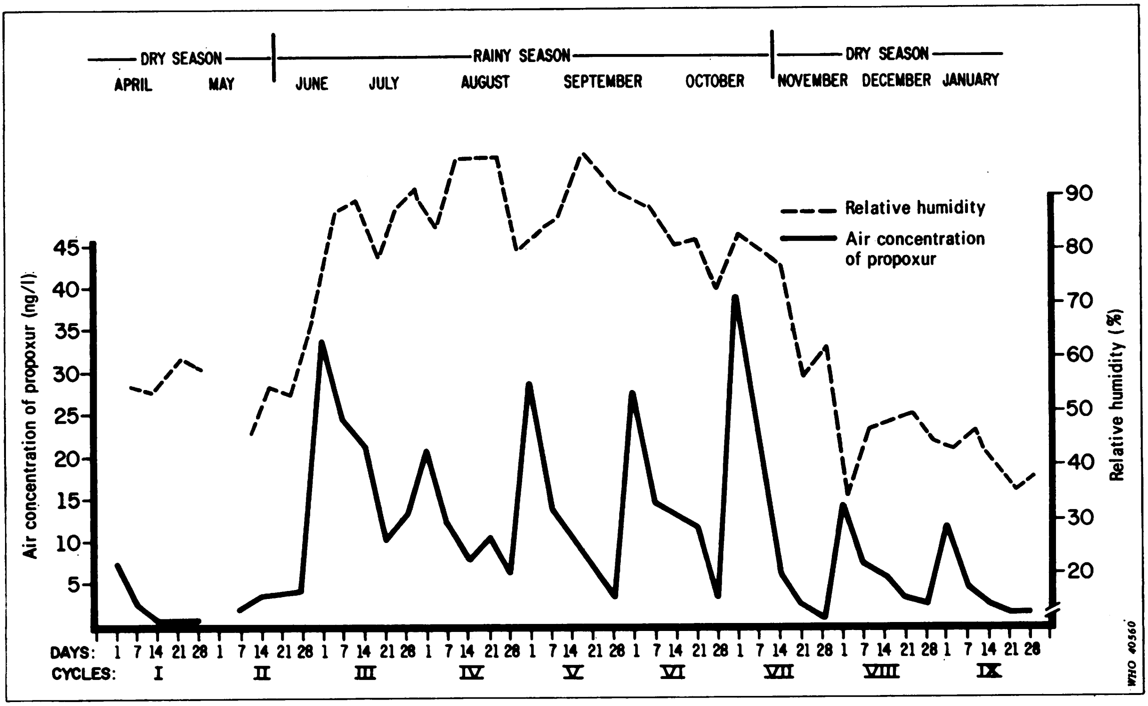

Fig. 1. Average air concentration of propoxur in relation to repeated applications at 35-day intervals, climatic change, and relative humidity.

the dry season to a high of 99% during the rainy season (Fig. 1). Air concentrations of propoxur were generally high when relative humidity was high, and decreased to low levels during the dry period. Thus it appears that the higher concentrations are a function of the moisture content of the air, and not of air temperature.

DISCUSSION

Barlow & Hadaway (1), working with *A. stephensi*, found humidity had little effect in increasing the toxicity of fresh deposits of propoxur, but that it enhanced the activity of aged deposits of the chemical, especially on materials of cellulose composition such as plywood and filter paper. The enhancement of activity was attributed to sorption of water by the cellulose fibres, which altered in structure. This alteration, coupled with displacement by water of insecticide that had penetrated the material, allowed for diffusion and migration of the chemical to the surface where it became more readily available to the test insect. The fact that no enhancement of toxicity due to humidity was recorded when the insecticide was applied to glass filter paper was attributed to the impermeability of this surface to moisture, and indicates that there is no direct interaction between water and the chemical itself or its carrier.

A similar series of events may have occurred during the field trial in El Salvador. The insecticide applied during the first 2 cycles probably penetrated into the fibrous surface, where it was tightly bound. With increased humidity at the time of the third application, a majority of sorption sites in and on the target surface were occupied by both water molecules and chemical, some of the latter having migrated to the surface. This discouraged further penetration in all subsequent applications during the rainy season and hence a greater portion of chemical was available to undergo transition from the solid to the vapour state. As humidity decreased, the moisture bound within the surface was depleted by evaporation and more sorption sites were made available. Additional applications resulted in penetration of the insecticide into the surface, where it was tightly bound and not free to become volatile. We conjecture that, depending on the degree of microbial degradation and/or physical decomposition of the bound insecticide, this situation would be reversible. Subsequent increases in humidity could result in an increase in air concentrations of propoxur as the residual chemical becomes displaced and is converted to its vapour phase.

Vapour phase toxicity is not a criterion for the selection of insecticides in malaria control. Vaporization represents loss of the chemical from the target surface and hence is contrary to the goal of long-term effectiveness. That portion of the compound lost to the atmosphere is nonrecoverable, and the data from our study indicate that this is the case with propoxur. The possibility that the insecticide can provide dual action toxicity (contact and vapour) in field operations is intriguing, but it would remain to be demonstrated that it would be practical in a country where long periods of continual high humidity prevail. In such situations, careful consideration would have to be given not only to the cost of the insecticide involved in making the repeated applications necessary during the periods of high humidity, but also to the effectiveness of the treatments.

RÉSUMÉ

CONCENTRATIONS DE PROPOXUR DANS L'AIR APRÈS DES APPLICATIONS RÉPÉTÉES À L'INTÉRIEUR DES HABITATIONS

L'insecticide propoxur a été appliqué sur deux surfaces larges de 1 m environ, ne se chevauchant pas, à l'intérieur de maisons en El Salvador. Les applications ont été répétées tous les 35 jours pendant 9 mois. Durant toute la période de traitement, on a récolté des échantillons d'air tous les 7 jours. Dans la région où ont eu lieu les recherches, la température de l'air est relativement constante alors que l'abondance des chutes de pluie varie selon la saison.

On a constaté que la volatilisation de l'insecticide à partir des surfaces traitées, mesurée par les quantités décelables dans l'air, était surtout influencée par le degré d'humidité de l'air. Les concentrations de propoxur dans l'air étaient plus élevées durant les périodes où l'humidité était relativement forte que pendant les périodes où elle était relativement faible.

Les mécanismes du phénomène et ses répercussions sur l'efficacité du propoxur dans les campagnes de lutte antipaludique sont examinés.

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