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Chlorpyrifos in the Air and Soil of Houses Four Years after Its Application for Termite Control

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Chlorpyrifos; Dursban®; (0,0-diethyl 0-(3,5,6-trichloro-2 pyridyl) phosphorothioate) is used by many pest control firms for the control of termites in buildings. Studies were initiated in 1984 to determine chlorpyrifos levels in the ambient air of kitchens and bedrooms of houses where the soil under and around the houses had been treated with this insecticide for termite control. Data through two years were reported by Wright et al (1988) and showed no ambient air level above the National Academy of Sciences (NAS) proposed guideline level of 10.0 $\mu g/m^3$. This paper reports data from ambient air and treated soil samples taken four years after termiticide application in order to determine chlorpyrifos levels present.

MATERIALS AND METHODS

Air sampling and analysis of the samples were the same as reported in Wright et al (1988). To determine the efficiency of the analytical method, polyurethane foam (PUF) trapping plugs (2cm od. x 3 cm) (Wright and Leidy 1978) were fortified with known amounts of chlorpyrifos varying from 0.05 to 12.0 µg per plug. Using the same pipette, an equivalent amount was added to a 12.0 mL tube, which was stoppered and refrigerated until the samples were analyzed. Thirty fortified plugs and the equivalent tube, diluted to the same final volume, were analyzed with the air samples. Recoveries ranged from 89 to 131% with an average recovery of 97%. The data were not corrected for recovery values.

Soil along the foundation walls and piers were sampled as reported by Leidy et al (1985). Sampling sites around each house were selected based upon the type of construction. Composite soil samples were taken from both sides of the foundation walls of crawl-space houses. For slab houses, soil samples were collected only from around the outside perimeter of the house with no holes being drilled through the slab for sampling. Using a stainless steel coring device (30 by 2.5 cm), soil samples were secured from two locations along each of the four longest foundation walls,

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both inside and outside of the crawl space houses, and from one site around the base of two pillars in the crawl space area. On a crawl space house 10 soil samples were taken under the house and 8 samples along the outside walls. Inside and outside samples were composited separately for analysis. There were 8 samples taken and composited from around the exterior perimeter of a slab house. An attempt was made to obtain separate samples from 0 to 10 cm and 10 to 20 cm depths, but in a few instances location of the foundation footing and construction debris interfered with sampling at the 10 to 20 cm depth. In these instances samples were taken from similar sites in other locations to secure the desired number of samples for compositing. Samples from the 0 to 10 cm depth were discarded while those composited from the 10 to 20 cm depth were placed in 950 ml jars, the jars sealed and placed on ice until returned to the laboratory where they were stored at -20C until analyzed.

Soil samples were extracted using a procedure described by Merriam et al. (1981). Fifteen g of soil were tared into a 950 mL glass jar and the following were added; 200 mL distilled water containing 0.5% NaCl, 2.0 mL of HCl(conc) and 100 mL of hexane. The jars were sealed with a teflon sheet, capped and shaken for 30 min. After sitting overnight, the hexane layer was removed by suction, filtered through Na_2SO_4(anhyd) and evaporated to 2 to 3 mL under reduced pressure at 30 C. Ethyl acetate was used to dilute samples for GLC analysis using the same chromatographic conditions described previously.

The efficiency of the methods was determined by adding various concentrations of chlorpyrifos to untreated soil, mixing thoroughly and allowing the sample to sit at room temperature for 2 hr prior to extraction. Two fortified samples were extracted with each set of soil samples. Recoveries from untreated soils averaged 93%. The data were not corrected to reflect extraction efficiencies.

All data were subjected to an analysis by the Tukey HSD Test, a procedure generally preferred when analyzing unequal replications (Wilkinson 1989).

RESULTS AND DISCUSSION

Temperatures and relative humidities in the sampled rooms ranged from 15° to 31°C and 42 to 88%, respectively, during air sampling.

Chlorpyrifos levels detected in the ambient air of kitchens and bedrooms four years after its application to houses for termite control are given in Table 1. Levels of chlorpyrifos in rooms ranged from 1 to 9 $\mu g/m^3$. Significantly ($P = 0.01$) more chlorpyrifos was present in the air of houses built over sand than clay soils. There was no difference in chlorpyrifos levels in the ambient air by room or house construction types (slab, crawl or crawl-slab). When the chlorpyrifos levels in the ambient air for 4 years were compared with the earlier post application sampling times of 6 mo and 1 and 2 years (Wright et al 1988) significantly ($P = 0.05$) more chlorpyrifos occurred at 1 and 4 years than at the other two time intervals. This reason for this difference is unknown. No chlorpyrifos odor was detected during the sampling time nor reported as being noticed by any of the residents during the last few years. No termite infestations have been detected in the houses since chlorpyrifos application for their control.

Chlorpyrifos detected in the soil adjacent to the exterior and interior foundation walls for all houses ranged from 0 to 1640 ppm and 0 to 1684 ppm, respectively, at 4 years (Table 1). Houses with the greater concentrations around the exterior walls were not necessarily those with the higher concentrations around the interior walls. There was no significant difference in chlorpyrifos levels found in soils adjacent to the interior versus the exterior foundation walls nor for all clay versus all sand soils combined. No soil samples were taken at any of the earlier air sampling times, therefore no comparison could be made with the 4

Table 1. Mean concentration of chlorpyrifos detected in the ambient air and soil four years after its application for termite control in houses (Four rep's.)

Type of soil and construction	Chlorpyrifos detected: Ambient air ($\mu g/m^3$)[a,b] K	B	Soil (ppm)[a,c] O	I
Sand, Slab	6 ± 2[d]	4 ± 1[d]	39 ± 39[d]	c[d]
Sand, Crawl	5 ± 3	5 ± 3	177 ± 129	256 ± 139
Clay, Crawl	2 ± 1	2 ± 1	16 ± 15	58 ± 95
Clay, Slab-Crawl	3 ± 1	3 ± 1	499 ± 660	473 ± 703

[a]Mean ± standard error of 4 hours by each soil-construction type. O and I = outside and inside soil adjacent to the foundation wall sampled, respectively; K and B = kitchen and bedroom, respectively.
[b]Significantly ($P = 0.01$) more chlorpyrifos in the ambient air of houses on sand than clay soils.
[c]Unable to sample soil under the slab of slab-constructed houses, soil samples taken around the exterior of slabs.
[d]Three replications, new owner did not want air or soil samples taken.

year data. Chlorpyrifos detected in sandy soil around slab construction houses was lower than in clay soils at slab-crawl construction houses, which also occurred for chlordane in sand versus clay soils (Leidy et al. 1985). It is probable that equivalent amounts of chlorpyrifos are present in both soil types, but the chemical is distributed in a larger volume of sandy soil. However, the levels detected for crawl-construction houses on sand and clay soils were surprising, with the means for sand being higher and clay lower, which was opposite than expected. We do not know the reason for this result nor for the extreme range in levels detected in the various samples. We do know that the correct chlorpyrifos dilution rate (%) and quantities applied (L) as recommended on the insecticide label were used at each house. Several factors such as a variation in the application rate and technique, sampling locations around the houses and soil characteristics, might have contributed to this range.

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