

Chlordane and Heptachlor in the Ambient Air of Houses Treated for Termites^{1,2}

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Chlordane and heptachlor are used for preventative and remedial termite control in buildings. Quantities of the diluted insecticides are applied into the soil, wall voids, pilasters, chimney bases, termite-damaged wood and under slabs of dirt-filled porches, basement floors, and slab houses. In the working environment, the maximum allowable limit to a continuous exposure of chlordane is $500 \mu\text{g}/\text{m}^3$ (40-h workweek) (AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS 1980). However, the NATIONAL ACADEMY OF SCIENCES COMMITTEE ON TOXICOLOGY (1979) considered this level unacceptable in the home environment because of the potential for 24 h/day exposure, and they recommended a level of $5 \mu\text{g}/\text{m}^3$ as acceptable in homes.

MALINA et al. (1975) reported that chlordane was not detected in the air of 5 houses treated for termites, even though the sensitivity of the detection method was one hundredth of the air concentration reported to be safe. CALLAHAN (1970) reported that chlordane, inadvertently placed in heating ducts during termite control at an air base, vaporized and disseminated throughout the living area of a house when the furnace was activated. In 1978 a similar incident occurred at another air base in houses pretreated for termites (unpublished data, USAF, Occupational and Environmental Health Laboratory, Aerospace Medical Division, Brooks Air Force Base, TX 78235). These incidences prompted sampling of ca. 500 ground-floor apartments at a midwestern air base in 1980 (LIVINGSTON and JONES 1981). Chlordane concentrations ranged from below the detection level to $379 \mu\text{g}/\text{m}^3$. Insecticide levels varied widely. An additional study was performed at seven Air Force installations during the winter of 1980-81 in which airborne levels of chlordane were measured in 474 family housing units (LILLIE 1981). All units were treated with chlordane by either subslab injection or exterior ditching after construction. Eighty-six percent had chlordane levels below $3.5 \mu\text{g}/\text{m}^3$; 12% had levels between $3.5 - 6.5 \mu\text{g}/\text{m}^3$; and 2% had levels above $6.5 \mu\text{g}/\text{m}^3$.

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²Use of trade names in this publication does not imply endorsement of the products named or criticism of similar ones not mentioned.

KHASAWINAH (1981) reviewed the literature on chlordane air concentrations in treated homes. There have been no data published on the amount of chlordane or heptachlor actually applied in treating houses for termite infestations versus the amounts which should have been applied to the respective dwellings as per label directions nor on the chlordane or heptachlor levels in the air of houses at specific time intervals following treatment of the dwellings for termites with known amounts of the insecticides; therefore, a study was initiated to determine these levels after chlordane or chlordane plus heptachlor (Termide®) applications.

METHODS

Six single-family houses infested with active subterranean termites were used. All of the houses contained a crawl space or a crawl space-slab basement combination. Occupants agreed to allow ambient air samples to be taken from their houses 7 times during a 12-month period.

Three houses were treated with an insecticide. Prior to application of the insecticide, a 4-h air sample was taken at a height of ca. 46 cm and ca. 13 cm from an inner wall of the kitchen or living room in order to determine if any chlordane or heptachlor were present before their application for termites. Air samples were secured using personnel-type air samplers (WRIGHT and LEIDY 1978) with polyurethane foam trapping devices and a flow rate of 2.8 l/min. The lower limit of detection for the insecticides was 0.01 µg. Temperatures and relative humidities were recorded 3 times (immed. before sampling - at 2 h - immed. after sampling) and averaged during the 4-h sampling period.

Chlordane emulsion (1%) was prepared from an emulsifiable concentrate containing 0.97 kg AI/l. A chlordane (0.5%) + heptachlor (0.25%) emulsion was prepared from an emulsifiable concentrate containing 0.50 kg chlordane and 0.25 kg heptachlor AI/l.

Termite treatments were performed by pest control firms licensed by the N. C. Dept. of Agric. for the control of wood-destroying insects. Treatments with the chlordane plus heptachlor emulsion were performed by crews of different pest control firms while chlordane treatments were performed by 3 different crews from the same firm. All houses were treated per label directions. Measurements of the quantity of insecticide emulsion before and after application to a house gave the quantity used per house. Chlordane amounts applied to 3 additional houses were recorded and included in this section; however, air samples were not taken. House dimensions were calculated in m².

A 2nd 4-h air sample was taken at the same site in the houses upon completion of insecticide application in order to determine the amount of insecticide present in the air immediately after application. Additional 4-h samples were taken in the same position after 24 h, 1 wk, 1 and 6 mo, and 1 yr. Temperature and relative humidity were recorded at each sampling period using the same

procedure as during the preapplication sample. At least one of the authors was present during dilution of the insecticide, treatment of the house and air sampling of the house. Air samples were extracted and analyzed following the method of WRIGHT and LEIDY (1978).

One carpet swatch (7.6 x 15.2 x 1.3 cm) was placed on the floor of each house 24 h prior to insecticide application and taken up immediately before treatment. A 2nd sample was placed in the same floor site immediately upon completion of termite treatment and removed 24 h later. Carpet swatches were analyzed to detect the presence of any chlordane or heptachlor as follows.

Three circles (2.4 cm diam.), punched from the midline of each swatch, were tared in a Soxhlet thimble. They were extracted for 4 h with 200 mL of chloroform: methanol (1:1) at 10 turnovers per h. Following evaporation to 2 to 3 mL at 50 C under reduced pressure the liquid was placed in a glass column containing 20 g Florisil topped with 2.5 cm anhydrous sodium sulfate. The column was prerinsed with 50 mL of hexane and the chlorinated hydrocarbons were eluted with 200 mL of 6% diethyl ether in petroleum ether. After evaporation to 1 to 2 mL at 45 C under reduced pressure, the concentrate was taken up in ethyl acetate for GLC analysis. GLC conditions were the same as those used for air samples.

An analysis of variance was used to detect any differences in chlordane or heptachlor ambient air levels for the houses and time intervals at the 0.05 level.

RESULTS AND DISCUSSION

Insecticide amounts applied to 8 of the 9 houses were less than the amounts recommended by the insecticide label for the size and type of construction of the houses (Table 1). The correct amount was applied to the one house because the supervisor determined the amount of insecticide recommended for the house per label instructions, mixed that amount and had the treating crew to apply it to the house.

There was no relationship between temperature or relative humidity and the amount of airborne chlordane or heptachlor. LIVINGSTON and JONES (1981) also showed no correlation for the same parameters in houses with subslab and intraslab ducts. House temperatures ranged from 17 (Jan) to 27 (Oct) C during the months when air samples were taken (Table 2). There were no air samples taken in Aug. or Sept. (usually two of the hottest months in NC) or Dec. The lowest RH (44%) occurred in Feb. and Mar. and the highest (67%) in Oct. Again, no readings were made in Aug. or Sept. (months which usually have days with a high RH) or Dec.

Chlordane or heptachlor were not detected in carpet swatches placed in the houses prior to insecticide application, except for 1 house where 0.4 μ g of chlordane was present in one carpet swatch (Table 3). The reason for the chlordane in this preapplication

Table 1. Insecticide (ℓ) recommended per label directions and the amount actually applied in treating 9 houses for termites.

Insecticide	House	Recommended/label	Actual amount applied	% deviation from recommended ℓ
Chlordane	1	625	625 ^a	0
	2	825	719	-13
	3	644	606	-6
	4	587	379	-35
	5	859	568	-34
	6	867	511	-41
Termide ^b	1	1261	871	-31
	2	538	379	-30
	3	882	568	-36
	\bar{x}	787	579	-25
	sd	208	148	

^aSupervisor gave the treating crew the exact amount recommended for the house and told them to use the entire amount.

^bTermide® is a mixture of chlordane and heptachlor formulated by Velsicol Chemical Co., Chicago, IL 60611.

Table 2. Temperature and humidity in 6 houses treated for termite control.

MO	No. houses sampled	Temp ($^{\circ}\text{C}$) ^a	% RH ^a
J	3	18.3 \pm 0.9	56.3 \pm 5.2
F	3	19.3 \pm 0.5	47.0 \pm 3.6
M	4	19.8 \pm 0.4	46.8 \pm 1.9
A	1	22.0	59.0
M	6	25.0 \pm 1.0	55.2 \pm 5.8
J	1	23.0	47.0
J	1	24.0	63.0
A	0	-	-
S	0	-	-
O	1	27.0	67.0
N	1	23.0	46.0
D	0	-	-

^aMean with the standard deviation.

carpet swatch is unknown. All carpet swatches placed in the houses after chlordane application contained chlordane or chlordane + heptachlor in the Termide treated houses.

Table 3. Termiticide (μg) carpet swatch sample.^a

Rep	Pre	Post (0-1 Day)
Chlordane 1.0%		
1	< 0.01	1.45
2	0.36	1.69
3	< 0.01	3.62
Termide (Chlordane 0.5%) ^b		
1	< 0.01	0.96
2	< 0.01	1.12
3	< 0.01	1.38
Termide (Heptachlor 0.25%) ^b		
1	< 0.01	0.15
2	< 0.01	0.31
3	< 0.01	0.71

^aCarpet swatches were 7.6 x 15.2 x 1.3 cm.

^bTermide - Chlordane and heptachlor from the same carpet swatches placed in a house.

All but 1 of the 6 air samples taken in houses prior to insecticide application contained chlordane (Table 4) while only 1 of the 3 houses treated with Termide had a trace ($.02 \mu\text{g}/\text{m}^3$) of heptachlor in the preapplication air sample. The air of the 3 houses where the 1% chlordane was applied was not sampled for the presence of heptachlor prior to chlordane application. Chlordane in the preapplication air samples might have resulted from one or more of the following conditions: (1) some person might have used chlordane for controlling insects in the past; (2) several preapplication air samples were taken before any chlordane was applied, but the treating crews had parked the service vehicles containing chlordane and were preparing the house for application; thus, chlordane might have moved into the house from the truck or from the applicator's clothing contaminated during earlier applications; or (3) the house had been previously treated with chlordane and the resident did not know this fact. Preapplication air samples were not analyzed prior to actual insecticide application, and in one instance, when chlordane was found in a preapplication sample, the owner remembered that a "white liquid" was sprayed around the house during construction. The owner did not associate the "white liquid" with a possible termite pretreatment. In another instance, a preapplication sample taken from a house not included in this paper contained chlordane. The homeowner stated that the house had not been treated for termites. However, an earlier house

present on the same site, but torn down with subsequent construction of the existing house, had been treated for termites. Possibly the soil contained chlordane from the earlier termite treatment, with the chlordane volatilizing into the air of the present house.

Table 4. Chlordane and heptachlor detected in the ambient air of houses treated for termites.^a

Sampling time	$\mu\text{g}/\text{m}^3$ detected in a 4-h sampling period ^b		
	Termide®		
	1% Chlordane	0.5% Chlordane + 0.25% Heptachlor	
Pre	0.30 (± 0.28)	1.61 (± 1.13)	0.01 (± 0.01)
Immed after	2.75 (± 1.33)	4.48 (± 1.70)	1.41 (± 0.64)
1 dy	4.70 (± 2.65)	2.39 (± 2.05)	1.05 (± 0.41)
7 dy	4.48 (± 3.94)	3.32 (± 1.06)	1.18 (± 0.28)
1 mo	2.80 (± 3.32)	2.34 (± 0.78)	1.27 (± 0.24)
6 mo	3.32 (± 1.38)	5.81 (± 5.01)	1.80 (± 1.47)
12 mo	5.01 (± 0.97)	2.77 (± 2.69)	1.00 (± 0.70)

^aThree houses (replications) for each insecticide.

^bMean and standard deviation in parentheses.

All air samples taken after application contained insecticide, except for 1 air sample taken from a Termide treated house which contained heptachlor but, for unexplained reasons, no chlordane (Table 4). Insecticide levels in the ambient air of the houses varied greatly, with no discernible, predictable pattern, by house or time after application. Various factors, such as: (1) house construction, (2) outside and inside temperatures and relative humidities, (3) air movement due to outside ventilation, air-conditioning or fans, or (4) the use of the heating system, might have influenced these levels.

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