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Living Area Contamination by Chlordane Used for Termite Treatment

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Over the past several years, the United States Air Force has experienced incidences of living quarters contamination with airborne chlordane. The first noted incident occurred in two houses at a southwestern Air Force base (CALLAHAN 1970). Chlordane was inadvertently introduced into heating ducts during subslab injection for termite control. When furnaces were activated, chlordane vaporized and was disseminated throughout the living area. A second incident occurred at a large midwestern air base in housing constructed with heating ducts in the slabs. Termite pretreatment had been performed using 2% chlordane as a soil drench on the pea gravel and fill beneath the slab. When the heat was first turned on in the fall, an odor was noticed. Subsequent air sampling detected chlordane (1, 2, 4, 5, 6, 7, 8, 8a-octochloro-2, 3, 3a, 4, 7, 7a-hexahydro-4, 7-methanoindene). Sampling showed chlordane contamination to be common in those newly constructed houses (unpublished data).

The most recent incident of chlordane contamination was at a midwestern air base in October 1978. Two ground-floor apartments with subslab heating ducts were involved. One apartment was unoccupied at the time while the other was occupied. In late summer both apartments were treated by subslab injection with 2% chlordane for termite control. When the furnaces were first activated in October, a strong "organic" odor was noted in the occupied apartment. A similar odor but not as strong, was noted in the unoccupied apartment. Subsequent air sampling revealed airborne chlordane in both units. These findings precipitated a random sampling of ground floor apartments in the housing area. Based on the results of the random sampling, the decision was made to sample the air in all ground floor apartments at that air base. This report presents the results of the preliminary survey and the following complete sampling of all ground floor apartments.

MATERIALS AND METHODS

Initial air sampling was conducted in January 1979. Ground floor apartments chosen for sampling were divided into two groups treated for termites in 1978 by subslab injection, and those similarly treated prior to 1978. All 13 apartments treated in 1978 were sampled, while 43 randomly selected apartments from the prior-to-1978 treated group were sampled. Two apartments with no history

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of subslab chlordane treatment were sampled to serve as controls. Also, the apartments directly above 5543B (5543D) and 5020E (5020G) were sampled to determine if chlordane was diffusing upward.

The basic sampling train consisted of an electric Millipore vacuum pump with a sampling tube. The sampling tubes consisted of 200 mg Chromosorb 102 capped with anhydrous sodium sulfate in a 2.75 cm Pasteur pipette plugged with glass wool. The tubes were connected to the pump by a small piece of Tygon tubing. The accuracy of the rotometer was calibrated with a bubble meter. In instances where there was a slight drop in flow rate, the beginning and ending flow rate were averaged to give a mean flow. The range of flow rates in this survey was 2.7 - 4.5 L/min.

In the unoccupied apartments (5543B and 5020E), pumps were located on the floor in the approximate center of the living room. In all other apartments, pumps were located on the floor within 2.7M of the living or dining room heating vents, depending on the location of the occupant's furniture. The sampling tube inlet was always located 2 cm above the floor. Normal room temperature (21-24^{o}C) was maintained during the sampling period. Outside air temperatures ranged from -22 to 5^{o}C during the survey period.

All 1978 treated apartments were sampled utilizing two consecutive 4h samples except for 5543B, which had a total of 5 samples taken; 5020E, which had 4 and 5019B, which had only a single 2h sample taken. Those apartments treated prior to 1978 and the untreated controls were sampled with a single 2h sample. The time of day that the samples was taken was dependent on the availability of the occupant to provide entry.

Sampling precision was measured in apartments 5543B and 5020E. In 5543B, 2 sets of matched samples and one high-volume (4.3 L/min) sample were taken. The sets of matched samples were taken over a 4h period. The high volume samples were obtained over an approximately 5h period for the one set and 4h for the second.

Results from the 1979 sampling indicated the probability that 5% of the apartments would have greater than 7 $\mu g/M^3$ of chlordane. All 498 ground floor apartments in the housing area were subsequently sampled to identify those with high concentrations. All sampling procedures were carried out as in 1979 except all air samples were 2h samples. Sampling was accomplished during the last two weeks of January and the first week of February 1980. Inside air temperature and relative humidity were measured with a sling psychrometer at the time of sampling. Barometric pressure and air temperature were obtained hourly from the local air base weather service.

All chlordane analyses were performed as described by THOMAS and SEIBER (1974) and THOMAS et al. (1980). Data collected in 1980 were subjected to analysis of variance, stepwise regression, Pearson's correlation and Spearman's correlation.

RESULTS

Sampling and analytical precision showed a variability of 13.2% in one instance and 26.8% in the second (TABLE 1). Neither flow rate nor sampling time influenced the precision of the calculated concentration.

TABLE 1. Sampling precision as measured in unoccupied apartments 5543B and 5020E (1979).

Apartment	Flow Rate (L/min)	Time (min)	Concentration ($\mu g/M^3$)
5543B	2.9	240	292.01
5543B	2.6	240	208.59
5543B	4.3	292	268.62
5543B	2.8	222	293.96
5543B	2.9	222	254.24
5020E	4.0	300	29.60
5020E	4.0	300	31.87
5020E	4.0	260	16.35
5020E	3.5	260	24.68

In the 1979 survey all apartments treated in 1978 showed high concentrations of chlordane with a range of 0.4 to 263.5 $\mu g/M^3$ (TABLE 2). When compared to the average concentration of the random samples taken from all other apartments, the four highest concontrations were significantly higher ($p = .05$). In addition, the average concentration of all apartments was higher than originally expected since 60.3% of the apartments that had been treated had chlordane concentrations > 1.0 $\mu g/M^3$. Except for apartments treated in 1978, no correlation could be made between chlordane concentration and year of treatment.

The two apartments above the ground floor apartments with high chlordane concentrations were also sampled. Apartment 5543D, above 5543B, had 3.6 $\mu g/M^3$ chlordane and 5020G had 0.6 $\mu g/M^3$. This single set of samples suggests that there is some upward movement of chlordane vapor. Ground level apartments showed no lateral contamination of adjacent apartments.

Since no correlation could be made between year of treatment and chlordane concentration, a sampling program was instituted in all ground level apartments in the housing area. Prior to the survey in 1980, the four apartments having greater than 20 $\mu g/M^3$ chlordane were modified by sealing the subslab ducts, thoroughly cleaning walls and floors and installing new furnaces and ceiling air ducts.

Measured concentrations of chlordane in the 1980 survey ranged from below the detection limit to a high of 37.9 $\mu g/M^3$ (TABLE 3). Of the 498 apartments sampled, the six highest con-

centrations (range 14.5-37.8 μg/M) were found in houses treated in 1970. The same single clustering was noted in the previous year's sampling of units treated in 1978. Correlation of chlor-

TABLE 2. Concentration of airborne chlordane in randomly-sampled ground level apartments in January 1979.

Year	Apartment	Concentration ($\mu g/M^3$)	Year	Apartment	Concentration ($\mu g/M^3$)
1978	5543B	263.5	1972	5013B	1.0
	5020E	25.6	1971	5142A	1.6
	5445A	22.4		5519A	1.6
	5534F	22.3		5033E	1.2
	5220B	4.8		5311B	1.2
	5019B	4.6	1970	5462A	0.4
	5232A	4.5		5546A	1.8
	5534B	4.4		5546A	1.3
	5112B	4.0		5425A	1.0
	5301B	3.3		5426B	0.7
	5521B	0.6		5146B	0.6
	5551B	0.5		5466B	T
	5026A	0.4		5113A	T
1977	5112E	2.3		5109B	T
	5154E	1.4	1969	5414B	7.4
	5126B	4.0	1968	5474B	3.1
	5211E	1.0		5473B	1.9
	5317A	1.0		5436A	0.9
	5116A	0.6		5125B	0.6
1975	5033A	3.4		5544A	ND
	5110A	0.9	1966	5476E	T
1974	5517B	1.2	1965	5216B	1.2
	5136A	0.8		5033B	0.7
	5226A	0.5		5009B	0.6
1973	5322A	5.2	1964	5247A	4.1
	5117A	3.7		5476F	0.7
	5456A	3.0	Untreated	5009A	ND
	5239A	1.7		5117B	T
	5026E	1.7	Upstairs	5543D	3.6
	5126E	1.6		5020G	0.6
	5444B	1.3			
	5553B	0.7			

a
T = Trace

b
ND = None detected at a quantitative detection limit of 0.02 g/M

c
Unit above 5543B

d
Unit above 5020E

dane concentration could not be made with barometric pressure, inside or outside temperature, relative humidity, sampler location or time of day of sampling. Inside temperatures ranged from 17 -

32°C with the majority being 21-23°C. Barometric pressure ranged from 29.1 - 30.2 mm Hg (uncorrected); outside low temperature were -15 to 0°C and outside high temperatures were -8 to 12°C during the survey. Inside relative humidity ranged from 15 to 85%, with 95% of the units between 21 to 49%.

TABLE 3. Concentration of airborne chlordane in 498 ground level apartments sampled in January-February 1980.

Year of Treatment	N	$\bar{X}$ Concentration[a] (μg/M³)	Maximum Concentration (μg/M³)	No. Above Detection Limit	%
1964	14	1.7	4.5	11	79
1965	15	1.6	4.2	9	60
1966	17	0.9	1.9	9	53
1967	8	0.9	1.3	4	50
1968	28	1.6	8.5	26	93
1969	9	2.8	10.1	9	100
1970	68	4.1	37.8	50	74
1971	76	1.7	10.6	61	80
1972	41	1.9	11.6	32	78
1973	68	1.5	4.0	47	69
1974	22	1.8	4.3	18	82
1975	12	2.1	6.1	11	92
1976	23	1.7	5.7	15	74
1977	21	2.1	7.5	15	71
1978[c]	13	2.5	8.0	10	77
Untreated	63	1.2	5.1	35	56
TOTAL	498	1.9	37.8	362	73

[a]Mean calculated from only those values > trace.

[b]The detection limit varied with each sample. The quantitative detection was 0.2 μg chlordane/Chromosorb tube.

[c]These means differed from the sample taken in 1979 due to reducting and cleaning of 4 units that had concentrations > 20 μg/M³.

[d]The treated apartments were taken from a list of units which had no history of treatment.

Detection of chlordane in apartments with no history of termite treatment could possibly be explained by errors in record keeping whereby treated apartments were not adequately reported or by the use of chlordane by previous occupants for household pest control.

DISCUSSION

As readily seen, there are many dwellings with detectable chlordane vapor. In this single study, 335 out of 435 treated apartments (77%) had measurable levels of chlordane ranging from trace to 37.8 $\mu g/M^3$. In a previous Air Force survey of 146 houses at various bases, 61% of those houses had detectable levels of chlordane (unpublished data).

Weather parameters during both the 1979 and 1980 sampling periods had no significant effect on concentrations detected. Additionally, the year of treatment was not indicative of concentrations. Degradation curves could not be applied to the mean concentration by year. All concentrations appeared to be completely random with the exception of clustering of higher than average concentrations is those apartments treated in 1970 and 1978. This clustering indicated that the application procedure was faulty at that time.

The only features in common for those dwellings with chlordane contamination was intra or subslab heating ducts and the method of termite treatment was either high-pressure subslab injection or soil drench prior to pouring the slab. Chlordane entered the duct by either diffusing through cracks or joints in the ducts or by actual inadvertent injection directly into the duct.

Levels of chlordane above the detection limit in a majority (77%) of the apartments indicated that using high-pressure subslab injection in dwellings with ducts in the slab will probably result in detectable concentrations of airborne chlordane. At this time there is no reason to believe that the construction or termite treatment in these dwellings differs from similar houses or treatment practices in the civilian community. If this is the case, then the presence of chlordane vapor in dwellings may be quite widespread in intra-slab ducted dwellings which have been treated for termites.

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