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Insecticide Residues in the Air of Buildings and Pest Control Vehicles [1,2]

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Liquid insecticide concentrates are often stored in 3.8 to 19.0 liter (1 to 5 gal) containers in commercial pest control buildings and are poured into smaller containers before being carried to a spraying site. These insecticides are transported in pest control service vehicles, both as concentrates and dilutions, and are applied in buildings as dilute emulsions or solutions on a routine basis.

There are few data in the literature which discuss the amount of insecticide in the ambient air of these buildings and vehicles. WRIGHT & JACKSON (1976) reported an irritating and somewhat nauseating smell and burning sensation of the face of the person applying an experimental insecticide into the cracks and crevices of rooms. Chlorpyrifos applied into cracks and crevices of rooms moved into the ambient air in small amounts (WRIGHT & LEIDY 1978). Laboratory experiments by BARLOW & FLOWER (1966) indicated that selected insecticides can vaporize almost instantaneously when sprayed into rooms having temperatures of 21 to 32 C. WINNETT & SIEWIERSKI (1975) showed that a laboratory building was contaminated with pesticides that moved through the air from a nearby pesticide storage building, while TESSARI & SPENCER (1971) found airborne pesticides in the homes of occupationally exposed men. Dichlorvos residues were found in very small amounts in houses containing dichlorvos strips; the rate of emission increased with increases in ambient temperature (ELGAR & STEER 1972). WARE & CAHILL (1978) found that more chlorpyrifos was released into a room's atmosphere from emulsion sprays than from a 2% slow release paint. The percentage of spray fallout into nontarget surfaces varies among persons applying liquid sprays and is influenced by their spraying technique, according to RISHIKESH et al. (1977). They found the fallout was greater in rectangular huts than in circular huts, presumably because of the more complex technique of spraying and higher ratio of target surface to floor area in the former.

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

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The amount of insecticide present in the air of commercial pest control buildings, service vehicles and food preparation-serving areas following routine commercial insecticide application has not been reported; therefore, a study was initiated to determine the amounts of selected insecticides in these structures.

METHODS

Air samples, taken in (1) office and insecticide storage rooms in commercial pest control buildings, (2) food preparation-serving areas, and (3) in vehicles used daily by commercial pest control firm technicians, were analyzed to determine the presence of certain organophosphates. The methods which are specific for the three sampling sites are discussed separately. Air samples were secured with personnel type air samplers and methods described earlier (WRIGHT & LEIDY 1978).[3] The samplers ran on AC when used in the pest control buildings and food preparation-serving areas and DC when used in vehicles.

Air samples were taken to the laboratory and analyzed as described by WRIGHT & LEIDY (1978). A completely randomized analysis of variance was performed to determine significant differences at the 1 or 5% levels.[4]

Office and Insecticide Storage Rooms in Commercial Pest Control Buildings. Insecticides in the storage rooms of six North Carolina commercial pest control firms were inventoried between March 18 and September 26, 1977. Individual air samplers were placed in these storage rooms and an office room in the same building. The ambient air in each room was sampled simultaneously at each firm during a 4-hr period and analyzed for those organic phosphate insecticides present in the insecticide storage room.

Food Preparation-Serving Areas. The six food preparation-serving areas chosen for this study could seat 100+ people daily. Four-hour ambient air samples were taken prior to chlorpyrifos application to determine background levels.

Chlorpyrifos (0.5%) was applied as a pinpoint stream to cracks and crevices in each serving area by the regular pest control service technician. The amount of insecticide applied, volume of each serving area, any pertinent characteristics of the area and its environs, and treating procedures were noted. Ambient 4-hr air samples were taken immediately after completion of chlorpyrifos

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[3]Monitaire Sampler, Model S, and Midget-Impinger manufactured by Mine Safety Appliances Company, Pittsburgh, Pennsylvania 15208.

[4]Thanks are due to L. A. Nelson, Professor, Experimental Statistics, North Carolina State University, Raleigh, who performed the statistical analysis.

application and 24 hr later. Temperatures and relative humidity were taken at 0, 2, and 4 hr during each sampling period.

Vehicles Used by Commercial Pest Control Technicians. Ambient insecticide air samples were taken in six sedans, six vans, and nine pickups. All insecticide containers, except as indicated, were located on the floor of the vans and either in the trunk or behind the front seat of the sedans. In the pickups they were in a utility box attached to the truck bed or under a shell cover fastened to the pickup bed; none were carried in the cab. The compressed-air sprayers used by three technicians during routine service in the winter months were kept in the pickup cab to prevent freezing of the liquid spray. The sprayers in the other six pickup trucks were kept in the truck bed due to warmer, outdoor winter temperatures.

Before the start of sampling all insecticides present in a vehicle were inventoried. Next, an air sampler was positioned on the seat between the pest control technician and the researcher who operated the sampler. The sampler inlet tube was fastened to the ceiling of the vehicle, with the orifice of the inlet tube within 46 cm of the technician's head. The sampler was activated when the technician entered the vehicle and turned off when he left the vehicle. All time intervals when the technician was in the vehicle were recorded. Chlorpyrifos emulsion (0.5%) was used in servicing accounts during the test period. At the end of the work day the sample was frozen and later analyzed for the organophosphate insecticides present in the vehicle. Since the total sampling period depended on the technician's time in a vehicle, all insecticide data from the vehicles were converted to a 2-hr basis so that a comparison of the levels in the different vehicles was possible. Temperature in a vehicle was recorded every 2 hr during the sampling period.

RESULTS AND DISCUSSION

Office and Insecticide Storage Rooms in Commercial Pest Control Buildings. The organic insecticides chlorpyrifos, diazinon, malathion, and DDVP were in the storage rooms. The ambient air of the office rooms contained significantly less (1% level) insecticide than the insecticide storage rooms (Table 1) with the exception of malathion. The higher levels of chlorpyrifos, diazinon, and DDVP in the storage rooms might have been due to spillage occurring when these insecticides were transferred from larger to smaller containers. One recently constructed building with central air-conditioning had a high level of insecticide in the office area, even though it was separated by another room from the storage room. This high level was traced to the heating and air-conditioning systems design, which had a direct air flow from the storage to office rooms. The owner has corrected this situation.

TABLE 1

Insecticides detected in the ambient air of storage and office rooms of commerical pest control buildings in a 4-hr period.[a]

Insecticide	Amount detected (ng/m^3 air)[b] Storage	Office
Chlorpyrifos [5][c]	220 (83-595)	126 (26-357)
Diazinon [6]	284 (85-837)	163 (31-572)
Malathion [2]	128 (126-130)	None detected
DDVP [4]	617 (147-1501)	41 (19-66)

[a]Significantly (1%) more insecticide detected in the ambient air of the storage than the office rooms. There were no differences between the replications of an insecticide by room type nor between the insecticides within either room because of high standard deviations.

[b]Mean and the range in parentheses.

[c]The number of storage rooms which contained each insecticide.

Because of large standard deviations, there were no significant differences between ambient levels of any insecticide either within a room type, or for an individual insecticide within replications. DDVP had a higher storage room to office ratio, which might be attributed to the volatization rate of DDVP (v.p. 1.2×10^{-2} mm Hg at 20 C) which is greater than that of the other insecticides studied. Low levels of malathion might be due to the possibility that drums containing this chemical had not been opened recently; thus little volatization occurred.

Food Preparation-Serving Areas. Because of the large standard deviations, there were no differences or correlations between application method and rate of application, rate of application and chlorpyrifos detected, application method and chlorpyrifos detected, or air movement and chlorpyrifos detected. However, the data indicate interesting relationships. Significantly higher (1% level) residues of chlorpyrifos were present in the ambient air immediately after application than 24 hr later (Table 2). The amount of chlorpyrifos applied to an area and the method of application do not appear to have an influence on the amount of chlorpyrifos present in the ambient air, but air flow appears to influence the amount of chlorpyrifos present in the ambient air following application. Forced air systems were used in food preparation-serving areas 1, 2, and 3 during chlorpyrifos application and three of the four highest levels were found. Areas 5 and 6 had no forced air flow during application and the two lowest residue levels were detected. Area 4 did not have a forced air flow during application, but a high

TABLE 2

Chlorpyrifos in the ambient air of food preparation-serving areas following application of a 0.5% emulsion spray into cracks and crevices.[a]

	Food Preparation-Serving Area					
Condition	1	2	3	4	5	6
Air movement during appli.[b]	AL	AH	AC	N	N	N
Appli. method[c]	P	I	PL	P	P	PL
Appli. rate (g tech/28 m)^3	0.32	0.03	0.05	0.12	0.19	0.40
Chlorpyrifos (ng/m^3 air) detected in a 4-hr period						
Immediately after appli.	312	369	1488	1104	137	20
24 hr after appli.	119	60	361	47	84	4

[a]There were no significant differences or correlations due to large variations.

[b]Air movement conditions: AL=slow air movement from ceiling fans; AH=fast air movement from floor fans; AC=air movement from air-conditioning; and N=no forced movement.

[c]Application method: P=pin-stream spray directed into cracks and crevices, with some puddling of emulsion on the floor; PL=pin-stream spray directed into cracks and crevices, with no puddling of emulsion on the floor; and I=pin-stream spray applied directly into cracks and crevices with an applicator tip, with no puddling of the emulsion.

level of chlorpyrifos was detected in the air. The exception appears to negate the forced air flow assumption; however, the service technician, following application of the chlorpyrifos, used a space application of a resmethrin aerosol-type spray to flush cockroaches from their habitats so that they would contact the chlorpyrifos. In so doing air currents were initiated and these air currents probably moved the chlorpyrifos from application sites to the ambient air, thus producing the high level of chlorpyrifos in the air.

Vehicles Used by Commercial Pest Control Technician. When pest control service technicians used chlorpyrifos and kept the compressed-air sprayers in the cabs of the pickups, there was significantly more chlorpyrifos (1% level) present in the ambient air of the cabs than when the sprayers were kept either in the bed of the pickup or in vans and sedans (Table 3). The small amounts of chlorpyrifos detected in the two cabs not containing a sprayer could have resulted from residual material which had been spilled. Residues of diazinon were detected in all vans sampled (6) and in 5 of 6 sedans, and DDVP was detected in the cabs of pickups containing a sprayer and in 2 of 6 vans. The data show large variations in the amounts of residue detected, which might have been due to the fact that the vehicles were moving when sampling occurred. It is possible that air currents moving inside the vehicles from front to back and to the outside could have transported airborne residues to the outside, thus lowering the amount of insecticide being trapped during sampling. Vehicle configuration could certainly be an important aspect of this speculation. Air samples need to be taken when vehicles are stationary, as well as when they are moving, to determine if vehicle movement causes any insecticide movement from the vehicle. There were no significant differences for any of the insecticides when compared between all vehicles. High levels of chlorpyrifos (271 ng/m^3) and diazinon (543 ng/m^3) were detected in a pickup and van, respectively. These amounts might have been due to earlier, unrecorded spillage of these insecticides in the vehicles, thus producing the high levels when the air of the vehicles was checked.

Insecticide levels present in the buildings and vehicles were compared with the threshold limit values (TLV) of the American Conference of Government Hygienists which are standard for respiratory exposure in work situations (Table 4). All insecticide levels were far below the allowable limits.

TABLE 3

Insecticides detected in the ambient air of vehicles used on commercial pest control routes.[a,b]

Type of Vehicle	No sampled	Mean insecticide detected in 2-hr of sampling (ng/m^3 air)[c]			
		Chlorpyrifos	Diazinon	Malathion	DDVP
Pickups-A[d]	3	221(196-271)[3]			96(76-129)[3]
Pickups-B[e]	6	9(0.5,18)[2]		106[1]	
Sedans	6	53(3-175)[4]	88(7-239)[5]	48[1]	
Vans	6	100(39-168)[3]	171(11-543)[6]		124(16,231)[2]
Mean		96(0.5-271)[12]	130(7-543)[11]	77(48,106)[2]	110(16-231)[5]

[a]The amount of insecticide detected while the technicians were in their vehicles and the vehicles were moving, converted to an equal time (2 hr).

[b]Significantly (1%) more insecticide in pickup A than in pickup B, probably due to the fact that the compressed air sprayers were kept in the cabs of pickups-A and in the beds of pickups-B. There were no variations in the amount of insecticide detected in the replications.

[c]The numbers in parentheses and brackets give the ranges of insecticides and the number of vehicles in which residues were found, respectively.

[d]Compressed air sprayer kept in cab of the pickup.

[e]Compressed air sprayer kept in the bed of the pickup.

TABLE 4

Threshold limit values (TLV) of four insecticides compared to the greatest amount detected in the ambient air of offices of pest control buildings.[a]

	$\mu g/m^3$	
Insecticide	TLV-TWA[b]	Detected in office
Chlorpyrifos	200	1.26
Diazinon	100	1.63
Malathion	10,000	None detected
DDVP	100	0.41

[a]Calculated on the average insecticide level detected, converted from the 4-hr sampling period to a 40-hr work week.

[b]Threshold Limit Values--Time Weighted Average: Time-weighted average concentration for a normal 8-hr work day or 40-hr work week. (AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS 1976).

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