Bull. Environm. Contam. Toxicol. 26, 548-553 (1981)

Insecticides in the Ambient Air of Rooms Following Their Application for Control of Pests[1,2]

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Insecticides move from their site of application to nontarget areas. WINNETT & SIEWIERSKI (1975) proved that pesticides moved between buildings and WARE & CAHILL (1978) showed that emulsion sprays and slow release insecticide paints moved throughout a room. Insecticide movement from within cracks and crevices into a room's ambient air and onto surfaces in rooms, using two different techniques, was demonstrated by WRIGHT & JACKSON (1976) and WRIGHT & LEIDY (1978). WRIGHT & LEIDY (1980) reported low levels of insecticides in the ambient air of commercial pest control buildings, vehicles used by technicians of commercial pest control firms, and in institutional food preparation-serving areas following routine application in a preventive pest control service.

A comparison of airborne concentrations of insecticides, following their application into similar rooms as per recommendation has not been reported; therefore a study was initiated to compare these levels.

METHODS

Forty-nine similar rooms in a vacant three-story dormitory at North Carolina State University were used. Seven rooms on one floor and wing were utilized per week as follows: week 1 - 1st floor north, week 2 - 2nd floor south, week 3 - 2nd floor north, and week 4 - 1st floor south. This procedure reduced the possibility of insecticide movement from one room to another like-treated room since only one room was treated with an insecticide during one week and a 2-week interval elapsed before another room, on the alternate floor, in the same north or south direction was used. The typical room contained one 6-drawer dresser, two student desks, two closets, and either two single beds hinged to form openings to an enclosed storage area beneath or a single metal bunk bed. Hinged beds were raised and the drawers of the dressers and desks removed

[1]Contribution from the North Carolina University Agricultural Research Service. Published with the approval of the Director of Research as paper no. 6753 in the Journal Series.

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

0007-4861/81/0026-0548 $01.20

during application and then returned to the original position. Closet doors were open. Each room contained two windows, which remained closed during treatment, with shades lowered to the center of the window.

Personnel type air samplers with Midget Impingers were placed near the center of the test room the day prior to insecticide application with the inlet containing the trapping agent ca. 46 cm above the floor's surface. Samples were collected for 4 h to determine any background values for the insecticides[3]. 2-Methyl-2, 4-pentanediol (hexylene glycol) was used in the samplers to trap any bendiocarb, carbaryl, chlorpyrifos, diazinon, fenitrothion or propoxur present in the air. Background levels for acephate were determined using polyurethane foam as the trapping material since hexylene glycol was not suitable. Samplers were calibrated to give a constant flow rate of 2.8 L/min.

Acephate, chlorpyrifos, diazinon, fenitrothion, and propoxur were applied as emulsions containing: 1.0, 0.5, 1.0, 1.0, and 1.1% concentrations, respectively. Bendiocarb was applied as a wettable powder (suspension) at a 0.5% concentration. Carbaryl was applied as a 5% dust. Liquids were applied with a 3.8-L (1-gal) compressed air sprayer. Dust was applied with a commercial duster (Cal's Blo-Ezy duster, Stephenson Chem. Co., College Park, GA 30337). These chemicals were directed into cracks and crevices and to other sites in the rooms usually inhabited by cockroaches. The amount of insecticide applied per treatment was noted.

Each treatment was repeated once per week for 4 weeks. Before, immediately after application, and at 1-, 2-, and 3-day intervals, the air was sampled for 4 h to determine the amount of pesticide present. Temperature and relative humidity were recorded at the beginning and end of the test. Rooms were measured to determine their volume (m^3).

Air samples from rooms treated with chlorpyrifos, diazinon, and fenitrothion sprays were sampled and extracted according to the method described by WRIGHT & LEIDY (1978). Acephate samples collected in the foam were analyzed as follows. The foam plug was removed from a glass holder with a pair of forceps and placed in a 250-mL beaker. The holder was held above the beaker and rinsed with 200 mL ethyl acetate. The foam plug was squeezed against the side of the beaker at 5 min intervals for 30 min. The solvent was filtered through glass wool into a flask and concentrated to 2 to 3 mL at 40 C under reduced pressure. Residue levels of insecticides were determined by GLC or HPLC (Tables 1 and 2). Lowest detectable limits were as follows: 0.01 µg, acephate; 0.3 µg, bendiocarb; 0.01 µg, carbaryl; 0.01 µg, chlorpyrifos; 0.005 µg, diazinon; 0.02 µg, fenitrothion; and 0.05 µg, propoxur.

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

Table 1. GLC-FPD Detection of Organophosphorus Insecticides

Insecticide	Detector Temp. (C)	Column Temp.[a/] (C)	Column Flow-rate (mL N_2/min)
Acephate	185	165	120
Chlorpyrifos	195	190	80
Diazinon	185	175	100
Fenitrothion	185	170	110

[a/] 183 x 0.6 cm U-shaped glass column packed with 4% SE-30 + 6% QF-1 on 80-100 mesh Gas Chrom Q.

Table 2. HPLC-UV Detection of carbamate insecticides[a/]

Insecticide	Detector wavelength (nm)	Column[b/]	Solvent	Flow-Rate (mL/min)
Bendiocarb	220	25 by 0.6 cm Partisil-10 PAC(5 to 10μm)	20% 2-propanol in hexane	1.0
Carbaryl	225	50 by 0.6 cm LiChrosorb Si-60(5 to 10μm)	45% 2-propanol in hexane	1.1
Propoxur	223	50 by 0.6 cm LiChrosorb Si-60(5 to 10μm)	15% 2-propanol in 2,4,5 tri-methyl pentane	1.3

[a/] Varian Model 8500 HPLC equipped with Schoeffel SF-770 UV/Vis Detector and 10 mV recorder.

[b/] Columns used at ambient temperature.

RESULTS AND DISCUSSION

The temperature and relative humidity in the test rooms ranged from 23.5 to 25.4 C and 56.9 to 64.5%, respectively, during the experiment. The mean room size was 61.2 m^3. Total application time per room with the compressed air sprayer was 6.6 min with a range from 6.0 to 7.8 min. Application time using the duster averaged 10.3 min with a range from 10.0 to 11.0 min. The amount of active ingredient applied per room for all insecticides ranged from 1.0 to 4.9 g, with a mean of 2.8 g (Table 3). There was a direct correlation between the amount of active ingredient applied per room and the percent concentration of the insecticide being applied, except for the 5% carbaryl dust which was applied in much smaller quantities.

Table 3. Active ingredient applied in the dormitory rooms

Insecticide[a]	Conc. (%)	Applied[b,c] (g)	Insecticide[a]	Conc. (%)	Applied[b,c] (g)
Bendiocarb	0.5	1.7±0.1 (9.5±1.3)	Fenitrothion	1.0	3.7±0.3 (21.9±0.4)
Chlorpyrifos	0.5	1.7±0.2 (8.2±1.1)	Propoxur	1.1	3.8±0.8 (20.4±5.1)
Acephate	1.0	3.2±0.3 (18.5±3.7)	Carbaryl	5.0	1.2±0.1) (6.3±1.3)
Diazinon	1.0	3.3±0.2 (18.0±3.0)			

[a] Carbaryl applied as a dust, all other insecticides as sprays.

[b] Mean and the standard deviation for six replications of each insecticide.

[c] Numbers in parenthesis are the mean and standard deviation of active ingredient applied per room converted to a standard 100 m^3 volume.

Very small quantities of diazinon and chlorpyrifos were present in several of the preapplication air samples (Table 4). These insecticides are used by University pest control personnel and available on the retail market; therefore, it was not unexpected to find them present in small quantities. Carbaryl, bendiocarb, and propoxur, although available for household pest control, were not detected in the preapplication air samples, whereas acephate and fenitrothion have only experimental labels for structure use and are not available for commercial application.

Except for acephate (1.0%), the highest concentration of insecticide was present in the ambient air immediately following application (Table 4). The concentration of propoxur (1.1%) was the highest detected and was two times that of bendiocarb (0.5%). The level of propoxur in the air rapidly declined while bendiocarb was not detected after one day. Fenitrothion (1.0%) had the third highest level immediately after application, whereas acephate exhibited a characteristic different from the other insecticides, in that air levels were highest on day one, rather than immediately after application. Chlorpyrifos, at the 0.5% concentration had air levels almost as great as those for the 1.0% diazinon. Although carbaryl was applied as dust (with a much smaller amount of active ingredient), it was detected in levels equivalent to acephate, chlorpyrifos, and diazinon immediately after application. Its level in the air dropped rapidly at successive sampling periods.

Table 4. Airborne concentrations of insecticides in rooms ($\mu g/m^3$) following their application

Insecticide	Pretreat	Day 0	Day 1	Day 2	Day 3
Acephate (1.0%)	ND[a/]	1.3	2.9	0.5	0.3
Bendiocarb (0.5%)	ND	7.7	1.3	ND	ND
Carbaryl (5.0%)	ND	1.3	0.2	0.1	0.01
Chlorpyrifos (0.5%)	0.1	1.1	1.1	0.8	0.3
Diazinon (1.0%)	0.2	1.6	0.6	0.5	0.4
Fenitrothion (1.0%)	ND	3.3	1.1	0.8	0.5
Propoxur (1.1%)	ND	15.4	2.7	1.8	0.7

[a/]None detected

These data correlate with the vapor pressures of the insecticides (Table 5). Propoxur, bendiocarb, and fenitrothion have the highest vapor pressures and were, at the first sampling after their application, present in the greatest amounts in the ambient air. CRONIN (1977) reported that no bendiocarb was found in air samples at the limit of sensitivity of the method used when a canteen was treated according to label directions. Acephate, diazinon, and chlorpyrifos have similar vapor pressures and comparable levels were found in the air immediately following their application. The reason for the higher acephate level at day one, rather than immediately after its application, is unknown. Carbaryl, with the lowest vapor pressure and the smallest amount applied, was present in the smallest amounts in the air.

Table 5. Vapor pressures of the test insecticides

Insecticide	Vapor pressure
Fenitrothion	6×10^{-6} mm Hg (20°C)
Bendiocarb	5×10^{-6} mm Hg (25°C)
Propoxur	3×10^{-6} mm Hg (20°C)
Acephate	1.7×10^{-6} mm Hg (24°C)
Chlorpyrifos	1.9×10^{-5} mm Hg (25°C)
Diazinon	1.4×10^{-4} mm Hg (20°C)
Carbaryl	5.0×10^{-3} mm Hg (25°C)

[a/]Source of vapor pressure data for acephate is ANON. (1972), fenitrothion ANON. (1975) and the other insecticides PINTO & SPEAR (1980).

REFERENCES

ANON. Sumithion technical data sheet. Stauffer Chemical Co., Mountain View, CA. 94042 (1975).

ANON. Orthene insecticide experimental data sheet - Technical information. Chevron Chemical Co., Richmond, CA. 94804 (1972).
CRONIN, C. H.: Intern. Pest Contr. 19, 5 (1977).
PINTO, L. J. and P. J. SPEAR. Technical data for pesticides of the structural pest control industry. Nat'l. Pest Contr. Assoc., Vienna, VA. 22180 (1980).
WARE, G. W. and W. P. CAHILL: Bull. Environ. Contamin. Toxicol. 20, 413 (1978).
WINNETT, G. and M. SIEWIESKI: Bull. Environ. Contamin. Toxicol. 14, 681 (1975).
WRIGHT, C. G. and M. D. JACKSON: Arch. Environ. Contamin. Toxicol. 4, 492 (1976).
WRIGHT, C. G. and R. B. LEIDY: Bull. Environ. Contamin. Toxicol. 24, 582 (1980).
WRIGHT, C. G. and R. B. LEIDY: Bull. Environ. Contamin. Toxicol. 19, 340 (1978).