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A PILOT STUDY OF PESTICIDES IN INDOOR AIR IN RELATION TO AGRICULTURAL APPLICATIONS

David E. Camann [1], Paul W. Geno [1], H. Jac Harding [1], Nicholas J. Giardino[1], Andrew E. Bond [2], Robert G. Lewis [2], and Gerald G. Akland [2]

[1] Southwest Research Institute, San Antonio, Texas, U.S.A
[2] U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, USA

ABSTRACT

Integrated air concentrations of 24 pesticides were measured for three consecutive days both inside and outside of four farm houses to characterize levels and potential translocation following outdoor agricultural pesticide applications by the farmer. Air concentrations of recently applied herbicides were usually higher indoors than outdoors. Some elevations of outdoor and indoor air concentrations were concurrent with an agricultural application of the pesticides. Indoor elevation of lindane after spraying hogs was traced to volatilization of residues transported on the farmer's work clothing or tracked-in on his shoes.

INTRODUCTION

A prospective Agricultural Health Study of American farmers and their families is planned to investigate the observed excess of certain cancers among agricultural workers (1). A small pilot study was conducted at four farms during the herbicide application season to test methods for assessing exposure to selected pesticides in common use. Environmental and biological sampling/analytical methods were evaluated for estimating the personal exposure of the farmer during mixing, loading, and application, and the residential exposure of the family. This paper presents the measurements of agricultural and household pesticides in the indoor and outdoor air of the farm houses and discusses likely transport mechanisms.

METHODS

The study was performed at four family farms in southern Minnesota. Farms were selected from participants in an on-going surveillance study of farm pesticide applicators based on planned agricultural use of a target pesticide during the monitoring period (May 26-June 15), presence of children in the farm family, and diversity of agricultural practices. Sampling was performed near the end of the herbicide application season. Agricultural pesticide applications during the 72-h monitoring period included alachlor and atrazine on 65 acres of corn at Farms 1A and 1B, lindane sprayed on 60 hogs at Farm 1A, 2,4-D isooctyl ester mixed with a small amount of trifluralin on 40 acres of wheat at Farm 2, and imazethapyr on 220 acres of soybeans at Farm 3.

Daily 24-h (10.00 to 10.00) air samples were obtained simultaneously inside the farm house from the kitchen or family room and outside from a porch or in the yard. Air was drawn through a glass cartridge containing a 22-mm OD x 7.5-cm long precleaned polyurethane foam (PUF) plug (density 0.024 g/cm^3) at a flow rate of 3.8 L/min for 24 h (2). No agricultural pesticides were applied in the first 24 h (Day 1). Application of one or more agricultural pesticides occurred on Day 2 and often continued on Day 3.

Air samples were Soxhlet-extracted with 6% diethyl ether/hexane and analyzed for neutral pesticides (4 herbicides, 16 insecticides, and 4 fungicides). Extracts were quantitated by gas chromatography using dual-column electron capture detection and mass spectrometry selected ion monitoring and confirmed by GC/MS in full-scan mode (3).

RESULTS

Integrated daily indoor and outdoor air concentrations of target pesticides usually exhibited little variation over the three day monitoring period. Mean air concentrations of three agricultural herbicides with major use in Minnesota (alachlor, atrazine, and trifluralin) and of three common insecticides with both household and agricultural uses (chlorpyrifos, lindane, and propoxur) are presented in Table 1 for each study farm. The largest indoor air concentrations of the herbicides were observed for compounds which the farmer had concurrently or recently applied outdoors on his farm (Table 1 footnotes c and d). Air concentrations of herbicides and insecticides inside these four farm houses generally exceeded their outdoor air concentrations.

Two of the agricultural applications which were monitored appear to have elevated the integrated indoor and/or outdoor air concentrations for the concurrent 24-h sampling period above that measured on the previous day(s). Farmer 2 applied 2,4-D isooctyl ester mixed with residual trifluralin by groundboom sprayer to control weeds in several wheat fields on Day 2, including a brief (3 min) application in a field 50 m upwind from Farmhouse 2. The daily air concentrations of the applied pesticides are presented in Table 2. The air concentration pattern suggests that the herbicide application by Farmer 2 elevated the air concentration of 2,4-D isooctyl ester outside (but not inside) Farmhouse 2. The same application appears to have elevated trifluralin in both the outdoor and indoor air.

Farmer 1A applied lindane by hose sprayer to control mite mange on his hogs from 16.10 to 17.05 on Day 3. Some hogs were sprayed for 15 min in an outdoor pen which was 50 m upwind from House 1A. After performing additional chores, Farmer 1A visited his parents for supper in House 1B (500 m from House 1A) on adjoining Farm 1B. Farmer 1A did not change his work clothing until after he returned home. The integrated air concentration measurement of lindane showed a marked increase on Day 3 compared to prior days, both inside and outside of Farmhouse 1A and inside (but not outside) Farmhouse 1B (Table 2).

Spiked analytes were recovered well in performance evaluation PUF samples analyzed blindly (Table 3). Analyte recovery from PUF plugs spiked in the field was lower (Table 3), indicating some loss during field handling and storage. The PUF field blank indicated that low-level contamination (< 10 ng) could occur during sample set-up or take-down.

Table 1. Mean indoor and outdoor air concentrations of pesticides (ng/m^3) in American farm and urban homes.

		Minnesota Farm Homes May-June, 1992				Urban Homes(4)	
Pesticide	Location	1A (n=3)	1B (n=2)	2 (n=3)	3 (n=3)	Springfield Massachusetts[a] (n=49)	Jacksonville Florida[b] (n=72)
Alachlor	In	141	922	6	13	NA[e]	NA
	Out	45[c,d]	44[c,d]	2	2[d]	NA	NA
Atrazine	In	12	68	10	2	<1	<1
	Out	11[c,d]	7[c,d]	3[d]	5	<1	<1
Chlorpyrifos	In	9	58	8	4	10	205
	Out	2	0.7	2	0.4	14	4
Lindane	In	15	40	2	3	0.5	13
	Out	15[c]	0.6	0.3	0.1	<0.2	0.5
Propoxur	In	<1	<1	<1	29	27	222
	Out	<1	<1	2	<1	0.8	0.8
Trifluralin	In	0.7	2	21	1	NA	NA
	Out	0.1	0.3	12[c,d]	2	NA	NA

a - Weighted probability sample of 49 homes in May-June, 1987
b - Weighted probability sample of 72 homes in March-April, 1987
c - Agricultural applicaiton(s) of pesticide by farmer during monitored period
d - Agricultural application(s) of pesticide by farmer during month prior to monitored period
e - Not analyzed

Table 2. Daily indoor and outdoor air concentrations at the farm house in relation to nearby agricultural applications of the pesticide.

Pesticide	Farm	Day	Application exposure event[a]	Daily air concentration (ng/m³) Indoors	Outdoors
Lindane	1A	1		1.4	0.2
		2		1.7	1.1
		3	A	41[b]	44[b]
	1B	2		17	<0.2
		3	A,B	64[b]	1.2
2,4-D Isooctyl ester	2	1		1.9	5.4
		2	C	1.9	20[b]
		3		1.0	3.4
Trifluralin	2	1		19	5.1
		2	C	29[b]	14
		3		16	16

a - Application exposure events:

- A - Farmer 1A applied lindane by hand sprayer on hogs at Farm 1A to control mite mange.
- B - Farmer 1A visited his parents at Farmhouse 1B for supper after the lindane application.
- C - Farmer 2 applied 2,4-D isooctyl ester/trifluralin by groundboom sprayer to control weeds in wheat.

b - Apparent effect of concurrent application.

DISCUSSION

Agricultural pesticides are applied outdoors to treat crops and livestock. However, during a 72-h period in homes on four family farms near the end of the herbicide application season in Minnesota, the concentrations of agricultural pesticides including alachlor, atrazine, lindane, and trifluralin, were usually higher in the air indoors than in the concurrently sampled air outside the house. As in previous studies (4-6), air concentrations of insecticides such as chlorpyrifos, lindane, and propoxur were higher indoors than outdoors. Excluding the day with simultaneous lindane treatment of hogs, mean air concentrations of these insecticides in this limited sample of rural farm houses appear to be similar to those in urban American homes in Springfield, Massachusetts (same latitude) at the same time of year (Table 1). Higher indoor air concentrations of insecticides were found in urban American homes in spring in an area of a high household use (Jacksonville, Florida, Table 1).

Table 3. Mean percent recovery of spiked analytes from PUF plugs.

	Blind spikes from EPA (n=3)	Field spikes (n=3)
Alachlor	90%	66%
Atrazine	96%	84%
gamma-Chlordane	NS[a]	67%
Chlorpyrifos	91%	85%
Diazinon	88%	82%
Lindane	89%	NS
Propoxur	100%	59%

[a] not spiked

The lindane air concentration (44 ng/m³) on Day 3 outside Farmhouse 1A is attributed to aerosol drift from spraying hogs outdoors nearby (50 m upwind). Farmer 1A apparently introduced lindane into the indoor air of Farmhouse 1B (64 ng/m³) via residues on his work clothing (estimated as 78 mg based on analysis of patches affixed to both thighs and the nape of his neck) and shoes. Since the measured air exchange rate of Farmhouse 1A was only 0.34 air changes/h, volatilization from the work clothing and shoes of Farmer 1A probably contributed more than infiltration (measured rate of 160 m³/h) to the elevated indoor air concentration of lindane (41 ng/m³) in Farmhouse 1A on Day 3.

Elevation of the air concentration 2,4-D isooctyl ester (20 ng/m³) on Day 2 outside Farmhouse 2 is attributed to aerosol drift from groundboom spraying upwind of the house, including 3 min in an adjacent field. However, infiltration of 2,4-D isooctyl ester into House 2 was not detectable (Table 2).

This study demonstrates that a direct relationship can exist between outdoor application of a pesticide by the farmer and subsequent elevated indoor air concentrations of the pesticide in his home. The data suggest that transport of residues on the farmer's work clothing and/or track-in on shoes as well as infiltration of aerosol spray drift can be mechanisms contributing to elevated indoor air levels. More family farm homes need to be monitored to assess the generality of these observations.

Training programs for farm pesticide applicators should emphasize proper use of pesticides and personal hygiene after completing the application to minimize exposure of the applicator's family at home. Work clothing and shoes should be removed and stored outside the home. Greater attention to prompt hand-washing and showering is warranted.

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