Pesticide residu

Case study of a Midwestern farmer's coverall contamination

Janis F. Stone, Ph.D. H. Michael Stahr, Ph.D.

Abstract

Cotton coveralls actually worn by a Midwestern farmer for four crop seasons in applying eight different pesticides to corn and soybeans were analyzed for pesticide residues by gas chromatography. Although the family reported that the coveralls were laundered after every wearing and the farmer seemed in good health, residues of Treflan, Lorsban, and Counter were recovered from each of the 39 specimens taken from various areas of the garment. Residues of Thimet and Dyfonate respectively were found in several samples. One extraction with ethyl acetate failed to recover all the pesticides; additional quantities were found in specimens subjected to a second and third extraction. Although initial contamination was unknown, persistence of residues after repeated home laundering over such a period of time was unexpected. This case study suggests that applicators in minimum exposure situations should start with new cotton coveralls each application season and that previous studies based on one extraction may underestimate contamination.

Laboratory research on laundering methods to reduce pesticide residues in farm workers' clothing is designed to focus on particular variables, with the amount of contamination and laundering procedures under investigation carefully controlled. The cloth samples tested usually are bleached, never-worn fabrics, not exactly the same as those worn by farm workers, and the washing usually is performed in a Launder-Ometer rather than the kind of washing machine used in homes (4,5,6).

These procedures simplify the complexity of the research and reduce the number of variables, but farm families and others sometimes doubt the validity of the results. This doubt contributes to the difficulty of motivating people to accept safety recommendations related to care and use of protective clothing that are implied by the findings of the studies (11,12,13).

Concrete evidence of this doubt was provided in May 1988, when a farm family delivered a pair of worn coveralls to the Iowa State University Textiles and Clothing Extension Office. A letter of explanation said that the coveralls "might be of interest" in relation to the department's ongoing research into the care of pesticide-contaminated clothing.

The letter explained that the coveralls were worn for "four seasons, washed everyday in an automatic, dried in a dryer." It stated that the chemicals used were: "Counter, Lorsban, Dyfonate, Lasso/Atrazine, Treflan and Command."

To help dispel these doubts, the case study here reported was initiated to determine if the coveralls actually worn for pesticide application for at least three years and laundered after every wearing contained measureable pesticide residues, the levels of the contamination (if any), and if the contamination was localized or evenly distributed throughout the garment.

Materials and methods

The family launderer was interviewed by telephone to learn about the history of the coveralls, the years the various chemicals were used and the farmer's health. The coveralls were photographed and are shown in Figure 1.

Locations were selected where samples of coverall fabric would be removed (Figure 2) for analysis using gas chromatography. Previous studies have found that deposition differs with the type of application, the task and body part (2,3,8). A Louisiana study of entry into permethrin-treated soybean fields showed greater residue levels on lower legs (1).

Fiber content was determined by microscopic analysis and chemical solubility tests. Fabric weight was measured from samples cut from under the chest pocket, the area of the garment that appeared in best condition from the abrasion standpoint.

Samples were cut to measure 8 x 8 cm and placed in sterile extraction tubes. Some exactness in sample size was sacrificed to gain an understanding of how layers might affect pesticide entrapment and retention. Pesticide extraction and analysis using gas chromatography was conducted in the College of Veterinary Medicine Diagnostic Laboratory at Iowa State University with procedures similar to those reported earlier (10).

The cloth samples were placed in the extraction tubes, and 10 ml of ethyl acetate was added. The caps were screwed on the tubes, the tubes were shaken for 5 min and allowed to stand for 16 hrs. After 16 hours, the solvent was removed from the tubes and analyzed for Treflan by electron capture (EC) GLC. After the EC analysis, the samples were concentrated to 100 ul and analyzed for organophosphorous pesticides.

All samples were quantitated by two replicate systems. Standards were run after every five sample injections. Every fifth sample was amended with a mixture of the six pesticides anticipated to be present (those that the owner of the coveralls had reported using), and quantitative analysis for these were made; 80-100% recovery was obtained of the added pesticides.

Electron capture analysis showed many peaks that did not match the anticipated pesticides. Two different systems confirmed the presence of organophosphorous pesticides.

The pesticide deposition per square centimeter of fabric for each sample was separately calculated based on the sq cm size of the extracted sample. That is, if for any reason samples were divided before extraction, then the number of square centimeters was divided accordingly in the calculations. For the cuff and waistline samples, no addition in surface area was made because of the fabric layers in the sample. Samples from similar garment areas were averaged, but no statistical analysis was attempted with data from this one garment.

The second extraction of a few samples was done. Finally, two samples that gave the greatest recoveries on the first and second extractions were extracted in a reflux extractor for two days.

Results

A telephone interview with the farmer revealed that he was in good health and farmed ~~420~~ 4700 acres. All the pesticides mentioned in the letter had been used, but

Janis F. Stone, Ph.D., College of Family and Consumer Science, College of Veterinary Medicine, Iowa State University, Ames, Iowa.

Thimet also was used in 1985. Table 1 shows the amounts of the various brands of pesticides applied in the years for which records were available.

From 1985-1987 the coveralls were worn only during planting season, from mid-April to mid-June. In 1988 they were worn for the application of corn insecticide, but not for planting soybeans; therefore, they may not have been exposed to all chemicals listed in Table 1 for 1988. The coveralls usually were worn over other clothing (until it got too hot).

The telephone interview with the launderer revealed that the coveralls had been washed after every wearing in a Maytag washer using softened, hot (or sometimes warm) water and powdered detergent. No bleach or fabric softener was used. They were dried in an automatic dryer set for a regular cycle.

The prelaundering contamination levels and number of wearings or washings was impossible to estimate. The coveralls appeared quite "worn out" as shown in the photographs; however, they appeared as clean as could be expected after that period of use and had no noticeable odor. A few stained and discolored areas were visible.

Microscopic analysis determined that the coveralls were 100% cotton. Samples cut from the least-abraded sections of the coverall fabric (under the chest pocket) were weighed, showing the fabric weight to be about 10.5 oz/sq yd.

Measureable amounts of Treflan, Lorsban and Counter were found in all samples of the coveralls, but no Lasso/Atrazine was detected. The amounts in ng/sq cm recovered in the first extraction are shown in Table 2. A few samples showed contamination with Dyfonate and Thimet on the first extraction.

The level of contamination seemed to vary with the part of the garment. Greater levels of contamination were noted on sleeves, cuffs and areas that might frequently be touched by the hands, such as the waist and hip pockets. However, with the exception of the sleeve samples, these also were constructed and layered areas of the garment.

A second extraction from selected samples from lower leg, abdomen, shoulders, chest pocket, sleeve and cuff proved that pesticides had not been exhausted from the fabric by the first extraction. Dyfonate and Thimet were found in a few samples that had not shown these chemicals on the first extraction.

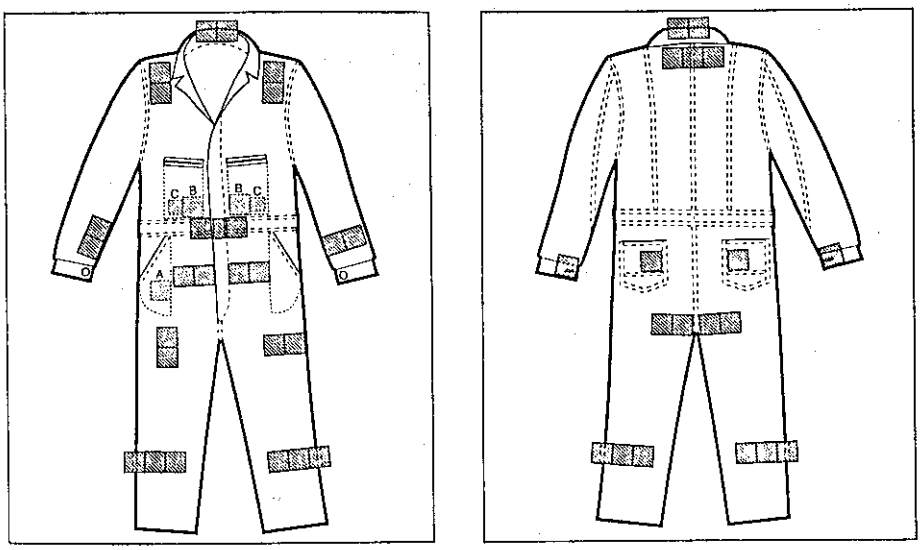
Treflan, Lorsban, and Counter were found in all nine of the samples extracted a second time. The amounts released in the second extraction are shown in Table 3. The two lower sleeve and cuff samples selected for a third extraction produced about 30% additional pesticide.

Figure 1

Cotton coveralls before samples were removed for chemical analysis: A=front, B=back

Figure 2

Locations of samples removed for chemical analysis: A= cotton/polyester twill pocket lining, B= coverall fabric layer next to body behind pocket, C = coverall fabric sample used to determine fabric weight.



Discussion

Although the amounts of pesticide per sq cm of fabric detected in the coveralls do not seem very important when considered on that limited basis, if the total surface area of the garment is considered and mean value for total contamination of each pesticide is used, then significant amounts of pesticide are present.

It would be presumptuous to form any conclusions about how these levels of contamination might affect worker health. Coveralls usually are worn over other clothing and if the pesticide is so firmly bound to the cotton that it does not come out in laundering, then it may be so firmly bound that it will not come out if soaked with perspiration when next to the worker's skin. However, no studies have been identified that consider whether oily skin secretions may more readily attract these residues.

Skin absorption of pesticide theoretically would occur at the interface of the clothing and skin, unless heat or another complicating factor caused the pesticide to be

Table 1

Pesticides applied

Year	Brand	Amount applied
1985	Lasso/Atrazine	4,613 gal.
	Lorsban	20,600 lbs.
	Thimet	12,700 lbs.
1986	Dyfonate	12,500 lbs.
	Lasso/Atrazine	4,614 gal.
	Lorsban	25,100 lbs.
1987	Counter	15,000 lbs.
	Lasso/Atrazine	3,388 gal.
	Treflan	16,950 lbs.
	Command	65 gal.
	(Treflan/Command tank mixed)	72 gal.
1988	Counter	5,350 lbs.
	Lasso/Atrazine	1,446 lbs.
	Lorsban	7,000 lbs.
	Treflan	604 gal.
	Command	411 gal.
	AATREX 90	1,325 lbs.

Table 2

Pesticide released from coveralls in first extraction reported in ng/sq cm of fabric

Garment part	Treflan	Lorsban	Counter	Dyfonate	Thimet
Lower leg (n=6)	4.9	7.3	0.7	0.2	0.5
Thigh (n=4)	6.5	11.8	2.6	*	0.3
Crotch (n=6)	5.8	22.1	2.8	2.1	*
Shoulders (n=5)	2.8	8.3	1.1	1.6	*
Sleeves (n=4)	9.7	33.4	4.1	*	*
Chest pocket, front (n=2)	1.6	13.4	1.4	*	*
Hip pockets, back (n=2)	11.9	77.9	3.9	*	*
Collar (n=2)	5.6	19.6	0.8	*	*
Multilayer samples					
Waistband (n=3)	29.5	71.1	13.6	2.8	*
Cuff (n=2)	14.0	91.9	10.5	*	*
Outside lower leg seam (n=2)	5.2	11.4	1.1	*	1.1
Cotton/polyester twill pocket lining fabric					
Side pocket (n=2)	42.9	30.6	14.4	*	*

n = total number of fabric samples extracted that were cut from locations on right, left, front and back
* = not detected

Table 3

Pesticides released in the second extraction in ng/sq cm

Garment part (n = 1)	Treflan	Lorsban	Counter	Dyfonate	Thimet
Lower leg front	0.5	3.5	0.3	0.2	0.1
Crotch front	2.1	4.3	1.2	*	*
Shoulder back	0.4	2.9	0.3	*	*
Sleeve (left)	1.4	7.7	0.9	1.7	*
Sleeve (right)	1.0	10.9	3.0	*	0.4
Chest pocket	1.5	16.3	1.2	*	0.1
Cuff (left)	5.9	23.4	3.1	*	0.1

n = number of fabric samples tested
* = not detected

volatilized so that it was deposited on the skin. The total surface area of the fabric touching the skin would seem to be more relevant in terms of estimating exposure than the total weight of the fabric.

For this reason and because weight of fabric samples varied from abrasion and wear, pesticide deposition was reported in ng per sq cm of surface area.

The findings from this study must be viewed in relation to their several limitations, because the exact conditions of exposure and levels of exposure were uncontrolled and are unknown. Also, there were no physiological data from the wearer to indicate exposure effects.

However, this study also was not dependent on alpha cellulose or other residue collection patches that are normally used in exposure studies (2,3,8). The ability of a pesticide to penetrate, permeate through, be absorbed by, or be removed from fabric is in part dependent upon the fabric structure and weight (1,4,5,6,7,). For this reason, exposure studies that base their conclusions on substrates other than the actual fabric worn by workers have limitations as well.

This study has demonstrated the difficulty with extraction methodology when the substrate is a textile matrix. One chemical extraction with ethyl acetate did not remove all the residue from the fabric samples. This suggests that work based on a single extraction may underestimate the amount of pesticide in fabrics both before and after laundering.

The amount of pesticide and extraction solvent, the type of solvent and fabric, the fabric weight, and the amount and time of agitation or soaking before extraction are experimental variables that seem to affect experimental results.

In practical terms, these coverall case study results are discouraging. Actual laundering after every wearing does not seem to completely clean pesticides from clothes even in conditions that would be considered "minimum exposure" (9).

Disposable coveralls have been sugges-

ted as the solution to the protective clothing problem, but they are expensive, they may be too hot for comfort and their disposal is a problem. An interim solution might be to use cotton coveralls, washing them according to recommended procedures, and replace them each season.

Suggested future work would include toxicological studies with contaminated cloth patches applied directly to living tissues of experimental insects and animals. Infrared NMR spectroscopy studies of organophosphorus binding by cellulose would help define how the pesticides are held in the clothing.

In addition, studies of the cholinesterase levels in workers and how they change with pesticide use would help determine the hazard of contamination to the wearer. Finally, behavioral studies of workers, using remote portable TV cameras and computer analysis of patterns of observed activity, would help define subliminal effects which may portend serious long-term effects on the workers.

Conclusions

The results from this case study should help dispel doubt about how adequately laboratory laundering studies represent the real world. It was shown that pesticide residues encountered in the normal management of corn and soybean crops are not removed completely from clothing with actual home laundering, that the residues remain in fabric for an extended time, and that the level contamination differs with the area of the garment and the type of pesticide.

No Lasso/Atrazine contamination was found in the used coveralls, but the levels of contamination from Treflan, Dursban and Counter found were unexpected on the basis of reported adherence to research-based laundering recommendations and the generally odor-free condition and clean appearance of the coveralls.

Also, the persistence of the Dyfonate, which had not been used since 1986 and the Thimet, which had not been used since 1985 was unexpected. The water solubility of Lasso-and Atrazine is consistent with the removal of these compounds with washing (4).

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This case study has provided a better understanding of pesticide residues in farm clothing because it is the first time that the level of contamination collected on clothing from a real-life corn-and-soybean operation has been examined. The variety of pesticides used, the period of extended use, and the reported attempts at decontamination through regular washing made this case a uniquely valuable additon to our understanding of pesticide residues in clothing. □

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