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THE EFFECTS OF WATER TEMPERATURE ON DECONTAMINATION OF PESTICIDE APPLICATOR CLOTHING

September 1980

Approved for public release; distribution unlimited

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The mean quantities of pesticide residue remaining in pesticide treated cloth samples were compared after washing in cold (30°C), warm (43°C), or hot (60°C) water. The pesticides malathion, bromacil, diazinon, chlordane, and propoxur were tested. A significant ($p = 0.01$) amount of pesticide residue was removed regardless of water temperature; however, there was a trend toward increased residue removal with increased temperature. It is recommended that the wash water temperature be $\geq$ 60°C to achieve maximum decontamination of pesticide applicator clothing.

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We are grateful to Ms Suzzane Salinas for assisting with the washing procedures.

I. INTRODUCTION

The clothing worn by pesticide applicators is subjected to contamination by both concentrated and diluted pesticide solutions during routine mixing and application activities. Significant levels of pesticide residues in worker clothing have been reported[1,2] and the type of fabric has been shown to affect penetration and retention of the residues.[3] Pesticide residue in contaminated clothing can be reduced with home laundering techniques;[4,5] however, it is not advisable to wash such material with the family wash.[6] Finley et al[4] have shown that DDT, toxaphene, and methyl parathion residues in contaminated clothing remain toxic to living organisms, even after the clothing has been subjected to repeated washings.

A washer and dryer are authorized by the USAF Table of Allowances (TA 483) for USAF pest management facilities but guidance on washing procedures has not been established. Specific procedures for decontaminating the clothing of workers exposed to methyl parathion have been published. Under such procedures, the recommended washwater temperature is 60°C or higher.[7] The USAF has also unofficially recommended the 60°C water temperature. The Department of Energy has recommended a maximum temperature setting of 40°C for general purpose hot-water lines[8]. This temperature was established for energy conservation.

At the request of the Armed Forces Pest Management Board, the USAF OEHL evaluated the effects of washwater temperature on decontamination of pesticide applicator clothing. The objective of this study was to compare the mean quantities of pesticide residue remaining in contaminated clothing after washing in cold (30°C), warm (43°C), or hot (60°C) water.

II. MATERIALS AND METHODS

A. Washing Procedures

The concentrated pesticides malathion (91.5%), bromacil (21.9%), diazinon (47.5%), chlordane (71.5%), and propoxur (13.9%) were tested. Dilute solutions of diazinon (0.5%), chlordane (1.0%), and propoxur (1.1%) were also prepared for testing. Cotton coveralls (NSN 8405-00-082-5529) were obtained through normal government procurement procedures and used as the test fabric. The coveralls were cut into 5 x 5 cm samples and 1 ml of a given pesticide was pipetted directly onto each cloth sample in a manner which prevented runoff from the cloth edges. The treated samples were allowed to air dry for 24 hours following treatment. Four samples of each pesticide and four blanks (untreated cloth samples) were prepared for each wash temperature.

All cloth samples, blank or pesticide treated, were washed together at a given temperature in a one-speed Whirlpool® washing machine operating at 68 agitations per minute. Fifty grams (1/2 cup) of government procured laundry detergent (Local Purchase No. 7930-L2024-54-3047) were added to each wash. The detergent was a no-phosphorus product which contained sodium carbonate, sodium sulfate, silica, and a trace of alkyl aryl sulfonate. The pH of a 1% solution of the detergent was approximately 11. After a 14-minute wash followed by two rinses (35-minute total time), the samples were dried for 30 minutes in a Whirlpool® gas dryer. The samples were then individually wrapped in aluminum foil and held for analysis.

An unwashed group containing control samples and blanks was also prepared for analysis. The control samples were treated with pesticide in the manner previously described.

B. Analytical Procedure

The bromacil samples were soaked for 30 minutes in 100 ml of methanol while all other pesticide samples were soaked for the same duration in 100 ml of pesticide grade hexane. The solution was then analyzed by either gas chromatography or ultraviolet absorption..

An external reference solution of each pesticide was used as a standard for all analyses. The type of detector employed was dependent upon the chemical structure of a given pesticide. The detection limit and range of sensitivity for each detector used is given in Table 1.

Table 1. Detection limit and range of sensitivity for each detector used in the analytical procedure.

PESTICIDE(S)	DETECTOR	LIMIT	SENSITIVITY
Diazinon and Malathion	Flame Photometric	200 ng	± 200 ng
Chlordane and Bromacil	Electron Capture	40 ng	± 40 ng
Propoxur	Ultraviolet	50 µg	± 50 µg

The columns used in the gas chromatographs were 3% Dexsil 300 on 80/100 Chromosorb W/AW on the electron capture instrument and 5% OV 210 on 80/100 Gas Chrom Q for the flame photometric instrument. A 5 µl injection volume was used on the gas chromatographic instruments.

III. RESULTS AND DISCUSSION

The analytical results for each pesticide at each temperature and the control samples were compared using an analysis of variance.[9] A significant ($p = 0.01$) amount of residue was removed regardless of water temperature (Table 2). There was a tendency for increased residue removal with increased temperature but the difference was not significant ($p = 0.05$) for all pesticides when the data were compared using Duncan's multiple range test (Table 3).[10]

Diazinon removal was the most sensitive to changes in water temperature (Table 2). For the concentrated material, 85.3% of the residue was removed in the cold treatment whereas 96.1% was removed in the hot treatment. The effect of water temperature was more noticeable for the dilute solution. The amount of residue removed by the hot water wash (99.4%) was significantly ($p = 0.05$) greater than the amount removed by the cold (68.2%) or warm (79.1%) water treatments.

Table 2. Percentage of pesticide residue removed from cloth samples by washing in cold (30°C), warm (43°C), and hot (60°C) washwater.

PESTICIDE (%)	% REMOVED BY WASH		
	COLD	WARM	HOT
Diazinon (47.5)	85.3	a	96.1
(0.5)	68.2	79.1	99.4
Propoxur (13.9)	81.9	99.6	ND
(1.1)	ND	ND	ND
Chlordane (71.5)	99.9	96.2	97.9
(1.0)	63.0	51.7	56.0
Bromacil (21.9)	90.4	96.6	99.97
Malathion (91.5)	93.0	95.4	97.1

ND = No residue detected
a = analytical error

The degree of propoxur removal was also influenced by water temperature (Table 2). The amount removed varied from 81.9% in the cold water to 99.6% in the warm water. This difference was statistically significant ($p = 0.05$). The amount of propoxur residue, if any, remaining in the hot water samples was below the detection limit. Essentially all of the propoxur residue was removed by the washing process from all samples treated with the dilute solution.

The pesticides bromacil and malathion followed the same trend of increased residue removal with increased temperature (Table 2). The results, however, were not significantly different ($p = 0.05$) when the data were compared using Duncan's multiple range test. The primary factor contributing to a lack of significant difference was that over 90% of the residue from both pesticides was removed by all wash temperatures.

Results from the chlordane tests did not follow the trend observed for the other pesticides (Table 2). Chlordane was more stable with regards to water temperature. The persistence of chlordane, like many other chlorinated hydrocarbons, is well documented.[11] The blank (untreated) cloth samples were even found to be contaminated with chlordane for this study. The degree of contamination ranged from 0.99 to 16.8 µg of chlordane when 16 samples were examined. The mean contamination rate was 7.41 µg/sample.

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Table 3. Mean retention of pesticide residue (mg), ± standard error, for the unwashed controls and samples washed in cold (30°C), warm (43°C), and hot (60°C) water. Means followed by a common letter for each pesticide are not significantly different at p = 0.05 using Duncan's multiple range test. 5 x 5 cm samples of cloth.

PESTICIDE (%)	UNWASHED	COLD	WARM	HOT
Diazinon (47.5)	360.00 ± 80.96[a]	53.35 ± 2.75[b]	analytical error	14.35 ± 1.85[b]
(0.5)	11.18 ± 0.93[a]	3.51 ± 0.69[b]	2.28 ± 0.50[b]	0.07 ± 0.02[c]
Propoxur (13.9)	167.00 ± 18.00[a]	30.25 ± 3.22[b]	0.68 ± 0.33[c]	ND [c]
(1.1)	1.21 ± 0.05[a]	ND [b]	ND [b]	ND [b]
Chlordane(71.5)	16,675.00 ± 3,745.30[a]	17.33 ± 3.76[b]	636.67 ± 205.99[b]	344.25 ± 42.96[b]
(1.0)	10.33 ± 1.10[a]	3.82 ± 0.70[b]	4.99 ± 0.55[b]	4.55 ± 0.34[b]
Bromacil (21.9)	321.75 ± 18.45[a]	30.90 ± 10.35[b]	10.82 ± 0.45[b]	0.09 ± 0.03[b]
Malathion(91.5)	585.00 ± 62.92[a]	40.80 ± 13.27[b]	27.20 ± 3.07[b]	16.70 ± 1.97[b]

ND = No residue detected

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The notable results, from our study, were the trend toward increased residue removal with increased washwater temperature, and the significant ($p = 0.05$) effect of washwater temperature on diazinon and propoxur removal. Over 80% of the pesticide residue was consistently removed in all temperatures for all pesticides except the dilute solutions of chlordane and diazinon. Over 96% of the residue was removed by the hot water wash for all pesticides except the dilute solution of chlordane. The amount of propoxur residue was significantly decreased by washing the contaminated cloth in water $\geq 43^{o}C$ and diazinon residue was significantly decreased in water $\geq 60^{o}C$. Both propoxur and diazinon are commonly used in the military and diazinon is probably the foremost used insecticide in the USAF. Use frequency should be considered when establishing general standards based on our results.

IV. RECOMMENDATION

The washwater temperature should be $\geq 60^{o}C$ ($140^{o}F$) to achieve maximum decontamination of pesticide applicator clothing.