Bull. Environm. Contam. Toxicol. 27, 518-523 (1981)

Methyl Parathion Transfer from Contaminated Fabrics to Subsequent Laundry and to Laundry Equipment[1]

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The absorption of a chemical by the skin can be controlled by the use of protective clothing (BAKER 1979). The Federal Register (May 1, 1973) reported that requirements for protective clothing include a "washable fabric." In a 1972 study, METCALFE found methyl parathion (MeP) residue in fabrics after three washings and determined that these residues were biologically active.

EASLEY et al. (1981) have demonstrated success in removal of MeP from fabrics in laundry. Removal was greater for encapsulated (ENC) and wettable powder (WP) formulations, with ranges of 93% to 99% as compared to emulsifiable concentrate (ENC) formulation (80% to 88%).

During the EASLEY et al. (1981) study insecticide odors prevailed for 24 hours following laundering procedures. Suspecting contamination of the washing apparatus with MeP, the canisters and the rubber sealing gaskets of the Launder-Ometer were acetone rinsed and analyzed for MeP residues. From the neoprene rubber gaskets 648 ng/cm^2 MeP were removed. Four acetone rinsings of the stainless steel canisters yielded 82,407 ng; 146 ng; 7 ng; and 1 ng, respectively. It was apparent that the potential existed for the transfer of pesticides in the home laundry situation. This study was undertaken to evaluate the transference phenomenon using laboratory procedures.

MATERIALS AND METHODS

Since EASLEY et al. (1981) investigated the efficacy of four selected laundry procedures in the removal of three formulations of MeP from cotton and cotton/polyester denim fabrics, these same factors were used in this study.

[1] Published as Paper No. 6600, Journal Series, Nebraska Agricultural Experiment Station. Research reported was conducted under Project 94-010, and was funded in part by a grant from United States Environmental Protection Agency Region 7.

0007-4861/81/0027-0518 $01.20
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Chemicals: Three formulations of MeP were used: 1) emulsifiable concentrate (EC); 2) encapsulated (ENC); and 3) wettable powder (WP). A 1.25% concentration of each of the formulations of MeP was used to contaminate fabric swatches.

Fabrics: Fabrics were of two types. Contaminated denim fabrics duplicated accidental contamination of clothing with a pesticide solution which were subsequently laundered in home laundry equipment. Cotton transfer fabrics duplicated family textile items laundered in the same household appliance immediately following the washing of pesticide contaminated clothing.

An all cotton denim and a 50 cotton/50 polyester denim were used as the contaminated fabrics. Both fabrics were 2/1 twill and similar in construction. Fabric swatches (8 x 8 cm), immersed in a 1.25% MeP solution, retained like amounts of MeP (0.56 to 0.66 mg/cm^2). After saturation, the swatches were air dried, and then subjected to the selected laundry procedures.

The transfer fabric was an all cotton batiste of plain weave construction. These fabric swatches (8 x 8 cm) were subjected to one complete laundering cycle immediately after the contaminated fabrics had been through one wash and two rinse cycles.

Laundry Procedures: Following contamination, the denim fabrics were randomly selected to be subjected to one of four laundry procedures.

1) Pre-rinse. Contaminated swatches were pre-rinsed for two min in warm water at 49°C; then laundered for 12 min in a phosphate detergent hot water (60°C) wash; followed by two warm water rinses (49°C) of three and five min, respectively. The phosphate detergent was American Association of Textile Chemists and Colorists (AATCC) Standard Detergent 124, a 12% phosphate detergent used in textile research.

2) Phosphate detergent wash (Det.). Contaminated swatches were laundered for 12 min in a phosphate detergent hot water (60°C) wash; followed by two warm water rinses (49°C) of three and five min, respectively.

3) Phosphate detergent wash plus ammonia additive (Det. + NH_3). This treatment was identical to that of the phosphate detergent wash with the addition of ammonia laundry additive (3.5% - 4% ammonia concentration) in the wash cycle.

4) Phosphate detergent wash plus bleach laundry additive (Det. + NaOCl). This treatment was the same as described for the phosphate detergent wash with the addition of liquid chlorine bleach (5.25% sodium hypochlorite) laundry additive in the wash cycle.

A modified AATCC test method 61-1975 (AATCC 1979) was used for the laundering procedures. Detergent weight and laundry additive volumes were proportioned to the 45 L volume found in home laundering equipment. In each 150 ml of wash solution, detergent was 0.2% of volume, and laundry additive was 0.015% of total volume.

Launder-Ometer canisters (500 ml) allowed for individual laundering of swatches, and steel balls added to each canister simulated laundry agitation. Constant temperature of the Launder-Ometer water bath was maintained. At the end of each cycle, water was decanted from the canisters. An additional 150 ml water, at the specified temperature, was then added for the subsequent cycle.

Following completion of the laundering process, the contaminated denim fabric swatch was removed, the rinse water decanted, and a clean cotton transfer fabric added to each canister along with 150 ml of phosphate detergent solution. Warm water (49°C) was used for the wash and two rinse cycles. After laundering, the transfer fabric was air dried and retained in glass until solvent extraction.

Extraction Procedures: MeP was extracted from the cotton transfer fabric using two aliquots of 100 ml each of glass-distilled acetone. The extract was concentrated by rotary vacuum evaporation to a volume of 3 ml. Three ml of toluene were added, and the extract was further condensed using N_2 stream to a final volume of 3 ml.

Gas Chromatographic Procedures: Extracts were analyzed using a Hewlett-Packard, model 5840A, gas chromatograph, with a nitrogen-phosphorous thermionic detector. The separation column was 1.83 m x 3 mm I.D. packed with 3% OV-25 on 100-120 mesh Chromosorb W HP. The column temperature was 213°C, that of the inlet was 217°C, and the detector was 300°C. Nitrogen carrier gas flow was 1.26 L/h, air flow was 3 L/h and hydrogen was 0.18 L/h. Standard solutions of MeP (technical grade 99.9% purity), from the Environmental Protection Agency Health Effects Research Laboratory, were injected after every fourth sample for calibration.

Bioassy of Transfer Fabrics: *Blattella germanica* (L.); (German cockroaches) biotype: Orlando normal were used to determine if insecticide residues present in the laundered contaminated fabrics and the laundered transfer fabrics were biologically active. All trials were conducted in environmental chambers at 30°C and 10-20% R.H. Cockroaches were anesthetized with CO_2, after which ten adult males were placed on each of the treated fabrics, dorsum up. Cockroaches recovered within five min and were noted to actively search the confines of the petri dish barrier. The cockroaches were held on the swatches for twenty-four h, after which time mortality was recorded.

RESULTS AND DISCUSSION

The laboratory laundry equipment had retained MeP such that the cotton transfer fabric washed through a full cycle immediately following the laundering of the contaminated denim fabric retained 3.58 ng/cm^2 to 13.00 ng/cm^2 MeP (Table 1). There was a significant correlation ($r=0.63$, d.f.$=70$, $p \leq 0.01$) between the amount of MeP on the contaminated denim fabric before laundering and the amount of MeP on the transfer fabric after laundering in contaminated equipment. A negative correlation ($r=-0.26$, d.f.-70, $p \leq 0.05$) was found between the amount of MeP on the laundered contaminated denim fabric and the laundered transfer fabric. Thus a relationship was observed between the amount of MeP introduced by contaminated denim fabric and the amount recovered from the transfer fabric. The percentage of MeP retained in the transfer fabric after laundering ranged from 0.00061 to 0.00181% of that which had been originally present on the contaminated denim.

TABLE 1
MeP IN CONTAMINATED FABRICS BEFORE AND AFTER LAUNDERING AND MeP IN TRANSFER FABRICS AFTER LAUNDERING.[a]

Treatment	After Laundry[b] $\bar{X}$ mg/cm^2	Transfer[c] Fabric $\bar{X}$ ng/cm^2	Treatment	After Laundry[b] $\bar{X}$ mg/cm^2	Transfer[c] Fabric $\bar{X}$ ng/cm^2
EC-C[d]			EC-C/P[f]		
Control (0.62 mg/cm^2)[e]			Control (0.59 mg/cm^2)		
Pre-rinse	0.08	4.54	Pre-rinse	0.02	4.07
Det.	0.09	4.55	Det.	0.07	5.92
Det.+NH_3	0.06	5.14	Det.+NH_3	0.03	5.36
Det.+NaOCl	0.08	4.95	Det.+NaOCl	0.07	3.58
ENC-C			ENC-C/P		
Control (0.59 mg/cm^2)			Control (0.59 mg/cm^2)		
Pre-rinse	0.00	5.22	Pre-rinse	0.00	5.31
Det.	0.02	10.64	Det.	0.01	5.44
Det.+NH_3	0.02	6.24	Det.+NH_3	0.01	5.44
Det.+NaOCl	0.04	5.81	Det.+NaOCl	0.02	5.85
WP-C			WP-C/P		
Control (0.66 mg/cm^2)			Control (0.84 mg/cm^2)		
Pre-rinse	0.00	5.24	Pre-rinse	0.01	13.00
Det.	0.05	9.41	Det.	0.08	10.56
Det.+NH_3	0.05	9.88	Det.+NH_3	0.06	11.20
Det.+NaOCl	0.04	7.26	Det.+NaOCl	0.06	9.38

[a] All data based on 3 replications
[b] EASLEY et al., 1981
[c] Amount of MeP extracted from cotton transfer fabric in nanograms (ng)
[d] Cotton denim
[e] Amount of MeP (milligrams/cm^2) on contaminated denim fabric before any laundering procedure
[f] Cotton/polyester denim (50:50)

Biological Assays of Fabric: MeP residues on laundered contaminated denim fabrics were toxic to German cockroaches confined on these fabrics, but neither the uncontaminated fabrics nor the uncontaminated, laundered fabrics caused cockroach mortality. Although MeP on the transfer fabrics reached levels as high as 13.00 ng/cm^2, the fabric laundered in contaminated equipment caused no German cockroach mortalities in 24 h or 48 h.

Difference Attributable to Fabrics, Formulations and Laundry Procedures: Fiber Content. Analysis of variance (ANOVA) comparing the sustained transfer of MeP to the cotton transfer fabric showed no significant differences ($F=.62$, d.f.=1,70 attributable to the fiber content of initially contaminated denim fabrics. These data agree with those of EASLEY et al. (1981).

Formulations. Significant differences in the amount of MeP transferred were found among the three formulations ($F=14.46$; d.f.=5,65; $p \leq 0.01$); therefore Duncan's Multiple Range Test was done. ENC ($\bar{X}$ ng/cm^2 = 6.48) and EC ($\bar{X}$ ng/cm^2 = 4.76) were significantly similar but apart from WP ($\bar{X}$ ng/cm^2 = 9.49).

Laundry Procedures. There were no significant differences in the transfer of MeP to the cotton fabric attributed to the laundry procedures used in washing the contaminated denim fabric ($F=1.57$; d.f.=6,65); however, in examining the Duncan's Multiple Range Test, a trend ($p \leq 0.10$) was noted for detergent washing ($\bar{X}$ ng/cm^2=8.07) to be superior to detergent with bleach additive ($\bar{X}$ ng/cm^2=6.14).

CONCLUSIONS

Based on these data, the percentages of MeP transferred in laundry were miniscule; however care should be exercised in laundering of pesticide contaminated clothing in the home. WP formulations may be most easily removed from the original fabric and most readily transferred to the clean fabric due to the particulate nature of their composition. Rinsing the laundry apparatus is recommended even though subsequent work may reveal more satisfactory ways to effect equipment clean up. Although the percentage of pesticide transferred by contaminated laundry apparatus may be slight in relation to a.i. made available in laundry of contaminated clothing, this amount may affect particularly susceptible individuals. These conclusions were based on Laundry-Ometer studies and before other recommendations can be made, further field work should be undertaken using home laundry appliances.

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Accepted July 18, 1981