Bull. Environ. Contam. Toxicol. (1997) 58:681-687

Environmental Contamination and Toxicology

Adult and Infant Abamectin Exposures Following Avert® 310 and Pressurized Gel Crack and Crevice Treatment

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Received: 10 October 1996/Accepted: 18 January 1997

A worse-case abamectin exposure study was developed in spring 1995 using a run-down hotel in the Central Valley of California. Exposure estimates and margins of exposure were developed for adults and infants following use of abamectin in a series of rooms with kitchenettes which offered excellent cockroach harborage. The rooms were given "clean-out" bait treatment by a licensed Pest Control Operator with Avert® Crack and Crevice Prescription Treatment® 310 dust or with Whitmire pressurized gel (Table 1). For 48 hr following the bait treatment, two air samples and two surface samples were collected at intervals and later analyzed for abamectin. The human exposure assessment was calculated following principles described by the Department of Pesticide Regulation, Worker Health and Safety Branch, California Environmental Protection Agency (Thongsinthusak et al., 1993) and the Exposure Factors Handbook (U. S. EPA, 1990).

MATERIALS AND METHODS

Treatment and environmental samples were obtained in 3 ground floor rooms and 5 on the second floor of a 35-year-old hotel. Each unoccupied room (about 21 ft x 13 ft) contained 2 beds, desk and chair, closet, kitchenette with sink, refrigerator and cabinets, plus a bathroom with toilet, sink, and shower. Windows in the bathroom and in the main living area were closed. Air conditioning units were available but were not used due to their poor condition.

Rooms were randomly assigned as controls (2) or for treatment with dust (4) or gel (2). Avert® Prescription Treatment® 310 (30 g tubes) and Whitmire TC 93A (4 oz cans) were supplied by Whitmire Research Laboratories, Inc. (St. Louis, MO). A licensed applicator applied bait at the highest rate for the prevailing conditions behind tile, bed headboards, wall voids, heaters, cracks and crevices around cabinets and other fixtures, as well as behind baseboards. Actual amounts of product and active ingredient applied are listed in Table 1.

We sampled air near the center of each room and approximately 18 in. from a treated wall. Cloth dosimeters (1711 cm^2) to collect surface deposition were placed on the bed and on the floor. Samples were continuously collected before treatment, from application until 30 min after treatment, 0.5 to 2 hr after treatment

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Table 1. Product Applied In Test Rooms

Product	Amount Applied(g)	Abamectin (mg)	Room Number
Dust	10.68	5.34	258
Dust	6.49	8.25	140
Dust	9.65	4.83	139
Dust	11.18	5.59	262
Gel	55.84	27.9	260
Gel	117.45	58.7	259

(HAT), 2 to 12 HAT, 12 to 24 HAT, and 24 to 48 HAT.

Air sampling was performed concurrently with surface deposition sampling. The inlets of the air sampling pumps were directed downward and were fixed 12 in. above the floor covering. A Teflon filter with a filter support pad (Gelman Zefluor filter with pad, 1 µm pore size, Supelco Cat. 2-3391) was secured in a 37 mm open-faced, 3-section, clear polystyrene cassette. Media were changed at the beginning of each sampling interval. A Kurz mass flow meter was used to calibrate the pumps to a rate of 1.5 L/min prior to each sampling interval. The cassettes were sealed after use and stored in an insulated box for transport for analysis to ABC Laboratories in Madera, CA.

Surface sampling was performed in each room. Two 100% cotton (T-shirt type material) dosimeters which measured 29 cm by 59 cm (1711 cm^2) were used to capture surface residues of abamectin. Dosimeters on aluminum foil to prevent penetration breakthrough were positioned near a treated wall and on the adjacent bed. Dosimeters were deployed and collected on the same schedule as air samplers. The samples were wrapped in foil and sealed in metallic Kapak bags for transport to the laboratory on dry ice in an insulated box. The temperature ranged from -45°F to 12°F.

Field fortifications of Teflon filters and cotton dosimeters were each prepared using abamectin, and recovery assessed based upon original solution concentrations. Fortified filters and dosimeters were held in an adjoining untreated room for one or 24 hr. One hundred µL solutions containing 406, 2030, and 25,400 ng avermectin for the dosimeters and 50.8, 203, and 2540 ng avermectin for the filters. After the appropriate periods of time the samples were processed like their counterparts.

Analytical standard (0.893% weight/weight B_{1a} and 0.044% weight/weight B_{1b} was supplied by Merck & Co., Inc., and was stored in a temperature monitored freezer.

Teflon air filters were extracted with 3 40 mL portions of acetonitrile to remove abamectin residues. The extract was quantitatively transferred to a silanized glass tube, concentrated to 1 mL using a stream of nitrogen, derivatized with a 1:2 mixture of trifluoroacetic anhydride:acetonitrile, and diluted to volume for analysis using reverse phase high pressure liquid chromatography with a C_{18} column. The mobile phase was 5% water in methanol (v/v), isocratic at a flow rate of 1.5 mL/min fluorescence detection (excitation, 365 nm; emission, 418 nm; Prabhu et al., 1990).

Abamectin residue was extracted from cotton dosimeters in amber jars using 1950 mL acetonitrile which was subsequently reduced to about 50 mL using a rotary evaporator. A portion was diluted 1:10 with deionized water, filtered under vacuum with a porcelain Buchner funnel, and the solution passed through an octyl (bonded C8) solid phase extraction column which retained the analyte. The residue was eluted with acetonitrile, concentrated to about 1 mL under a stream of nitrogen, made aqueous, and partitioned into hexane. Hexane was further purified using an aminopropyl (NH2) column. Abamectin was eluted with 50:50 acetone-methylene chloride which was evaporated to dryness and redissolved in acetonitrile for HPLC analysis. The minimum quantifiable levels (MQL) were 20.3 ng for Teflon air filters and 102 ng for cotton dosimeters. Standard curves were constructed using Maxima R 820 chromatography software. Residues detected in control samples were not subtracted from laboratory fortifications prior to calculation of recoveries.

RESULTS AND DISCUSSION

Five to 7 min were required to treat each of the 4 rooms with the avermectin dust. A total of 48 g containing 24 mg avermectin was dispensed. The two gel treatments of 55.8 g and 117.5 g required 4 and 6 min, respectively. Small amounts of dust were occasionally observed during application. There was no visible evidence of avermectin use at the completion of either the dust or gel application. The amounts applied in each room are listed in Table 1.

Indoor temperatures ranged from 17.8°C to 21.3°C, and relative humidity ranged from 36.0% to 60.2% during the two and one-half day test period.

During methods validation it was demonstrated that the average recovery of avermectin from Teflon filters was 99.7 ± 6.3% and that the average recovery from the cotton dosimeters was 85.0 ± 4.8%. During the analysis of the laboratory control all samples were below the MQL. Acceptable performance of the method was demonstrated by recovery of 50% to 120% of all laboratory fortifications. The Teflon filters yielded 91.4% and 76.2% recovery after 1 and 24 hr, respectively. Corresponding dosimeter recoveries were 88.7% and 83.1%. No adjustments were made for these minor losses during 24-hr sampling.

Analysis of the Teflon filter extracts did not yield any samples which exceeded the MDL during the entire 2-day study period. During day 1 when air residues would be expected to be highest samples were taken during application (0.5) and at 1.5, 10, and 12 hr later. The MDL was 20.3 ng/L, and the 24-hr time weighted average for air was 0.038 ng/L.

Extracts of surface deposition samples taken at intervals of 0.5, 1.5, 10, and 12 hr were all less than the MDL of 102 ng (Table 3). The surface area of the dosimeter was 1711 cm^2. The default deposition rate was 0.05 ng/cm^2.

A human exposure assessment was based upon continuous air and surface monitoring for abamectin b_1 which began before the bait treatment and continued for 48 hr. Since no samples contained more than the minimum detectable levels, default values of 20.3 ng for the air filters and 102 ng for the cloth dosimeters were used for the exposure assessment. The assessments further assume a 9 kg infant (Table 2) and a 70 kg adult with continuous 24 hr contact in a treated residence.

Since air samples were collected for varying periods, a 24-hr time weighted average was calculated for use in the exposure assessment. The infants' day was 16 hr of light activity (4.2 L per min) and 8 hr of resting (ventilation rate 1.4 L per min). The default adult ventilation rate of 20 m^3 per d was assumed. In both cases, 100% percent absorption of 50% of the abamectin in the air stream was assumed. The infants' inhalation dose was 0.09 µg/d and the absorbed daily dosage was 0.011 µg/kg/d. The corresponding figures for adults were 0.76 µg/d and 0.0054 µg/kg/d.

Dermal exposure potential was expressed using two different conservative models, the Regulatory Equality model and the Task-Specific Transfer Factor model (Nigg et al., 1984; Zweig et al., 1984).

The Regulatory Equality model assumes that surface levels of pesticide and skin levels are equal (often erroneously stated to be at “equilibrium”). This model assumes that the chemical comes to “equilibrium” with the residue on the body; therefore, the dermal exposure is equal to the body surface area exposed multiplied by the surface concentration. It is assumed that a 9 kg child has a surface area of about 3,900 cm^2 and a corresponding potential dermal dose of 0 to 195 ng abamectin.

The Transfer Factor (cm^2/h) model includes time (h) and dislodgeable residue (µg/cm^2). Potential dermal exposure of 70 kg adults is determined by a transfer factor of 3,500 cm^2/h, and the exposure of the 9 kg infant is estimated by a factor of 800 cm^2/h (Cal-EPA/DPR, 1992). A 24 hr contact period is assumed. Potential dermal exposure (PDE) was estimated according to the following equation:

PDE (ug/person) = TF(cm^2/hour) x 24 hours x DR(ug/cm^2)

when

TF = empirical transfer factor from indoor studies
t = time, 24 hours
DR = residue deposited on dosimeters

The use of a Transfer Factor probably yields the most representative worst-case dose since it is both time-dependent and task-specific *(Krieger, unpublished observations).* The potential infant and adult doses are 0.23 µg/d and 0.97 µg/d.

When these values are factored by dermal absorption and body weight the absorbed daily dosage is 2.6 ng/kg/d and 0.14 ng/kg/d.

In conclusion, abamectin is the common name for avermectin B_1, a natural product with insecticidal and miticidal activity of the soil microorganism, *Streptomyces avermitilis.* In pests abamectin interferes with GABA (gamma aminobutyric acid) mediated neurotransmission.

Risk assessments for potential human exposure to abamectin reference adverse reproductive and developmental effects of avermectin B_1 in animal studies. The lowest No-Observed-Adverse-Effect-Level (NOEL) was 0.05 mg/kg/d in the mouse. That NOEL has been used to evaluate the daily toxicological risk to residents (particularly infants) and adults. Additionally the combined exposures to abamectin from potential residues on foods (Cal-EPA/DPR, 1992).

Table 2. Potential Infant Exposures From the Residential Use of Abamectin

Model	Potential Exposure (μg/infant/d)	Absorbed Daily Dosage (μg/kg/d)
Regulatory Equality		
dermal contact	0.23	0.00026
inhalation	0.09	0.011
dietary		0.013
Transfer Factor		
dermal contact	0.12	0.0013
inhalation	0.09	0.011
ingestion		0.013

Inhalation exposure of 9 kg infant based upon 16 h light activity and 8 h resting activity and 0.038 ng abamectin/L. Ventilation rates are 4.2 L/min and 1.5 L/min, respectively. Fifty percent retention of air stream and 100% absorption were assumed, e.g. 16 h x 60 min/h x 4.2 liters/min x 0.038 ng/liter x 50% x 100% = 77 ng. Dermal contact exposure based upon a surface area of 3900 cm^2 for a 9 kg infant. The surface residue level was 0.06 ng/cm^2. One percent (0.01) dermal absorption per 24 h (Cal-EPA/DPR, Risk Characterization, 1992).

Regulatory Equality 3900 cm^2 x 0.06 ng/cm^2 = 234 ng x 0.01 = 2.3 ng

Transfer Factor 800 cm^2/h x 0.06 ng/cm^2 x 24 h = 115 ng x 0.01 = 1.2 ng

We studied potential human exposure resulting from avermectin crack and crevice bait treatments. The products were used in a prescription treatment program described by Whitmire Research Laboratories, Inc., as directed for cockroach control in residential, commercial, e.g. hospitals, hotels, etc., industrial buildings, and transportation facilities, e.g. buses, ships, trains, etc. Relative to these types

of facilities, there is little doubt that the Bakersfield hotel rooms represented a worse-case venue due to its general condition and considerable cockroach harborage. It included a series of rooms which were infested with roaches and was treated at maximum “clean-out” application rates.

Small amounts of bait were occasionally visible during treatment, but adjacent surfaces and air did not contain measurable avermectin. Since no positive air or surface samples were obtained, the actual sample levels are between zero and that determined by the MQL for surface dosimeters (0.05 ng/cm^2) and Teflon air filters (0.038 ng). The maximum hypothetical infant dosage was 0 to 2.6 ng/kg/d and that of an adult was 0 to 0.14 ng/kg/d (Table 2). These levels represent margins of exposure of nearly 200,000 and 350,000, respectively.

In a previous study, (Wright et al. 1992) used 114 mg abamectin in a large, three unit military food preparation, serving, and dining area. According to the current Avert 310 label, that amount of avermectin would be sufficient to treat 760 “bait points.” Availability of a set of hotel rooms permitted use of the abamectin products under conditions similar to the “worse-case” described in the Whitmire Prescription Treatment System Pest Management Manual (1984). “Bait points” were likely to be heavily infested with cockroaches. Overall, 24 mg abamectin in 48 g dust bait was applied within 1,092 ft^2 of living space of the hotel rooms and a larger amounts of abamectin (87 mg) were applied as 173 g gel in the other 2 treated rooms.

The exposure assessments show that when Avert Prescription Treatment 310 or TC-93A are used as directed there is negligible potential for human exposure. This is primarily a consequence of the pattern of crack and crevice bait use and product stability on treated surfaces.

Acknowledgments. This study was supported by Merck & Co., Inc., and Whitmire Research Laboratories, Inc. Toxicologists at the Department of Pesticide Regulation, California Environmental Protection Agency are thanked for protocol and manuscript review.

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