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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

MEMORANDUM

April 15, 1999

SUBJECT: HED's Review of "*Evaluation of Workers' Exposure to Chlorpyrifos During the Use of Dursban Pro Insecticide Concentrate for Broadcast Turf Applications.*" MRID 44729401. DP Barcode: D252357. Case No. 818975. PC Code: 059101.

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Attached is a review of a study (44729401) that was conducted by Versar, Inc., under the supervision of HED. It has undergone secondary review and has been revised to reflect Agency policies. HED has recalculated the chlorpyrifos dermal exposure estimates using a dermal absorption factor of 3% based on the recommendation of the Hazard Identification Assessment Review Committee (HIARC) in the March 4, 1999 report.

Conclusions

This study characterizes exposures to lawn care operators that apply an average of 183 gallons of 0.12 percent Dursban Pro (EPA Reg No. 62719-166) by broadcast applications to turf for an average of 6 hours (range of 4.4-8.2 hours). Exposures were estimated based on both dosimetry measurements and biomonitoring of urinary 3,5,6-TCP (the primary metabolite of

chlorpyrifos). The study examined exposures to 15 lawn care insecticide applicators from two different companies in Ohio, that each treated 11-15 turf blocks (approximately 6,500 ft^2). The total area of treated turf ranged from 74,740 to 97,500 square feet (mean of 95,983 ft^2), while the total amount of chlorpyrifos handled ranged from 1.57 to 2.95 lb ai chlorpyrifos (mean of 2.17 lb ai). In addition, the workers unloaded and reloaded the hose following application to each lawn (i.e., repeated 15 times per replicate). This study does not characterize exposures associated with mixing and loading the insecticide.

Table 8 summarizes the total absorbed doses of chlorpyrifos via inhalation and dermal exposures, estimated from passive dosimetry and biomonitoring that should be used in the risk assessment. The total absorbed doses estimated from dosimetry range from 0.21 to 2.24 µg/kg BW, with a mean of 0.88±0.62 µg/kg BW. Approximately 33 percent of the absorbed doses resulted from inhalation and 67 percent from dermal exposure. The total absorbed doses estimated from biomonitoring ranged from 0 to 4.84 µg/kg BW, with an arithmetic mean of 0.65 ± 1.43 µg/kg BW (this average includes seven of the 15 workers that had exposures of zero because of high baseline chlorpyrifos exposure). The geometric mean for workers who had exposure above baseline levels is 0.4 µg/kg BW. The mean values are in somewhat good agreement with the estimates from dosimetry. The biomonitoring average for the eight workers who had exposures above background was 1.23 µg/kg (i.e., excludes the seven workers with no exposure from lawn treatment). The registrant speculated that the highest exposure of 4.84 µg/kg (for OH05) was from a secondary source because 67% of the TCP was excreted on day 5 post exposure. However, this value was included in the average exposure because each volunteer was instructed to avoid chlorpyrifos for 10 days prior and 5 days following the study. As shown on Table 8, baseline chlorpyrifos exposure ranged from 0.2 to 3.73 µg/kg with a mean of 1.54 µg/kg, despite the fact that workers were instructed to avoid chlorpyrifos exposure 10 days prior to the study initiation. The high baseline chlorpyrifos exposure makes it difficult to interpret the biomonitoring results. For example, seven of the fifteen workers had exposure levels (based on urinary TCP) less than baseline levels, and therefore, their exposure from broadcast turf application is probably in the baseline range (0.94 to 3.73 µg/kg), and not zero as concluded by the registrant.

The analysis of blood samples drawn from each applicator 24 and 48 hours post exposure indicated that no significant depression in plasma and red blood cell cholinesterase activity occurred to the applicators after the application of the Dursban Pro insecticide. All of the plasma and red blood cell cholinesterase activities were within the reference range for the laboratory of 1,000 to 3,500 and 5,300 to 10,000 international units (IU)/ liter (L), respectively except for the plasma pre-exposure level for volunteer OH15 (352 IU/L). It should be noted, however, that in animals peak cholinesterase inhibition occurs 3-6 hours post exposure. In addition, the prior exposure of many of these PCOs may have resulted in suppressed baseline cholinesterase levels.

The lower leg (calves) coverall samples contained approximately 80% of the total coverall chlorpyrifos, despite that only 9% of the dermal dose was attributed to the sock dosimeters. Therefore, the labels should be revised to recommend knee high chemical resistant

boots in order to mitigate chlorpyrifos exposure to pesticide control operators (PCOs) during lawn care using Dursban Pro. However, it should be noted that each worker wore knee high chemical resistant footwear during application. In addition, as shown on Table 6, the exposure from hand washes represented 11% of the total dermal exposure, despite the fact that each worker wore chemically-resistant gloves. This suggests that workers could also be exposed through the oral route of exposure if proper hygiene is not used.

The majority of the exposure data meet the criteria specified in Series 875 Group A. The applications used in this study deviated slightly from those recommended by the label, and are likely to underestimate exposure. For example, the label recommends using 0.03 to 0.12% for high volume broadcast sprays at a rate of 10 gallons/1000 ft^2, whereas, the exposures from this study were based on 0.12% applied at 2 gallons/1000 ft^2. The label recommends that higher concentrations of 0.5% chlorpyrifos be applied using low volume sprays (i.e., 2 gallons /1000 ft^2). Therefore, it is possible that this study underestimates the actual exposures to PCOs following the label recommendations for broadcast treatment (i.e., the study should have either used a four-fold more concentrated solution of 0.5% chlorpyrifos, or increased the spray volume five-fold to 10 gallons/ 1000 ft^2). For comparison purposes, dose estimates were also calculated based on the adjusted flow rate of 10 gallons/1000 ft^2, as shown on Table 8. The flow-rate adjusted dose estimates are five times higher than the estimated biomonitoring exposures, with a mean of 3.3 μg/kg.

Despite the limitations, the data collected in this study are of sufficient scientific quality to be used in the Reregistration Eligibility Decision (RED) document.

A worker exposure study - Evaluation of Workers' Exposure to Chlorpyrifos During the Use Of Dursban Pro Insecticide Concentrate for Broadcast Turf Applications (MRID # 447294-01) was submitted in support of the registration requirements for the Dursban Pro insecticide . The requirements for this study were specified by the U.S. Environmental Protection Agency under Series 875 Group A of the Pesticide Assessment Guidelines (U.S. EPA, 1996).

The following information could be used to identify the study:

Title:	Evaluation of Workers' Exposure to Chlorpyrifos During the Use of Dursban Pro Insecticide Concentrate for Broadcast Turf Applications
Sponsor:	Dow AgroSciences LLC 9330 Zionsville Road Indianapolis, Indiana
Performing Laboratory:	Global Environmental Chemistry Laboratory-Indianapolis Lab Dow AgroSciences LLC 9330 Zionsville Road Indianapolis, Indiana
Analytical Laboratory	Global Environmental Chemistry Laboratory-Indianapolis Lab Dow AgroSciences LLC 9330 Zionsville Road Indianapolis, Indiana
Authors:	D.E. Barnekow and B.A. Shurdut
Report Dates:	November 10, 1998
Identifying Codes:	MRID # 447294-01

Executive Summary

Dursban Pro Insecticide Concentrate is an insecticide widely used to control insect pests in turf as part of a lawn care program. The formulation contains 23.4 percent of the active ingredient (a.i.) chlorpyrifos. This study examined dermal and inhalation exposures of the lawn care insecticide applicator to chlorpyrifos during the broadcast application of Dursban Pro Insecticide.

The study was conducted in Cygnet, Ohio during the month of September, a typical season for application of insecticide. The study examined exposures to 15 lawn care insecticide applicators from two different companies. The applicators worked 4 to 8 hours on the day of application (mean of 6 hours), treating 11-15 turf blocks (approximately 6,500 ft^2) each with 0.12 percent (a.i.) dilute Dursban Pro Insecticide. In addition, the workers unloaded and reloaded the hose following application to each lawn (i.e., repeated15 times per replicate). The total area of turf treated by each applicator ranged from 74,750 to 97,500 square feet with a mean of 95,983 square feet. An average of 183 gallons (160-205 gallons) of 0.12 percent Dursban Pro Insecticide was applied by each applicator at a rate of 2 gallons per 1,000 square feet with hand-held spray gun. The total quantity of chlorpyrifos handled ranged from 1.57 to 2.95 lb ai. The potential dermal and inhalation exposures to chlorpyrifos during application were monitored using a combination of passive dosimetry and personal air sampling pumps. Total absorbed dose was also estimated by biomonitoring of the primary chlorpyrifos metabolite, 3,5,6-trichloro-2-pyridinol (3,5,6-TCP) in urine samples of the applicators.

Dermal exposure was estimated using the following dosimeters: (1) a pre-laundered cotton coverall; (2) pre-laundered cotton socks, cotton briefs, and cotton T-shirts (undergarment); (3) a hat to which denim patches were affixed; and (4) hand washes. The coverall and undergarments were sectioned and analyzed to estimate exposures to arms, leg and torso regions. The patches affixed to the hat served as a surrogate for face, head, and neck exposure. Hand washes were used to estimate the dermal exposure to hands. (It should be noted that chlorpyrifos was measured up to 1,047 μg in hand washes despite the use of chemically resistant gloves). The total dose of dermal absorption was estimated by multiplying the total dermal exposure with an absorption factor of 3 percent.

Inhalation exposure was assessed through use of personal air sampling pumps with the sampling unit attached to the lapel near the breathing zone of the applicators. The sampling unit consists of a 37-mm mixed cellulose ester filter and a connected 99-mg Chromosorb 102 tube packing. Air samples were continuously collected at a rate of 1.5 liter per minute during the insecticide application. The chlorpyrifos trapped in the filter and the Chromosorb tube were extracted and analyzed using GC. The amount of chlorpyrifos found was divided by the volume of air sampled to give a time weighted air concentration. The potential inhalation dose was estimated based on this time averaged concentration, an inhalation rate of 1.5 m^3/hour, and the duration of insecticide application.

Total absorbed dose was also estimated directly by biomonitoring of the chlorpyrifos metabolite 3,5,6-TCP in the urine samples of applicators to confirm the absorbed dose estimated from the dosimetry data. Each applicator collected all the urine voided on the day before application, the day of application, and for four consecutive days after initial exposure. The urine was collected at 12-hour intervals. A total of 12 urine samples were collected for each applicator. The urine samples were analyzed for 3,5,6-TCP using gas chromatography to estimate the total absorbed dose of chlorpyrifos.

A method validation study was conducted before the field study to determine laboratory recoveries, valid concentration ranges, limit of detection (LOD), and limit of quantitation (LOQ) for all matrices used in dosimetry and biomonitoring. Field control recovery and storage stability recovery data were also collected for dosimeter matrices. In addition, separate field recovery samples for urine were prepared for each applicator using urine samples collected on the day before application.

Laboratory recoveries for the matrices used in dosimetry and biomonitoring range from 85.9 percent to 108.1 percent, with the lower 95 percent confidence limit greater than 70 percent. Field control recoveries for the matrices used in dosimetry range from 70.8 percent to 96.2 percent. Field control recoveries for individual applicator urine samples range from 88.98 percent to 154.52 percent. The laboratory and field recoveries were used to correct the results for analytic error and possible losses during sample handling. The storage stability recoveries of chlorpyrifos range from 94.9 to 104.2 percent and they were not used to correct the results for possible losses during sample storage.

The total absorbed dose estimated based on passive dosimetry ranged from 0.21 to 2.24 µg/kg body weight, with a mean of 0.88 ±0.62 µg/kg body weight (BW). The absorbed dose determined by biomonitoring was found to range from 0 to 4.84 µg/kg body weight (BW), with a mean of 0.65 ±1.43 µg/kg BW (this average includes seven of the 15 workers that had exposures of zero because of high baseline chlorpyrifos exposure). The average biomonitoring dose only for the eight workers whose exposure was above background was1.23 µg/kg. The registrant speculated that the highest exposure of 4.84 µg/kg (for OH05) was from a secondary source because 67% of TCP was excreted on day 5 post exposure. However, this value was included in the average exposure because each volunteer was instructed to avoid chlorpyrifos for 10 days prior and 5 days following the study. Baseline chlorpyrifos exposure ranged from 0.2 to 3.73 µg/kg with a mean of 1.54 µg/kg, despite the fact that workers were instructed to avoid chlorpyrifos exposure 10 days prior to the study initiation. The high baseline chlorpyrifos exposure makes it difficult to interpret the biomonitoring results. For example, seven of the fifteen workers had exposure levels (based on urinary TCP) less than baseline levels, and therefore, their exposure from broadcast turf application is probably in the baseline range (0.94 to 3.73 µg/kg), and not zero as concluded by the registrant.

The lower leg (calves) coverall samples contained approximately 80% of the total coverall chlorpyrifos, despite that only 9% of the dermal dose was attributed to the sock

dosimeters. Therefore, the labels should be revised to recommend knee high chemical resistant boots in order to mitigate chlorpyrifos exposure to PCOs during lawn care using Dursban Pro. However, it should be noted that each worker wore knee high chemical resistant footwear during application.

The analysis of blood samples drawn from each applicator 24 and 48 hours post exposure indicated that no significant depression in plasma and red blood cell cholinesterase activity occurred to the applicators after the application of the Dursban Pro insecticide. It should be noted, however, that in animals peak cholinesterase inhibition occurs 3-6 hours post exposure. In addition, the prior exposure of many of these PCOs may have resulted in suppressed baseline cholinesterase levels.

Based on the review by Versar, most of the requirements contained in Series 875 Group A of the Pesticide Assessment Guidelines (U.S. EPA, 1996) were met in this exposure study. The applications used in this study deviated slightly from those recommended by the label. For example, the label recommends using 0.03 to 0.12% for high volume broadcast sprays at a rate of 10 gallons/1000 ft^2. Whereas, the exposures from this study were based on 0.12% applied at 2 gallons/1000 ft^2. The label recommends that higher concentrations of 0.5% chlorpyrifos be applied using low volume sprays (i.e., 2 gallons /1000 ft^2). Therefore, it is possible that this study underestimates the actual exposures to PCOs following the label recommendations for broadcast treatment (i.e., the study should have either used a four-fold more concentrated solution of 0.5% chlorpyrifos, or increased the spray volume five-fold to 10 gallons/ 1000 ft^2).

Study Review

Study Background

Dursban Pro Insecticide is a widely used insecticide for controlling insect pests in turf. It contains 23.4 percent of the active ingredient chlorpyrifos (0,0-diethyl-0-(3,5,6-trichloropyridinyl phosphorothioate). This study examined dermal and inhalation exposures of the lawn care insecticide applicators to chlorpyrifos during the broadcast application process.

Field Study Design

The study was conducted in Cygnet, Ohio, during a typical insecticide application season (September) using Dursban Pro Insecticide Concentrate. The study involved 15 lawn care insecticide applicators from two companies. Each applicator wore a new cotton coverall to simulate long-sleeved shirt and a pair of pants. In addition, the applicators wore a new set of cotton underwear (T-shirt and brief) and new cotton socks as dosimeters to represent the applicators' skin and to estimate the penetration of the insecticide through the outer clothes. A hat with denim patches affixed was worn by each applicator to simulate exposures to face and neck. Hand washes were used to estimate the hand exposure, although each worker wore chemically resistant nitrile gloves. In addition, each worker wore knee high chemical resistant footwear. A pump-driven air sampling unit was attached to the lapel near the breathing zone of the applicators to estimate inhalation exposure. Each volunteer was instructed to avoid chlorpyrifos exposure 10 days prior to application and for 5 days following application.

The PCOs applied the Dursban Pro via broadcast application and were involved in the unloading and reloading of the hose following each application to each lawn (i.e., repeated15 times per replicate). Loading and mixing the Dursban Pro was performed by another worker not evaluated in the study. The applicators equipped with dosimeters described above worked four to eight hours on the day of application, treating 11-15 blocks of turf with an average of 185 gallons (160-205 gallons) of ~ 0.12 percent (a.i.) Dursban Pro dilute solution, typically 1 pound ai/acre. Each block is about 6,500 square feet large and the total area of turf treated by applicators ranged from 74,750 to 97,500 square feet with a mean of 95,983 square feet. The dermal and inhalation exposures were continuously monitored by passive dosimetry and an air sampling pump during the application process. The total absorbed dose of chlorpyrifos was estimated by summing the dermal dose and the inhalation dose. The absorbed dose of chlorpyrifos was also directly measured by biomonitoring of the metabolite 3,5,6-TCP in the urine samples of the applicators.

The creatinine excretion rates in urine for each applicator were measured as a QC procedure to make sure that all the urine voided during the individual interval was collected. In addition, a total of three blood samples were to be drawn from each applicator, one prior to the application monitoring period, one at 24 hours and the other at 48 hours following the

application monitoring period. The blood samples were analyzed to determine if plasma or RBC cholinesterase activity was depressed following the handling of Dursban Pro insecticide.

Material and Application

Dursban Pro Insecticide Concentrate used for this study was obtained from Dow AgroSciences, Indianapolis, Indiana, and was from a single lot of product. This formulation contains 23.4 percent of the active ingredient (ai) chlorpyrifos. According to the label direction, the Dursban Pro insecticide was diluted with water to 0.12 percent ai solution before the application. It was applied with hand-held spray guns at a rate of two gallons of the 0.12 percent solution per 1,000 square feet. The application equipment used in this study consists of a 200-400 gallon tank, a gasoline powered pump, a hose/hose reel and a hand-held spray gun. The equipment conformed to that recommended on the Dursban Pro insecticide label.

Study Replicates

This study involves 15 lawn care insecticide applicators. The volunteers were from two local lawn care companies. Each applicator was instructed to avoid products containing chlorpyrifos for at least ten days prior to participation and for at least five days after the day of application. On the day of application, they were responsible for moving the dilute (0.12 percent) chlorpyrifos suspensions between sites and application of Dursban Pro with hand-held spray guns for four to eight hours. They wore dosimeters and air sampling pumps during application and submitted urine samples as instructed. The volunteers did not mix and load the Dursban Pro.

Sampling

Dermal exposure was estimated for each applicator during the entire application period using hand washes and the following dosimeters: (1) a pre-laundered cotton coverall; (2) pre-laundered cotton socks, cotton briefs, and cotton T-shirts (undergarment); and (3) denim patches which were affixed to a hat. At the end of the application, these dosimeters were collected from each applicator. The coverall and undergarments were sectioned into pieces representing arm, leg, and torso regions. The samples were then stored in glass jars and shipped to the analytical laboratory on dry ice for analysis.

Hand washes were collected during the course of monitoring when workers would ordinarily wash their hands. Hand washes were also collected before and after the monitoring period. Hand washing was conducted with a mild soap solution containing 0.004 percent Emcol 4500, followed by rinsing with an equivalent volume of clean water. The combined wash and rinse were extracted with 100 mL of isooctane after dissolving approximately 15 g of analytical grade NaCl into the sample. Two ~ 5 mL aliquots of the isooctane were then transferred to the vials which were then submitted to the analytical lab.

Inhalation exposure was assessed for each applicator during the application period, through a personal air sampling pump with the sampling unit attached to the lapel near the breathing zone of the applicators. The sampling unit consists of a 37-mm mixed cellulose ester filter and a connected 99-mg Chromosorb 102 tube packing. All pumps were calibrated at the beginning and the end of the sampling period using a calibrated rotameter. The air sample was continuously collected at a rate of 1.5 liters per minute throughout the monitoring period. At the end of the monitoring period, the filter and Chromosorb tube were removed from the pump, capped, and placed into an 8 ounce glass jar. The samples were placed on dry ice and shipped to the analytical lab. Before analysis with GC, the chlorpyrifos trapped in filters and Chromosorb tubes was extracted with 5 mL of hexane.

Several of the pumps developed flow problems and shut down during data collection. However, each worker had two pumps, one on the right and the other on the left. Therefore, the left pump was used when the right pump shut down during the monitoring period.

Biomonitoring of the chlorpyrifos metabolite 3,5,6-TCP in the urine samples of applicators was conducted to confirm the total absorbed dose estimated from the dosimetry data. Each applicator collected all the urine they voided on the day before application, the day of application, and for four consecutive days after the initial exposure. The urine was collected as 12 hour samples. A total of 12 urine samples were collected for each applicator. The urine was collected in brown plastic jugs and kept cool on blue ice. The sample volume was recorded and two 10-mL aliquots were taken. The aliquots were stored frozen and shipped to the analytical lab. The urine samples were analyzed for the chlorpyrifos metabolite 3,5,6-TCP and urinary creatinine. The GC sample preparation procedures can be found on page 26 of the study report.

Field Fortification/Spike Samples

Tubes, filters, coverall sections, underwear sections and hand wash samples were spiked in the field and exposed to the same field conditions as the samples to assess losses associated with field conditions and losses during the storage and shipment of samples. The spiked or fortified samples were prepared each monitoring day throughout the course of the study using stock solutions of Dursban Pro Insecticide in isooctane. The spikes were prepared to approximate the loading levels in each matrix. Spikes for urine were also prepared to assess possible losses during sample storage and shipment.

Spike samples for air monitoring were prepared by fortifying filters and Chromosorb tubes with 0.01 mL of a 50 µg/mL chlorpyrifos solution in isooctane. The storage stability samples were fortified, allowed to vaporize for ten minutes, capped, placed in a glass jar, and then stored frozen. The field recovery samples were prepared by loading the spiked filters and Chromosorbs into the pump and then sampling clean airs in an area far from the test site for the interval approximating the sampling period. A total of five spiked samples (one control, two storage stability, and two field recoveries) were prepared for each day worker exposure replicates were collected.

Spike samples for hand washes were prepared by fortifying 500 mL of 0.002 percent Emcol with 2 mL of solution containing 10 µg a.i./mL of Dursban Pro insecticide in acetonitrile. The spiked samples were then treated in the same manner as an actual field sample.

Spike samples for clothing dosimeters were prepared by fortifying the 20 x 20 cm sections of coverall and underwear with 2 mL of the Dursban Pro insecticide solution. The final fortification levels were 50 µg chlorpyrifos/20 x 20 cm squares for coveralls and 8 µg chlorpyrifos/20 x 20 cm section for underwear. The field recovery samples were exposed to the field conditions in a control area far from the test sites for the same amount of time as the monitoring period. The storage stability recovery samples were not exposed to the field conditions after spiking.

Spike samples for urine were prepared by adding 0.10 mL of acetone containing 20 µg TCP/mL to a 10.0 mL aliquots of urine collected from a person who had not been exposed to chlorpyrifos or TCP. Two sets of fortified samples were prepared for each applicator and an unexposed individual using the urine collected in the morning before the application. One set of fortified samples was prepared at the beginning of the monitoring period and the other at the end of the monitoring period. Each set of samples consists of one control and three fortified samples.

Sample Storage and Handling

All samples collected during or after the monitoring period were stored in ice or frozen during storage and shipment.

Analytic Method

The samples collected were first extracted with solvents and then analyzed for chlorpyrifos and the chlorpyrifos metabolite 3,5,6-TCP (for urine samples only), using gas chromatography. A detailed description of the analytic methods appear in Appendix D of the study report.

Before the field study was initiated, an analytic method validation study was conducted to determine the method recoveries, valid determination range, limit of detection (LOD), and limit of quantitation (LOQ) for all the matrices used in dosimetry and biomonitoring. The LOD and LOQ for each matrix are summarized in Table 1 of this document. The method validation study was summarized in the study report, but was not provided for review.

In addition, laboratory recovery samples were prepared in the laboratory and included with each set of field samples to provide additional QC. The procedure was the same as that for field fortified samples but without exposure to the field conditions.

Data Summary

QA/QC Results

The average recoveries for laboratory fortified/spiked samples prepared with the filters, tubes, hand washes, coverall materials, underwear materials, and urine samples are summarized in Table 2. These recoveries suggest that the chromatographic method used for analysis of these samples were performing well. The laboratory recoveries were used to correct the data for the corresponding matrices.

The field control recoveries for matrices used for dosimetry ranged from 70.8 ±15.3 percent to 98.6±4.3 percent (Table 3). These recoveries were applied to correct the data for each corresponding matrix.

Storage stability recovery values for the matrices used in dosimetry ranged from 94.9 percent to 104.2 percent, demonstrating the stability of the chlorpyrifos during storage and shipping of samples (Table 3). No field storage stability recovery correction was applied to the monitoring data.

Field fortified samples of urine were prepared for each applicator using the urine samples collected in the morning before the insecticide applications. The overall field recoveries for 15 replicates ranged from 88.98 percent to 154.53 percent, with a mean of 109.41 percent. These recoveries were applied to correct the 3,5,6-TCP data for the corresponding replicates.

Exposure Results

The amount of chlorpyrifos found on the air monitoring filters and tubes for each replicate are provided in Table 5. The method for estimating absorbed dose via inhalation is described in the table. The absorbed doses via inhalation ranged from 0.06 to 1.02 µg/kg BW, with an average of 0.29±0.28 µg/kg BW, accounting for 60 percent of the average total doses.

The total dermal exposure, as well as the exposures to the various regions of the body for each replicate are provided in Table 6. The dermal exposures to various body regions were estimated by amounts of chlorpyrifos found on underwear and hand washes. However, the exposure to legs and arms (where no underwear were worn) was estimated by multiplying the amount of chlorpyrifos found in the corresponding regions of the coveralls with the overall average penetration factor. Based on the monitoring results, the upper legs accounted for ~ 67 percent of total dermal exposures, followed by ~11 percent for hand and ~ 9 percent for lower legs.

The absorbed doses of chlorpyrifos obtained via dermal exposure were estimated by multiplying the dermal exposures with an absorption factor of 3 percent. The calculation of absorbed doses was documented in Table 7. The estimated absorbed doses via dermal exposure

ranged from 0.09 to 2.03 µg/kg BW, with a mean of 0.59±0.54 µg/kg BW, accounting for 67 percent of the total average doses of chlorpyrifos. The estimated dermal exposure (not accounting for absorption) range from 3.06 to 67.82 µg/kg BW, with a mean of 19.61 ±17.9 µg/kg BW.

The amount of the chlorpyrifos metabolite 3,5,6-TCP excreted in the urine from each replicate for the day before the application, the day of the application and the consecutive five days after the application are provided in Tables V to XIX of the Study Report. Total amount of 3,5,6-TCP excreted over the background level for each replicate are provided in Table 8. The total (5 day) amount of 3,5,6-TCP excreted as a result of exposure ranged from 0 to 137.92 µg, with a mean of 18.09 µg. The method of estimating the absorbed doses of chlorpyrifos from the amount of 3,5,6-TCP is described in Table 8.

Table 8 summarizes the total absorbed doses of chlorpyrifos via inhalation and dermal exposures, estimated from passive dosimetry and biomonitoring. The total absorbed doses estimated from dosimetry range from 0.21 to 2.24 µg/kg BW, with a mean of 0.88±0.62 µg/kg BW. Approximately 33 percent of the absorbed doses resulted from inhalation and 67 percent from dermal exposure. The total absorbed doses estimated from biomonitoring ranged from 0 to 4.84 µg/kg BW, with a mean of 0.65 ± 1.43 µg/kg BW (this average includes seven of the 15 workers that had exposures of zero because of high baseline chlorpyrifos exposure). The mean values are in good agreement with the estimates from dosimetry. The biomonitoring average for the eight workers who had exposures above background was 1.23 µg/kg (i.e., excludes the seven workers with no exposure from lawn treatment). The registrant speculated that the highest exposure of 4.84 µg/kg (for OH05) was from a secondary source because 67% of the TCP was excreted on day 5 post exposure. However, this value was included in the average exposure because each volunteer was instructed to avoid chlorpyrifos for 10 days prior and 5 days following the study. As shown on Table 8, baseline chlorpyrifos exposure ranged from 0.2 to 3.73 µg/kg with a mean of 1.54 µg/kg, despite the fact that workers were instructed to avoid chlorpyrifos exposure 10 days prior to the study initiation. The high baseline chlorpyrifos exposure makes it difficult to interpret the biomonitoring results. For example, seven of the fifteen workers had exposure levels (based on urinary TCP) less than baseline levels, and therefore, their exposure from broadcast turf application is probably in the baseline range (0.94 to 3.73 µg/kg), and not zero as concluded by the registrant.

The analysis of blood samples drawn from each applicator 24 and 48 hours post application indicated that no significant depression in plasma or red blood cell cholinesterase activity occurred to the applicators after the application of the Dursban Pro insecticide. The results for each applicator are summarized in Table 9. It should be noted, however, that in animals peak cholinesterase inhibition occurs 3-6 hours post exposure. In addition, the prior exposure of many of these PCOs may have resulted in suppressed baseline cholinesterase levels.

Review Summary

Compliance with Series 875 Group A of the Pesticide Assessment Guideline (U.S.EPA, 1996) is critical for determining whether a study is acceptable to the Agency. The itemized list below is based on the" Checklist for Applicator Monitoring Data" and summarizes the major points of Series 875 Group A:

- *Typical end use product of the active ingredient tested.* This criterion was met since a commercial product was used in the study.

- *End use product handled and applied using recommended equipment, application rates, and typical work practices.* This criterion was partially met. The equipment used in this study was recommended by the label direction. However, the applications used in this study deviated slightly from those recommended by the label. For example, the label recommends using 0.03 to 0.12% for high volume broadcast sprays at a rate of 10 gallons/1000 ft^2. Whereas, the exposures from this study were based on 0.12% applied at 2 gallons/1000 ft^2. The label recommends that higher concentrations of 0.5% chlorpyrifos be applied using low volume sprays (i.e., 2 gallons /1000 ft^2). Therefore, it is possible that this study underestimates the actual exposures to PCOs following the label recommendations for broadcast treatment (i.e., the study should have either used a four-fold more concentrated solution of 0.5% chlorpyrifos, or increased the spray volume five-fold to 10 gallons/ 1000 ft^2).

- *For outdoor exposure monitoring at least five replicates at each of at least three sites for each job function with the exception of pilots should be monitored.* This criterion was met. Three days of five replicates (total of 15 test subjects treating 11-15 different turf areas) were evaluated in Ohio.

- *For indoor exposure monitoring at least five replicates at each of at least three sites for each job function must be monitored.* This criterion is not applicable to this study.

- *Monitoring period is sufficient to collect measurable residues, but not excessive so that residue loss occurs.* This criterion was met as the liquid phase of the insecticide was applied and the matrices of dosimeters have a high absorbing capacity.

- *Dermal and/or inhalation exposure must be monitored by validated methodologies. Biological monitoring is consistent with and supported by pharmacokinetic data accepted by the Agency.* This criterion was met as the monitoring and analytic methods were validated before the field experiments (see "Analytic Methods" above). In addition, biological monitoring was consistent

with and supported by the pharmacokinetic data published in the professional journals.

- *Quantity of active ingredient handled and duration of monitoring period reported for each replicate.* This criterion was met. The study examined exposures to 15 lawn care insecticide applicators from two different companies in Ohio, that applied an average of 183 gallons of 0.12 percent Dursban Pro by broadcast applications to turf for an average of 6 hours (4.4-8.2 hours). Each PCO treated 11-15 turf blocks (approximately 6,500 ft^2), with a total treated turf area of 74,740 to 97,500 square feet (mean of 95,983 ft^2). The total amount of chlorpyrifos handled ranged from 1.57 to 2.95 lb ai chlorpyrifos (mean of 2.17 lb ai).

- *Clothing worn by each study participant and location of dosimeters reported.* This criterion was met. Each PCO wore: (1) a pre-laundered cotton coverall; (2) pre-laundered cotton socks, cotton briefs, and cotton T-shirts (undergarment); and (3) denim patches which were affixed to a hat. At the end of the application, these dosimeters were collected from each applicator. The coverall and undergarments were sectioned into pieces representing arm, leg, and torso regions. Patches were affixed to the hat to serve as a surrogate for face, head and neck exposure. In addition, each PCO wore chemically-resistant nitrile gloves and knee high chemically-resistant boots.

- *Quantitative level of detection is at least 1 $\mu g/cm^2$.* This criterion was met. LOQs for dosimeters are shown in Table 1 of this review, however, LOQ values were not reported for socks or head patches.

- *Storage of samples consistent with storage stability data.* This criterion was met as the storage stability spikes were prepared for each matrices used in the dosimeters. The recovery results indicate that chlorpyrifos was stable during storage of samples.

- *Efficiency of extraction in laboratory provided as mean plus or minus one standard deviation. Lower 95 percent confidence limit is not less than 70 percent based on a minimum of seven replications per fortification level or prior Agency approval of extraction methodology provided.* This criterion was met. Recovery data was provided as mean plus and minus one standard deviation and each of the lower 95 percent confidence limit values was greater than 70 percent (refer to Table 2 and 3 of this review).

- *At least one field fortification sample per worker per monitoring period per fortification level for each matrix. At least one field blank per worker per monitoring period for each matrix.* This criterion was not met. Triplicate field

recovery samples per monitoring period per fortification level for each matrix were collected but not for each one of 5 replicates per monitoring period.

Based on this review, most of the requirements contained in Series 875 Group A of the Pesticide Assessment Guidelines (U.S. EPA, 1996) were met in this exposure study. The data are considered adequate to characterize lawn care operator application exposures for use in the RED.

Table 1. Limit of Detection of Limit of Quantitation of Matrices used in Dosimetry and Biomonitoring

Matrices	LOD (µg)	LOQ (µg)
Filters	0.013	0.04
Chromosorb Tube	0.013	0.04
Coverall (20 x 20 cm)	1.3	4.0
Underwear (20 x 20 cm)	0.13	0.4
hand washes	0.7	2.0
Urine (ng/mL)	0.30	0.99

Table 2. Average Laboratory Recoveries of Chlorpyrifos for Matrices Used for Dosimetry and Biomonitoring)(µg levels listed are for Chlorpyrifos)

	Dosimetry					Biomonitoring	
	Air Filters	Chromosorb Tubes (air)	Hand Wash	Coverall	Underwear	Urine 200 ng/mL	Urine 2 ng/mL
Recoveries (%)	108.1	106.8	104.8	85.9	91.1	88.4	101.2
STD Deviation	6.6	4.3	7.0	6.5	4.1	0.1	0.1

Table 3. Overall Average Field Control Recoveries of Chlorpyrifos for Matrices Used for Passive Dosimetry

	Air Filters	Chromosorb Tubes (air)	Hand Wash	Coverall	Underwear
Recoveries(%)	92.7±13.9	96.2±6.4	98.6±4.3	70.8±15.3	72.7±8.8
Recoveries for Storage Stability (%)	102.9	94.9	98.6	104.2	102.3

Table 4. Overall Average Field Control Recoveries of Chlorpyrifos Metabolite 3,5,6-TCP for Urine Samples of 15 Replicates Used for Biomonitoring

Replicates	Recoveries	Standard Deviation
OH01	92.22	1.55
OH02	112.67	2.67
OH03	106.97	5.28
OH04	90.47	0.91
OH05	88.98	1.04
OH06	103.35	3.28
OH07	154.52	1.74
OH08	112.53	2.09
OH09	95.08	0.98
OH10	110.20	3.20
OH11	111.40	3.72
OH12	122.82	3.38
OH13	111.38	2.38
OH14	133.50	3.30
OH15	95.03	2.03
Overall Average	109.41	2.5

Table 5
Estimated Inhalation Dose for Lawn Care Operator Workers

Replicate Number	Body Weight (kg)	Average Flow (L/min)	Length of Replicate (min)	Air Sample Volume (m3)	Analytical Result Filter+Tube (ug Chlorpyrifos)	Air Concentration (ug/m3)	Estimated ug Chlorpyrifos Inhaled (a)	Potential Inhalation Dose (ug/kg) (b)
OH01	93.44	1.05	462	0.485	1.83	3.77	43.54	0.47
OH02	79.38	1.13	430	0.484	0.67	1.38	14.84	0.19
OH03	86.18	1.5	451	0.677	0.32	0.48	5.41	0.06
OH04	74.84	1.13	492	0.554	3.43	6.20	76.26	1.02
OH05	84.82	1.1	489	0.538	1.92	3.58	43.77	0.52
OH06	77.11	1.5	304	0.456	0.74	1.63	12.39	0.16
OH07	79.38	1.4	293	0.410	0.69	1.68	12.31	0.16
OH08	81.65	1.13	266	0.299	0.32	1.08	7.18	0.09
OH09	81.65	1.15	288	0.331	0.85	2.56	18.43	0.23
OH10	90.72	1.1	285	0.314	0.48	1.54	10.97	0.12
OH11	58.97	1.23	407	0.499	2.12	4.25	43.24	0.73
OH12	83.91	1.38	268	0.369	0.51	1.37	9.18	0.11
OH13	58.97	1.08	300	0.323	0.44	1.37	10.28	0.17
OH14	83.91	1.1	301	0.331	0.98	2.96	22.27	0.27
OH15	99.79	1.45	283	0.410	0.53	1.28	9.06	0.09
Mean								**0.29**
Std Dev.								0.28

(a) Estimated ug Chlorpyrifos Inhaled = ug/m3 * 1.5 m3/hr * (replicate length/60)

(b) Inhalation Dose = Estimated ug Chlorpyrifos Inhaled/ Body weight.

Table 6
Summary of Dermal Exposure to Various Body Regions for Lawn Care Operator Workers

Replicate Number	Underwear Arms (ug) (a)	Underwear Legs (thighs) (ug) (a)	Underwear Torso Front (ug)	Underwear Torso Back (ug)	Socks (ug)	Head Patch (ug)	Head/Neck Exposure (ug) (b)	Hand Exposure (ug)	Total Dermal Exposure (ug) (c)
OH01	69	748	88	62	62	25	163	117.8	1309
OH02	55	1282	42	29	73	12	78	980.0	2539
OH03	23	755	78	61	96	21	137	69.5	1219
OH04	50	249	141	80	83	35	227	84.4	915
OH05	24	484	91	41	28	22	143	10.6	822
OH06	4	1080	18	17	186	5	33	8.3	1346
OH07	6	335	2	2	121	6	39	3.8	509
OH08	17	898	2	2	4	3	20	43.5	986
OH09	5	632	2	1	39	10	65	18.3	762
OH10	2	184	25	13	22	3	20	12.8	278
OH11	40	1131	66	43	517	19	124	1047.5	2968
OH12	20	4992	18	19	568	10	65	6.9	5689
OH13	46	1166	43	35	124	4	26	23.4	1463
OH14	17	830	23	24	155	25	163	24.7	1236
OH15	6	441	66	19	53	3	20	14.3	619
Mean	26	1014	47	30	142	14	88	164.4	**1511**
Std Dev.	21	1153	41	24	170	10	66	346.6	1359
% of Total	1.7	67.1	3.1	2.0	9.4		5.8	10.9	

(a) Arm and Leg (Thigh) values for the underwear were calculated - amount of chlorpyrifos on the coverall multiplied by the penetration factor.

(b) Head/neck exposure = head patch/ 200 cm2 * 1300 cm2
(c) Total Dermal Exposure = Arms Exposure + Legs Exposure + Torso Back Exposure + Torso Front Exposure + Hand Exposure + Head/Neck

Table 7

Estimation of Total Dose from Passive Dosimetry for Lawn Care Operators

Replicate Number	Body Weight (kg)	Estimated Total Dermal Exposure (ug)	Estimated Total Dermal Exposure (ug/kg)	Estimated Amount Dermally Absorbed (ug) (a)	Estimated Total Absorbed Dermal Dose (ug/kg)(b)	Potential Inhalation Dose (ug/kg)	Estimated Total Dose (ug/kg)(c)
OH01	93.44	1306	13.98	39.18	0.42	0.47	0.89
OH02	79.38	2542	32.02	76.26	0.96	0.19	1.15
OH03	86.18	1219	14.14	36.57	0.42	0.06	0.48
OH04	74.84	916	12.24	27.48	0.37	1.02	1.39
OH05	84.82	822	9.69	24.66	0.29	0.52	0.81
OH06	77.11	1346	17.46	40.38	0.52	0.16	0.68
OH07	79.38	507	6.39	15.21	0.19	0.15	0.34
OH08	81.65	986	12.08	29.58	0.36	0.09	0.45
OH09	81.65	759	9.30	22.77	0.28	0.23	0.51
OH10	90.72	278	3.06	8.34	0.09	0.12	0.21
OH11	58.97	2970	50.36	89.1	1.51	0.73	2.24
OH12	83.91	5691	67.82	170.73	2.03	0.11	2.14
OH13	58.97	1462	24.79	43.86	0.74	0.17	0.91
OH14	83.91	1233	14.69	36.99	0.44	0.27	0.71
OH15	99.79	617	6.18	18.51	0.19	0.09	0.28
Mean			19.61		0.59	0.29	0.88
Standard Dev.			17.90		0.54	0.28	0.62

(a) Estimated amount dermally absorbed = Estimated total dermal exposure * 0.03 (dermal absorption factor).

(b) Estimated total absorbed dermal dose = Estimated amount dermally absorbed / body weight

(c) Estimated total dose = total absorbed dermal dose + total inhalation dose

Table 8. Summary of Absorbed Doses of Chlorpyrifos Estimated from Dosimetry and Biomonitoring Data for the Lawn Care Operator Worker Exposure Study

Replicate Number	Body Weight (kg)	Doses Estimated from Passive Dosimetry (µg/kg BW)				Total Dose Estimated from Biomonitoring (µg/kg BW)			
		Absorbed Dermal Dose (5)	Dermal Exposure	Inhalation Dose	Total Dose	Total 3,5,6-TCP Excreted (1) (µg)	Baseline Chlorpyrifos Exposure (3)	Total Estimated Dose (2, 7)	Total Dose Adjusted for Flow Rate (6)
OH01	93.44	0.42	13.98	0.47	0.89	18.32	0.2	0.58	2.92
OH02	79.38	0.96	32.02	0.19	1.15	4.2	1.86	0.16	0.79\
OH03	86.18	0.42	14.14	0.06	0.48	12.32	1.2	0.43	2.13
OH04	74.84	0.37	12.24	1.02	1.39	82.83	0.2	3.29	16.5
OH05	84.82	0.29	9.69	0.52	0.81	137.92	0.26	4.84 (4)	24.2
OH06	77.11	0.52	17.46	0.16	0.68	0	0.94	0	0
OH07	79.38	0.19	6.39	0.15	0.34	0	3.73	0	0
OH08	81.65	0.36	12.08	0.09	0.45	0	2.45	0	0
OH09	81.65	0.28	9.3	0.23	0.51	4.33	0.94	0.16	0.79
OH10	90.72	0.09	3.06	0.12	0.21	0.55	0.75	0.02	0.09
OH11	58.97	1.51	50.36	0.73	2.24	0	2.3	0	0
OH12	83.91	2.03	67.82	0.11	2.14	0	2.52	0	0
OH13	58.97	0.74	24.79	0.17	0.91	0	2.5	0	0
OH14	83.91	0.44	14.69	0.27	0.71	0	2.51	0	0
OH15	99.79	0.19	6.18	0.09	0.28	10.92	0.67	0.33	1.63
MEAN		0.59	19.61	0.29	0.88	18.09	1.54	0.65	3.3
STD DEV		0.54	17.9	0.28	0.62	39.29	1.09	1.43	7.14
MEAN WITHOUT ZEROS								1.23	6.13
Geo.Mean								0.4 (7)	

(1) 3,5,6-TCP concentration reported as zero when baseline TCP excretion exceeded the amount excreted following the application measured in the study. In reality, exposure is not really zero but not quantifiable due to the high baseline chlorpyrifos exposure (despite the volunteers avoiding exposure for 10 days).

(2) Measured absorbed chlorpyrifos dose (μg/kg BW) =[(Total 3,5,6-TCP excreted over baseline levels) * (350.6/198) (molecular weight ratios for chlorpyrifos and TCP)] / [(0.85 (fraction of oral chlorpyrifos dose expected to be excreted in the urine in 5 days, i.e., 0.6124/0.72, See Appendix A) * 0.72 (fraction of chlorpyrifos excreted in urine as TCP) * Body weight (kg)]

(3) Measured absorbed chlorpyrifos dose (μg/kg BW) =[(Total 3,5,6-TCP pre-study) * (350.6/198) (molecular weight ratios for chlorpyrifos and TCP)] / [0.72 (fraction of chlorpyrifos excreted in urine as TCP) * Body weight (kg)]

(4) Over 65 percent of the 3,5,6-TCP excreted by replicate OH05 was excreted on the last day of monitoring. This pattern is inconsistent with a single exposure event, and suggests that there was a secondary exposure to chlorpyrifos after the day of application, despite the fact the workers were instructed to avoid chlorpyrifos exposure for five days following application.

(5) Estimated assuming 3% dermal absorption.

(6) Total estimated dose * 5 (to adjust from a 2 gal/1000 ft2 flow rate to the label-recommended flow rate of 10 gal/1000 ft2).

(7) Geometric mean calculated only for workers who had exposure above baseline levels. Data lognormally distributed without zero values based on Shapiro Wilks test.

Table 9
Summary of Cholinesterase Data for Lawn Care Operators

Replicate Number	Pre-Exposure Sample (IU/L)		24 Hours Post-Exposure Sample (IU/L)				48 Hours Post-Exposure Sample (IU/L)			
	Plasma	RBC	Plasma		RBC		Plasma		RBC	
			Value	% of Baseline	Value	% of Baseline	Value	% of Baseline	Value	% of Baseline
OH01	2300	8601	2177	94.7	6846	79.6	2218	96.4	7124	82.8
OH02	2835	7322	2700	95.2	5536	75.6	2826	99.7	6756	92.3
OH03	2658	7399	2414	90.8	6326	85.5	2632	99.0	7163	96.8
OH04	2398	7960	2350	98.0	6406	80.5	2386	99.5	6984	87.7
OH05	2422	7976	2337	96.5	6150	77.1	2320	95.8	6915	86.7
OH06	1742	7587	1639	94.1	7738	102.0	1637	94.0	7767	102.4
OH07	1868	7960	1787	95.7	7228	90.8	1963	105.1	8032	100.9
OH08	1968	8512	1873	95.2	8338	98.0	1921	97.6	7994	93.9
OH09	2710	7218	2861	105.6	7199	99.7	2646	97.6	7141	98.9
OH10	2257	7530	2108	93.4	6970	92.6	2172	96.2	7441	98.8
OH11	1750	5907	1890	108.0	7410	125.4	1793	102.5	7000	118.5
OH12	1810	7173	1759	97.2	7760	108.2	1745	96.4	8344	116.3
OH13	2735	6397	2725	99.6	7192	112.4	2688	98.3	8777	137.2
OH14	2835	5413	2920	103.0	6569	121.4	2919	103.0	7251	134.0
OH15	352	6051	2676	760.2	7991	132.1	2462	699.4	6772	111.9
Mean	2176	7267	2281	142	7044	99	2289	139	7431	104
Std Dev.	644	946	430		758		410		613	

Note: The reference range for the laboratory was 1,000-3,500 and 5,300-10,000 international units/L for plasma and red blood cell cholinesterase, respectively.

APPENDIX A
Pharmacokinetic Model Used by DowAgroSciences to Estimate the Amount of Chlorpyrifos Absorbed After Exposure

$$Xu(t) = Ka * fXo\ [1/Ka + Exp\ (-Kt)/(K-Ka) - K * exp\ (-Ka * t) / (Ka*(K-Ka))]$$

Where:

t = time in hours
K = 0.0258 = rate constant for elimination, per hr
Ka = 0.0308 = rate constant for absorption, per hr
f = 0.72 = fraction of absorbed dose excreted as 3,5,6-TCP

Xo = 1

Days	*Hours Post Dosing*	*Ka*f*	*1/Ka*	*exp(-Kt)/ (K-Ka)*	*-K*exp(-Ka*t)/ Ka*(K-Ka)*	*Cum. Exc. Xut(t)*	*Int Excr. Xut(t)-Xut(t-1)*
	0	*0.0222*	*32.47*	*-200.00*	*167.53*	*0.0000*	*0.0000*
	12	*0.0222*	*32.47*	*-146.75*	*115.77*	*0.0331*	*0.0331*
1	*24*	*0.0222*	*32.47*	*-107.67*	*80.00*	*0.1064*	*0.0733*
	36	*0.0222*	*32.47*	*-79.01*	*55.28*	*0.1941*	*0.0877*
2	*48*	*0.0222*	*32.47*	*-57.97*	*38.20*	*0.2820*	*0.0879*
	60	*0.0222*	*32.47*	*-42.53*	*26.40*	*0.3626*	*0.0806*
3	*72*	*0.0222*	*32.47*	*-31.21*	*18.24*	*0.4329*	*0.0703*
	84	*0.0222*	*32.47*	*-22.90*	*12.60*	*0.4922*	*0.0593*
4	*96*	*0.0222*	*32.47*	*-16.80*	*8.71*	*0.5412*	*0.0490*
	108	*0.0222*	*32.47*	*-12.33*	*6.02*	*0.5808*	*0.0396*
5	*120*	*0.0222*	*32.47*	*-9.05*	*4.16*	*0.6124*	*0.0316*
	132	*0.0222*	*32.47*	*-6.64*	*2.87*	*0.6372*	*0.0248*
	133	0.0222	32.47	-6.47	2.79	0.6392	0.0020
6	*144*	*0.0222*	*32.47*	*-4.87*	*1.99*	*0.6569*	*0.0197*
	156	*0.0222*	*32.47*	*-3.57*	*1.37*	*0.6719*	*0.0150*
7	*168*	*0.0222*	*32.47*	*-2.62*	*0.95*	*0.6837*	*0.0118*
	180	*0.0222*	*32.47*	*-1.92*	*0.66*	*0.6928*	*0.0091*
8	*192*	*0.0222*	*32.47*	*-1.41*	*0.45*	*0.6995*	*0.0067*
	204	*0.0222*	*32.47*	*-1.04*	*0.31*	*0.7047*	*0.0052*
9	*216*	*0.0222*	*32.47*	*-0.76*	*0.22*	*0.7088*	*0.0041*
	228	*0.0222*	*32.47*	*-0.56*	*0.15*	*0.7118*	*0.0030*
10	*240*	*0.0222*	*32.47*	*-0.41*	*0.10*	*0.7140*	*0.0022*

Values used for calculating chlorpyrifos exposure

0.85 = 0.6124 (amount excreted in 5 days)/ 0.72 (total amount of chlorpyrifos excreted in the urine as TCP)