Industrial Hygiene Assessment of an Occupied Residence for the Presence of Selective Pesticides

[redacted]

Prepared for:

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EXECUTIVE SUMMARY

On Friday, May 29, 2009, personnel from Forensic Applications Consulting Technologies, Inc. (FACTs) visited the residence located at [redacted], in Parker, CO (the subject property). The purpose of the visit was to perform specific sampling to determine the presence of specific pesticides within the property at select locations.

Based on information provided to FACTs by the occupant of the subject property, [redacted], a local pest management company, [redacted],[1] applied pesticides to the exterior of the subject property on two occasions. According to [redacted], neither of the applications were authorized, and each were an accident by [redacted] who had been contracted to perform other work at the property.

According to the occupant, following the unauthorized applications of pesticides, the occupant began to experience a constellation of symptoms which resulted in at least two emergency room self admissions.

Using the available information, FACTs employed standard Industrial Hygiene sampling techniques to determine the extant presence of specific pesticides within the interior of the subject property. FACTs confidently confirmed the presence of a single pesticide known as "permethrin" in the subject residence.

Using the available information, FACTs employed standard exposure modeling techniques to determine the relative significance of specific pesticides within the interior of the subject property. From an Industrial Hygiene perspective, based on state of knowledge, and the highest standard of care, the presence of the permethrin and other pyrethroids/pyrethrins inside the residence is insignificant.

This report describes our methods, observations, results, conclusions and recommendations.

INTRODUCTION

The site assessment and author of this report was Caoimhín P. Connell, Forensic Industrial Hygienist. Mr. Connell was assisted in the field by Ms. Christine Carty, Field Technician. During our assessment, FACTs was accompanied by the resident, [redacted].

Use of Terms: Pyrethrum, Pyrethrin, Pyrethroids

The identification of compounds in this family of pesticides can be somewhat confusing due to similar sounding names for different compounds. Pyreth*rum* is the naturally occurring extract found in some Chrysanthemums. Pyrethrum has long been recognized

[1] [redacted]

as possessing insecticidal properties. There are six natural active insecticidal compounds of pyrethrum and these are called the pyreth*rins*. As technology progressed, industry discovered ways to artificially alter the chemical structure of the pyrethrins to make them more stable in the environment and to enhance other qualities to improve their use as pesticides. These altered compounds, are called pyreth*roids*; and are synthetic analogs and derivatives of the original pyrethrins; each pyrethroid has one or more trades names.

For ease of discussion and reading, throughout this report, we will sacrifice precision of terminology for readability and simply refer to all pyrethrum/pyrethrins/pyrethroids as "pyrethrins" regardless of the compound's actual structure. Where we are discussing a specific pyrethrin, we will refer to that compound by name (deltamethrin, cyfluthrin, pyrethrin II, etc.)

This assessment was focused primarily on four pyrethrins. Since a single compound in chemistry can have dozens of synonyms, a unique number, called a "Chemical Abstract Service Registry Number" (CAS) is assigned to the compound to avoid confusion. This assessment focused on four specific pyrethrins:

Pyrethrin I (CAS 121-21-1)
Pyrethrin II (CAS 121-29-9)
Cyfluthrin (CAS 68359-37-5)
Deltamethrin (CAS 52918-63-5)

The selection of the compounds of interest was based on [redacted] Service Tickets dated [redacted] and [redacted][2] The service tickets identify these compounds as those which were applied at the subject property.

Upon receipt of the analytical results, we included a fifth compound of interest:

Permethrin (CAS 52645-53-1).

Toxicological Considerations

FACTs was not contracted to perform a detailed toxicological review of the compounds and none will be presented here.

Since the structural variations associated with modifications seen in the pyrethrins is large, the toxicology associated with the pyrethrins similarly extends across a broad range of responses. However, the signs and symptoms of adverse physiological responses associated with acute exposures to different pyrethrins are similar. [3]

[2] For this service ticket, the pesticide applicator, [redacted], accidentally dated the ticket [redacted].

[3] World Health Organization *Toxicological evaluation of certain veterinary drug residues in food*. WHO Food Additives Series 39. Cyfluthrin. Prepared for the forty-eighth meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA), World Health Organization, Geneva (1997). Current as of November 19, 2007

A World Health Organization review of hundreds of cases of acute pyrethrin poisoning due to occupational or accidental exposure revealed symptoms that included a sensation of burning, itching, and tingling of the skin, which resolved after several hours.

The systemic symptoms included dizziness, headache, nausea, anorexia, and fatigue; vomiting was most common in cases due to ingestion of pyrethrins. Although less frequently reported, tightness of the chest, paraesthesia, palpitation, blurred vision, and increased sweating were observed in some cases. Coarse muscular fasciculations were observed in more serious cases. Convulsions and coma can also result from acute poisoning with pyrethrins.[4]

The subjective self-reported symptoms described to us by the occupant were consistent with some symptomology reported in peer-reviewed literature.

Exposure Considerations

Due to the fact that the pyrethrins are both naturally occurring and intentionally broadcast in homes by homeowners using over-the-count products and by industry and agriculture, exposure to pyrethrins is, to some degree, ubiquitous and unavoidable.

Due to the low volatility of the pyrethrins,[5] the use of air monitoring and airborne exposures in the assessment of residual pyrethrins in residential environments is not considered appropriate.[6] Inhalation usually represents an insignificant route of exposure to residual pyrethrins in outdoor[7] and indoor residential settings.[8] By contrast, residential exposures have been successfully assessed[9] in surfaces using wipe and microvacuum techniques, similar to that used on this project.

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[4] ToxNet, HSDB and other published sources associated with the US Department of Health and Human Services, *Agency for Toxic Substances and Disease Registry*, 4770 Buford Hwy NE, Atlanta, GA 30341

[5] US EPA *Reregistration Eligibility Decision (RED) for Permethrin*, Prevention, Pesticides and Toxic Substances, April 2006 (EPA 738-R-06-017)

[6] Couture C; Fortin M; Carrier G; Dumas P; *et al Assessment of Exposure to Pyrethroids and Pyrethrins in a Rural Population of the Montérégie Area, Quebec, Canada*, J. Occ. Env. Hyg, (V6, No. 6, June 2009 , Pages 341 – 352)

[7] US EPA *Reregistration Eligibility Decision (RED) for Permethrin*, Prevention, Pesticides and Toxic Substances, April 2006 (EPA 738-R-06-017)

[8] Couture c; Fortin M; Carrier G; Dumas P; *et al Assessment of Exposure to Pyrethroids and Pyrethrins in a Rural Population of the Montérégie Area, Quebec, Canada*, J. Occ. Env. Hyg, (V6, No. 6, June 2009 , Pages 341 – 352)

[9]Bradman A, Whitaker D, Quirós L, *et al Pesticides and their metabolites in the homes and urine of farmworker children living in the Salinas Valley, CA*. J Expo Sci Environ Epidemiol. 2007 Jul;17(4):331-49.

A retrospective exposure assessment immediately following the application of the pesticides at the subject property is impossible; however, in this discussion, we have attempted to estimate a reasonable worst case exposure scenario. One can either identify extant conditions, or one can perform qualitative modeling and qualitatively estimate a range of concentrations which may have been present at the peak of exposure during the application of the pesticides (which we have done here). Although these are the only two feasible options available, neither method is capable of determining, with high confidence, the peak exposures a particular person would have received on the days of pesticide application.

Evaluating the extant residual concentrations is valuable since the occupant reports sustained symptomology up to the date of our assessment when she enters the property.

Literature supports the use of urinary metabolites to determine exposure; however, due to the ubiquitous nature of the pyrethrins, the presence of the urinary metabolites merely establishes exposure, not temporal or previous exposures within any particular time frame.

Industrial Hygienists use various approaches for estimating the amount of contaminants entering the human body based on the contaminant present in the environment. The approaches are called "models," and the final results are expressed as "dose." The dose of a contaminant is the amount of contaminant that enters the body per unit body weight, per day (milligrams of contaminant per kilogram of body weight, per day, mg/kg/d).

The final estimated dose can be compared with a "reference dose" (RfD). An RfD is the conservatively estimated upper dose which an average person may receive everyday for their entire lives without an observable adverse physiological effect. The RfD does NOT take into account a specific person's susceptibility, volume of health, personal toxicology, or any other person-specific trait. Rather, the RfD merely provides the Industrial Hygienist with a milestone to allow the Industrial Hygienist to apply a description of the reported value as "high" or "low" or "significant" or "normal" or some other subjective term that can be used to place the reported value into context. In this case, as discussed below, FACTs conclusively identified a single pyrethrin called "permethrin" at the residence; and the US EPA has reported an RfD for permethrin of 0.25 mg/kg/d.[10]

All models are based on assumptions. Some assumptions are based on objective observations and other parameters generally considered reasonable by the scientific community and are typically found within peer-reviewed literature. For example, the size (and weight) of a person, the size of their hands, the surface area of their hand, the volume of blood in their body, etc, are all objective parameters. Other assumptions, such as the number of times a person may bring their hand to their mouth and the fraction of

[10] US EPA, Office of Water, Drinking Water Standards and Health Advisories, 2002 (Publication number: EPA 822-R-02-038)

contaminant that may then be transferred to their mouth each day, however is unknown and must be assumed without foundation.

Although FACTs was not contracted to perform a toxicological assessment or characterize body burden, we nevertheless wished to be able to place the results of the samples into some kind of context for the client. We used a qualitative model to perform the estimate. Several assumptions are incorporated into our estimates used in this study, and those assumptions may be legitimately challenged, or revised upon detailed review by FACTs or other toxicological professionals.

Based on the chemical properties of permethrin, it can be assumed that volatilization of the chemical from surfaces in the residence is negligible.[11] Therefore, the contaminant is assumed to be available from all surfaces for the entire exposure period. We assume that there is an amount of contaminant deposited on skin upon contact with the surface that could be transferred to the mouth and ingested. We also assumed that a small portion of the material may be inhaled, and thus enter systemic circulation. Essentially we estimated the amount of contaminant that could enter the body of an occupant at the study residence from oral, dermal and inhalation routes.

SAMPLE COLLECTION

Hypothesis Testing

Sampling, any kind of sampling, should be designed to answer a very specific question. The more narrow the question, the tighter the quality of the data necessarily becomes (and generally, the more expensive the work becomes).

In this case, as previously mentioned, the objective was to determine *presence* of the selected compounds in the subject property, at technically feasible detection limits, using standard analytical methodologies.

Our hypothesis became:

> Detectable concentrations of pyrethrins are **not** present in removable debris from fabrics and carpets in the interior of the subject property.

Sampling was then performed, to diligently demonstrate the validity of the hypothesis. The samples thus collected would be used to support the hypothesis.

Data Quality Objectives

Prior to the collection of any kind of environmental sample, one should establish data quality objectives (DQOs) by which the results may be properly interpreted. The DQOs

[11] US EPA *Reregistration Eligibility Decision (RED) for Permethrin*, Prevention, Pesticides and Toxic Substances, April 2006 (EPA 738-R-06-017)

become the "guidelines" to determine the limitations and usefulness of the data. The DQOs describe the precision, accuracy, representativeness and comparability of the data thus derived from the sampling.

Frequently, an *a priori* decision criteria is established by which the data results may be judged. In this case, no *a priori* decision criteria was established for two reasons: 1) The hypothesis being tested was merely for *presence* of pyrethrins, (and not characterization), and , 2) The levels of pyrethrins in the environment vary enormously with location and circumstances, and without knowing the normal background levels for the area of the subject property, no comparison value was available.

ALL samples exhibit uncertainty; ALL analyses exhibit uncertainty. Budgetary considerations prevent the elimination or characterization of sampling errors associated with this assessment. It is well established that concentrations of contaminants in a structure exhibit lognormal or even parametric distributions; large variations in contaminant concentrations are seen over very short distances.

Therefore, for this assessment, in an attempt to minimize sampling error and yet control costs, FACTs elected to collect ten samples from specific locations within the subject property and combine the ten samples into a single composite.

Sampling Theory

Consistent with good sampling theory, the location of the samples was based on professional judgment. In this case, it was FACTs' professional judgment that a sampling approach known as "authoritative biased sampling" would be appropriate.

During this project, FACTs personnel selected those areas which had the highest probability of exhibiting the highest concentrations of contamination. Based on our experience, state of the art information on indoor contamination migration patterns and professional judgment, FACTs selected specific locations throughout the structure in an attempt to represent the highest possible concentrations of pyrethrins.

The selected locations cannot be used to determine source, or temporal parameters, only presence.

False Contamination

Prior to entering the subject property, FACTs was cognizant of introducing contaminants into the property. FACTs personnel donned fresh disposable Tyvek booties prior to entering the property and fresh booties every time a new entry was made until the samples had been collected.

Prior to the collection of the samples, the Industrial Hygienist donned fresh surgical gloves. Since the study area was the entire interior portion of the residence, the issue of "cross contamination" is moot (one cannot cross contaminate a single homogenous study

area). Therefore, a single set of surgical gloves was used for the collection of all the samples.

FACTs' equipment was staged at the front entrance. All collection equipment and materials were single use disposable materials; therefore, "memory" and residual contamination were not an issue.

Sample Collection Methodologies

For the purposes of this assessment, FACTs collected two types of samples: vacuum samples and wipe samples.

Vacuum Samples

The vacuum samples were collected using standard Industrial Hygiene microvacuum sampling procedures,[12] as a guideline. After an area had been selected and measured, a commercially available 25 mm diameter, extended-cowl cassette, fitted with mixed cellulose ester (MCE) membrane was attached to a commercially available Industrial Hygiene air sampling pump. The pump was adjusted to draw approximately 15 liters of air per minute at approximately 2 inches of water column pressure. The cassette was opened to present an "open face" and the selected area was vacuumed with the cassette. Samples were maintained in control of FACTs personnel at all times, and submitted via UPS to Analytical Chemistry, Inc. in Tukwila, Washington. A copy of the laboratory report is included with this discussion as Appendix A.

The table below, presents the sampling information for the vacuum samples.

Location	Surface Area (cm2)
Basement carpet by southeast window	929
Basement carpet by furnace	929
Basement carpet on southeast side	929
Master bedroom carpet in northwest corner	929
Runner carpet from laundry room to hallway	929
Runner carpet in laundry room	929
Northwest bedroom couch	929
Living room carpet in northeast quadrant	929
Living room central throw rug	929
Living room carpet in southeast quadrant	929
Total Surface Area of Composite Sample	9288

Table 1
Location of Microvacuum Sample (CP052909-01)

[12] ASTM Method D 5756-02

Field Blank

For data to be valid, it must be tenable, and one must demonstrate that the contaminant identified in the sample was due to the presence of the contaminant at the study site, and not as a background constituent of the materials used in the study. One of the ways to demonstrate that the contaminant of interest was not due to contaminated sampling materials, or extraneous cross contamination in handling or laboratory procedures is through the employment of "field blanks."

A field blank is a "sample" that is handled in every way like other samples used in the study, except the "sample" has not actually been opened and nothing has been collected onto the sampling media. The sample is submitted to the laboratory for analysis; to ensure the integrity of the field blank, the laboratory is not informed of the nature of the blank. In this project, FACTs personnel, randomly selected one of the two cassettes used, and set the cassette to the side, for submission as a field blank (Sample CP052909-02).

Wipe Samples

A single composite wipe sample was collected in a manner consistent with normal industrial hygiene wipe sample procedures.[13] The wipe sample medium was individually wrapped commercially available Johnson & Johnson™ gauze pads (FACTs Lot # G0901). Each pad was moistened with reagent grade methyl alcohol (FACTs Lot # A0801). The sampling media were prepared in small batches; the blanks and the actual sample kit to be used on any subject property is not known in advance. Each sampling medium is prepared in a clean environment and inserted into an individually identified polyethylene centrifuge tube with cap.

Prior to the collection of the sample composite, the Industrial Hygienist donned fresh surgical gloves, to protect against the possibility of false contamination from an outside source. The proposed sample area was selected and measured.

The wipe sample was collected by methodically wiping the entire surface of the selected area with moderate pressure; first in one direction and then in the opposite direction, folding the gauze to reveal fresh material as necessary. The sample was returned to its centrifuge tube and capped with a screw-cap. The wipe sample was maintained in the control for FACTs personnel at all times, under chain of custody, and is currently held in a freezer in our offices pending further decision making criteria.

[13] See for example, State of Colorado 6 CCR 1014-3 Appendix A, Regulations pertaining to the cleanup of illegal methamphetamine laboratories.

Location	Surface Area cm2
Furnace air handling interior	52
Furnace exterior at trapped dust	71
Kitchen window blinds	748
Kitchen top of light fixture	809
Hallway furnace air return duct	6
Total Surface area of wipe composite	1,686

Table 2
Location of Wipe Sample Composite

Sample Results

The laboratory analyzed the vacuum samples using a standard analytical technique known as GCMS (gas chromatography coupled with mass spectrometry). The method identifies and quantifies the mass of unknown constituents. In this case, the laboratory found an unknown peak on the chromatogram that did not correspond with any of the four target analytes (pyrethrin I, pyrethrin II, cyfluthrin and deltamethrin). The laboratory identified the peak as corresponding to the pyrethrin known as "permethrin." The laboratory reported finding 9.6 micrograms (µg) of permethrin in the sample, and no permethrin in the field blank. Therefore, we conclude, with confidence, that the reported permethrin was due to permethrin present at the residence.

The laboratory reported that their surrogate recovery from the sample was 71%; this indicates that the reported value may be slightly lower than the actual mass present in the sample, and FACTs has adjusted the reported value, now called a "corrected value." FACTs used the corrected value, and the estimated mass of permethrin in the sample becomes 13.5 µg.

The ten-parted sample composite represented ten equal areas each of 928.8 square centimeters. Therefore, the sample result has two limits which can be thought of as:

1) The entire amount of permethrin found in the sample came from just one sample location.

2) The permethrin is evenly spread throughout the residence and came from each sample location equally.

The worst case scenario, for this study, would be the latter, since if the permethrin was spread equally and homogeneously throughout the residence, there would be a greater probability of repeated exposure, and therefore, an higher body-burden associated with the presence of the contaminant.

The *concentration* of the contaminant can be expressed as mass per unit surface area, and becomes 0.001 µg of permethrin per unit area (square centimeter, cm2).

Permethrin is relatively unstable in the environment and degrades when exposed to light. The apparent half-life of permethrin in residential settings, is approximately 30 days.[14] If we presume the unfounded assertion that the permethrin concentration was depleted by half every thirty days, then the original concentration of permethrin in the residence on the earliest day of application (November 2008) could have been as high as 0.093 µg/cm2. This worst case scenario concentration ultimately becomes the reported result we have used in our calculations.

Significance of the Sample Result

The significance of the sample result may be viewed in many contexts. For the purpose of this study, we view the significance in two ways:

1) In the context of our hypothesis.

2) In the context of human exposure.

Significance in Terms of the Hypothesis

In the context of our hypothesis, the sample result failed to support the hypothesis and we therefore accept the "null hypothesis" and make the following statement:

> Detectable concentrations of pyrethrins **are** present in removable debris from fabrics and carpets in the interior of the subject property.

Significance in Terms of Human Exposure

Based on the sample result, we estimated that a "ballpark" worst case scenario dose during the first month following the first application, would be on the order of 0.009 mg/kg/d, which is only 3% of the life-time no observable adverse effect level reported by the EPA. Each month thereafter, the estimated dose would be one half of the previous month. Based on this, we conclude that from an Industrial Hygiene perspective, the concentration of pyrethrins in general and even permethrin in particular, at the residence, as determined by our sample composite could be best described as "insignificant."

The physiological effects of the dose(s) received by [redacted], however, are medical evaluations that are not within the realm of competency of the practice of Industrial Hygiene and may, in the opinion of her health care professionals, be significant, and of greater concern than our exposure estimates would indicate. It remains the responsibility of [redacted] health care providers to take our data and place that data into context with regard to [redacted] health.

[14] World Health Organization *Environmental Health Criteria 94 – Permethrin*, International Programme on Chemical Safety, WHO Geneva, 1990

CONCLUSIONS

The presence of permethrin was confidently confirmed at the residence.

The concentrations of pyrethrins identified inside the residence are within an exposure range that is generally regarded as safe for humans.

Cats are particularly susceptible to permethrin, over and above human responses.[15] Feline exposures and considerations are beyond FACTs' scope of work.

RECOMMENDATIONS

FACTs does not make any specific recommendations regarding decontamination or cleaning operations for the property. The levels of contaminant estimated to be present at the subject residence already appear to be below those concentrations that FACTs would establish as cleanup thresholds.

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[15] National Pesticide Information Center Technical Fact Sheet, Oregon State University, 333 Winiger Hall, Corvallis OR, 97331 – Rev. March 2009