Factors Affecting the Movement of Pesticides Applied in Residential Settings

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Introduction

- Research on off-site movement of pesticides in non-agricultural settings has been conducted for over 20 years in Europe and North America.
  - Much of this work is based on concepts from studies conducted for agricultural applications to soils and plants.
    - For example, sorption and runoff processes.

- Recently research and monitoring of residential applications has been conducted in California by a number of organizations.
Introduction

- The recent activities in California have included studies in outdoor residential settings conducted by the Pyrethroid Working Group
  - The results are helpful in understanding the important transport mechanisms and potential ways to minimize transport to nearby surface water bodies for all compounds applied in residential settings.
Introduction

- Studies conducted
  - Small scale
    - Building Material Washoff-washoff from slabs of different building materials
    - Formulation Washoff-washoff of different formulations from concrete slabs
  - Full-size scale
    - Pathway ID-identification of important transport pathways and effect of mitigation measures
    - Washoff Dynamics-effect of formulation and drying time between application and rainfall events
Building Material Washoff Study

- Objective: Determine the relative washoff losses from building materials that could be used on the vertical sides of houses

- Study design
  - Commercial EC and WP formulations of a representative pyrethroid (cypermethrin)
  - 10 building materials
  - Test conditions
    - Dry for 24 hours after application followed by 25 mm of simulated uniform rainfall over an hour
Building Material Washoff Study

Application to concrete slab by track sprayer
Building Material Washoff Study

Slabs positioned in rainfall simulator
# Building Material Washoff Study

<table>
<thead>
<tr>
<th>Slab Material</th>
<th>Washoff (% of applied)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EC</td>
</tr>
<tr>
<td>vinyl</td>
<td>14.1</td>
</tr>
<tr>
<td>aluminum</td>
<td>1.0</td>
</tr>
<tr>
<td>unpainted wood</td>
<td>1.6</td>
</tr>
<tr>
<td>unpainted concrete</td>
<td>0.14</td>
</tr>
<tr>
<td>dirty painted wood</td>
<td>0.30</td>
</tr>
<tr>
<td>asphalt</td>
<td>0.06</td>
</tr>
<tr>
<td>painted wood</td>
<td>0.10</td>
</tr>
<tr>
<td>painted stucco</td>
<td>0.04</td>
</tr>
<tr>
<td>painted concrete</td>
<td>0.06</td>
</tr>
<tr>
<td>unpainted stucco</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

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Building Material Washoff Study

- **Results**
  - The amount of washoff varied greatly with the building material
    - Surface roughness and porosity seemed to affect washoff
  - Definite effect of formulation on runoff
    - Direction of the effect varied with the surface
Objective: Determine the relative washoff losses of different formulations applied to concrete slabs representative of driveways

Study Design

- 17 commercial formulations
- Test conditions similar to building material washoff study except for the angle of the slabs
  - Dry for 24 hours after application followed by 25 mm of simulated uniform rainfall over an hour
### Formulation Washoff Study

<table>
<thead>
<tr>
<th>Product</th>
<th>Active Ingredient</th>
<th>Washoff (% of applied)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cynoff® WP</td>
<td>cypermethrin</td>
<td>9.30</td>
</tr>
<tr>
<td>Cynoff® EC</td>
<td>cypermethrin</td>
<td>0.11</td>
</tr>
<tr>
<td>Demon® Max</td>
<td>cypermethrin</td>
<td>0.09</td>
</tr>
<tr>
<td>Demon® WP</td>
<td>cypermethrin</td>
<td>9.97</td>
</tr>
<tr>
<td>Demand® CS</td>
<td>lambda-cyhalothrin</td>
<td>10.85</td>
</tr>
<tr>
<td>Scimitar® GC</td>
<td>lambda-cyhalothrin</td>
<td>12.22</td>
</tr>
<tr>
<td>Warrior®</td>
<td>lambda-cyhalothrin</td>
<td>0.32</td>
</tr>
<tr>
<td>Suspend® SC</td>
<td>deltamethrin</td>
<td>16.81</td>
</tr>
<tr>
<td>Dragnet® SFR</td>
<td>permethrin</td>
<td>0.11</td>
</tr>
<tr>
<td>Prelude®</td>
<td>permethrin</td>
<td>0.10</td>
</tr>
<tr>
<td>Talstar® Professional</td>
<td>bifenthrin</td>
<td>5.68</td>
</tr>
<tr>
<td>Wisdom® TC flowable</td>
<td>bifenthrin</td>
<td>13.48</td>
</tr>
<tr>
<td>Cy-kick® CS</td>
<td>cyfluthrin</td>
<td>7.91</td>
</tr>
<tr>
<td>Danitol® 2.4 EC</td>
<td>fenpropathrin</td>
<td>0.29</td>
</tr>
<tr>
<td>Ortho Bug-B-Gon®</td>
<td>esfenvalerate</td>
<td>0.43</td>
</tr>
<tr>
<td>Tempo® Ultra SC</td>
<td>beta-cyfluthrin</td>
<td>13.65</td>
</tr>
<tr>
<td>Tempo® Ultra WP</td>
<td>beta-cyfluthrin</td>
<td>19.41</td>
</tr>
</tbody>
</table>
Formulation Washoff Study

○ Results
  ● Wide range of washoff measurements: 0.1 to 20% of applied
    ○ Also variability within a formulation type
  ● EC formulations tend to have lower washoff values than WP or SC formulations
  ● Results consistent with other small scale studies with pyrethroids

Note that formulation can also affect the amounts of active ingredient or the number of sprays per season needed to achieve and maintain insect control and the extent of VOC emissions
Objectives

- Determine the important pathways for off-site movement from residential applications
  - Essential to developing effective mitigation practices
- Determine the effectiveness of spot (crack and crevice) treatments for reducing residues from applications to driveways and adjacent surfaces
Basic Study Design

- Two treatment regimes
  - Historic practices (standard perimeter)
  - Revised label (spot, crack and crevice)
- Three house plots per treatment regime
  - Front walls, front lawn, and driveway
  - Lawns irrigated with residential lawn sprinklers
  - Natural and simulated rainfall
- Study duration: 1 year
  - August 1, 2011 to August 2, 2012
House Lot
Pathway ID Study Site
Basic Study Design

- Applications of five different pyrethroids per house plot
  - Application to lawn (1 per year)-granular formulation
  - Perimeter treatments (6 per year) of four products-liquid formulations
    - Lawn within 1.5 m of house wall
    - House wall next to grass
    - House wall/garage door next to driveway
    - Driveway
- Collection, quantification, and analysis of runoff
Location of Application-Driveway

Historic Practices: blue and pink
Revised Practices: pink only
Location of Application-Garage/Wall

Historic Practices: blue and pink
Revised Practices: pink only
Sample Collection
Irrigation

- Lawns were irrigated with residential lawn sprinklers
  - Installed, maintained, and operated by a local lawn service according to their standard residential practices
- One or two storms were simulated per month from October to March to supplement natural events
Interpretation

- The losses of the individual pyrethroids were determined for each irrigation and rainfall event
  - The pyrethroid losses incurred were expressed as total mass and as a percent of the amounts applied
Study Numbers

- Applications were made August 2, October 4, December 6, February 2, April 3, and June 5
- 187 lawn irrigation events
- 34 rainfall events, totaling ~320 mm
  - 8 simulated events (~150 mm)
  - 26 natural events (~170 mm)
- A total of 1683 runoff samples were collected
  - 1182 samples were analyzed
Note: Different application practices occurred only on the driveway and garage door and adjacent walls.
Runoff Losses by Surface

<table>
<thead>
<tr>
<th>Surface</th>
<th>% of Total Losses</th>
<th>Historic Practices</th>
<th>Revised Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driveway</td>
<td>65</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Garage Door</td>
<td>35</td>
<td></td>
<td>54</td>
</tr>
<tr>
<td>Lawn</td>
<td>0.087</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>Grass Perimeter</td>
<td>0.11</td>
<td></td>
<td>5.0</td>
</tr>
<tr>
<td>House Wall</td>
<td>0.052</td>
<td></td>
<td>9.8</td>
</tr>
</tbody>
</table>

Note that the overall losses with the revised practices are about a factor of 40 lower than with the historic practices.
Average Losses (% of Applied)

Note: Different application practices occurred only on the driveway and garage door and adjacent walls.
Summary of Results

- Reductions due to changes in application procedures (combination of reduced amount applied and reduced losses as a percent of applied
  - Driveway: factor of 265
  - Garage:  factor of 25

- Most losses occurred from rainfall rather than lawn irrigation
Summary of Results

- Differences due to different products
  - Grass perimeter (same pyrethroid and application rate, different washoff potential on concrete)
    - No significant difference (Koc controls behavior)
  - Grass lawn (two different granules, different application rates)
    - Factor of 1.7 (% of applied) Koc differences?
  - House wall (different pyrethroids and application rates, different washoff potential on concrete)
    - Factor of 4.5 (% of applied)
Pathway ID Conclusions

- With the historic application practices, the highest losses are from the driveway and garage.

- The revised application practices consistently and significantly reduce residues from the driveway and the garage.
  - Overall losses were a factor of 40 lower
  - Now required for pyrethroid applications in the U.S.
Washoff Dynamics Study

- Objectives
  - Determine the effect of formulation under actual use conditions
    - Wall adjacent to garage door
    - Broadcast applications to driveway
  - Examine effect of drying time on washoff under actual use conditions (including sunlight and wind)
Washoff Dynamics Study

- **Study design**
  - Same site as pathway id study
    - Operation of site essentially the same
  - 5 pairs of products with contrasting washoff in the formulation washoff study
    - 1 pair applied to the wall adjacent to the garage door
    - 4 pairs applied as a broadcast application to locations on the driveway (two different timings of application relative to significant rainfall events)
# Results from Driveway Applications

<table>
<thead>
<tr>
<th>Pair</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to Rain</td>
<td>8</td>
<td>8</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Loss (% of Applied)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Washoff Product&lt;sup&gt;1&lt;/sup&gt;</td>
<td>1.22</td>
<td>0.79</td>
<td>0.15</td>
<td>0.96</td>
</tr>
<tr>
<td>Higher Washoff Product&lt;sup&gt;1&lt;/sup&gt;</td>
<td>1.25</td>
<td>2.69</td>
<td>0.27</td>
<td>4.60</td>
</tr>
<tr>
<td>Ratio (higher/lower&lt;sup&gt;1&lt;/sup&gt;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washoff Dynamics</td>
<td>1.02</td>
<td>3.39</td>
<td>1.82</td>
<td>4.78</td>
</tr>
<tr>
<td>Formulation Washoff</td>
<td>2.37</td>
<td>2.24</td>
<td>33.9</td>
<td>168</td>
</tr>
</tbody>
</table>

<sup>1</sup>Based on the formulation washoff study with concrete slabs
## Results from Wall Application

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss (% of applied over entire study)</td>
<td></td>
</tr>
<tr>
<td>Lower Washoff Product</td>
<td>0.54</td>
</tr>
<tr>
<td>Higher Washoff Product</td>
<td>0.22</td>
</tr>
<tr>
<td>Ratio (higher/lower)</td>
<td>0.41</td>
</tr>
<tr>
<td>Washoff Dynamics</td>
<td></td>
</tr>
<tr>
<td>Building Material Washoff (painted stucco)</td>
<td>5.9</td>
</tr>
<tr>
<td>Formulation Washoff (concrete)</td>
<td>85</td>
</tr>
</tbody>
</table>

1Based on the formulation washoff study with concrete slabs
Washoff Dynamics Conclusions

- Product formulations may affect washoff on impervious surfaces in residential settings
  - The size of the effect in the field appears to be less than observed in several laboratory studies
  - In some cases the **direction** of the effect is also different in laboratory experiments than under field conditions
Overall Conclusions

- Broadcast applications to impervious surfaces with a direct pathway to street drains have the greatest potential to generate runoff that may reach urban streams
  - Applications to concrete driveways sloping to the street are especially vulnerable
- Switching from broadcast applications to spot (crack and crevice) applications can greatly reduce overall washoff losses
  - A 40 fold reduction was observed in our experiments
Overall Conclusions

- Washoff from impervious surfaces does not seem to be correlated with Koc
  - Influencing factors include surface properties such as surface roughness and porosity, formulation effects, and time between application and rainfall (work of other researchers)

- Formulation effects on washoff potential are complicated
  - Affect pest control, VOC emissions
  - Lab studies are not necessarily predictive of behavior under actual use conditions