Ecological Risk Characterization for the Pyrethroid Insecticides

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Regulatory History of Synthetic Pyrethroids

- Synthetic pyrethroids (SPs) are a class of compounds that have been used to control insects for over 35 years
- Used as insecticides in either agricultural or urban environments
  - approximately 22 SPs including enriched isomers
- Seven SPs were conditionally registered in 1984 on cotton as substitute for organophosphate and carbamate pesticides.
  - bifenthrin, cyfluthrin, cypermethrin, esfenvalerate, lambda-cyhalothrin, permethrin and tralomethrin
Regulatory History of Synthetic Pyrethroids

- They were classified as restricted use pesticides due to high toxicity to fish and other aquatic organisms.
- In 1985 EPA issued Data Call-in Notices (DCIs) for chemical specific aquatic toxicological data to maintain existing registrations and support new registrations of SPs on cotton.
- Due to similar aquatic toxicity, EPA decided to treat all SPs registered on cotton as a class.
- More uses and SPs were added later:
  - zeta-cypermethrin, deltamethrin, fenpropathrin, gamma-cyhalothrin.
Regulatory History of Synthetic Pyrethroids

- Pyrethroid Working Group (PWG) formed in 1990 to address the data needs
  - composed of major manufacturers of pyrethroids plus National Cotton Council
- Manufacturers of SPs were initially requested to submit an interim risk reduction proposal to mitigate aquatic risk
  - labeling changes to reduce exposure including buffer zones
  - educational program to reach growers, applicators and consultants regarding label changes
  - field studies to monitor the effectiveness of buffer zones
EPA presented the preliminary assessment to FIFRA Scientific Advisory Panel (SAP) in May 1999
- sediment toxicity and fate of SPs

PWG currently developing additional data to address the conditions of registration

EPA reviewing fate and toxicity data submitted by PWG
EPA is required under FIFRA to assess all new uses.

Since the conditional registration of SPs on cotton, more than 50 new agricultural and domestic uses have been submitted to registration.

EPA has completed the re-evaluation of existing chemicals (food use only) in August 2006 that was mandated by congress.
Evaluation of New and Existing Uses of Pyrethroids - 2

- EPA completed REDs for the following chemicals: cypermethrin, permethrin and resmethrin
- EPA completed ecological risk assessments for new uses for the following chemicals: bifenthrin, cyfluthrin, cyhalothrin, cypermethrin, zeta-cypermethrin, prallethrin
Use Characterization: Agricultural Uses

- Pesticide label information is critical for estimating the exposure in the environment:
  - date of application
  - maximum application rate
  - number of applications per season
  - minimum retreatment interval

- Highest agricultural uses are typically reported on cotton, corn, soybean, and alfalfa
Use Characterization
Non-agricultural (Urban) Uses

- Mosquito control (permethrin, resmethrin, prallethrin)
- Pre-treated clothing (permethrin)
- Pharmaceutical and pet products (permethrin)
- Residential cracks and crevices (cypermethrin, bifenthrin)
- Residential lawn and ornamentals (permethrin, cypermethrin)
- Residential (outdoor) perimeter pest control (cypermethrin)
- Residential (outdoor) misting system (permethrin)
- Indoor food and non-food (e.g. feed handling establishments)
Exposure Characterization
Fate and Transport

- Physical Chemical Properties
  - moderate to low vapor pressure
  - low solubility in water (exception is prallethrin)

- Persistence
  - majority are stable pH 5 and 7 but undergo some degree of hydrolysis at pH 9
  - stable to aqueous photolysis (few exceptions)
  - biotic degradation varies widely depending on the chemical
Persistence in Abiotic Systems

Half-life (days)

-50  0  50  100  150  200  250  300

Chemicals Above line are Stable

Acid Hydrolysis  Neutral Hydrolysis  Alkaline Hydrolysis  Aqueous Phtolysis  Soil Photolysis

△ Pralle  ○ Perm  ■ Bifent  ◆ Cyflu  × Cyperm  □ Deltam  ◇ Fenpropa  ● Fenval  △ Cyhalo  ○ Teflu  ◆ Tralom  ○ Resm
Persistence in Biotic Systems

![Persistence in Biotic Systems](image.png)
Exposure Characterization
Fate and Transport

● Mobility
  - preferentially bind to soil and sediments

● Bioaccumulation
  - moderate bioaccumulation in fish
  - rapid depuration with few exceptions

● Exposure to surface water
  - reach surface water via erosion and drift
  - quickly partition into sediment
Exposure Characterization
Concentrations in surface water/sediment

- Linked EPA PRZM/EXAMS model
- Estimated Exposure Estimates (EECs) in water column
  - 1 in 10 year peak EEC for acute exposure
  - 1 in 10 year 21 or 60 day values for chronic exposure
- Estimated Exposure Estimates (EECs) in sediment
  - acute/chronic exposure from pore water
  - acute/chronic exposure from whole sediment
Exposure Characterization
Concentrations in surface water

- Use of different crop scenarios to evaluate major routes of exposure
  - Runoff vs. Erosion vs Spray Drift
- Most scenarios show major drift contribution
  - ND corn and CA lettuce for permethrin and cypermethrin
- Few scenarios show major contribution from erosion
  - MN potatoes and NC cotton for permethrin and cypermethrin
- Minimal contribution from runoff
Exposure Characterization
Concentrations in Surface Water

- Use of buffer zones to evaluate exposure from drift (permethrin, cypermethrin)
  - modeled EECs using maximum and typical application rates
  - buffer zones of zero, 100 ft, 150 ft, and 200 ft
  - ND corn scenario was evaluated for permethrin
  - NC cotton scenario was evaluated for cypermethrin

- For permethrin, increase in buffer zones showed a gradual decrease in exposure

- For cypermethrin, the buffer zones did not result in a significant decrease in exposure. This is because the NC cotton is a low drift scenario

- More scenarios need to be evaluated
Effects Characterization

- Acute and chronic toxicity to fish and invertebrates in the fresh water environment
- Acute and chronic toxicity to fish and invertebrates in the estuarine/marine environment
- Acute and chronic toxicity to sediment dwelling organisms (sediment and pore water) in freshwater and estuarine/marine environments
Effects Characterization
Acute Toxicity

- Teflu
- Deltam
- Bifent
- Esfenv
- Resm
- Cyperm
- Cyhalo
- Perm
- Cyflu
- Tralom
- Fenpropa

Acute Toxicity - LC50 in ppb

FISH INVERTS
FRESH WATER ESTUARINE/MARINE
Effects Characterization
Chronic Toxicity

Out of Scale: 0.0000075 & 0.0002
Risk Characterization
Risk Estimation - Agricultural Uses

- Calculation of Risk Quotient (RQ)
- \[ RQ = \frac{EEC}{TRV} \]
  - \( EEC = \text{Estimated Environmental Concentrations (ppb)} \)
  - \( TRV = \text{Toxicity Reference Value (ppb)} \)
- Aquatic RQs (acute and chronic) are calculated for fish and invertebrates in freshwater and estuarine/marine environment
  - exposure estimates from PRZM/EXAMS, AgDRIFT
  - monitoring data
  - aquatic toxicity studies (acute & chronic)
Risk Characterization
Acute RQs

- Esfenv
- Cyflu
- Perm
- Cyperm
- Bifent
- Cyhalo
- Resm
- Z-Cyperm
- Paralle

Risk Quotient (RQ)

- Acute Risk (0.5)
- Restricted Use (0.1)
- Listed Species (0.05)

Species and Environments:
- FISH
- FRESH WATER
- INVERTS
- ESTUARINE/MARINE
Risk Characterization

Chronic RQs
Risk Characterization
Risk Estimation - Agricultural Uses

- Sediment RQs for benthic organisms
  - equilibrium partitioning method to estimate toxicity
  - sediment toxicity tests
  - PRZM/EXAMS generated EECs for pore water and whole sediment

- Sediment toxicity studies that have been reviewed
  - 10-day test on *Chironomus tentans* (acute freshwater)
  - 65-day test on *Chironomus tentans* (chronic freshwater)
  - 28-day test on *Leptocheirus plumulosus* (chronic estuarine/marine)
Major Risk Assessment Challenges

Urban/Residential Aquatic Risks

- **Main Concerns:**
  - Exposure from adulticide uses
  - Drift, runoff to storm water
  - Releases to POTWs from indoor uses

- **Challenges:**
  - Quantifying residential pesticide use patterns
  - Constructing meaningful residential exposure
    * application timing, method, frequency
    * uncertainty in housing density, impervious surface
    * refinement of exposure to POTWs (bench scale treatability study, POTW monitoring)
Assessed adulticide use for permethrin, resmethrin, d-phenothrin (Sumithrin®) and prallethrin

Adulticides are more efficacious when in contact with insects in flight. Applied as fog over water bodies

Developed a new modeling approach using spray drift model, AGDISP and surface water model PRZM/EXAMS
  - AGDISP provides the level of deposition and drift
  - these estimates are used in PRZM/EXAMS to estimate EECs
  - various depths representing shallow water, marshes and ponds

Acute and chronic LOCs exceed for freshwater fish and invertebrates and for estuarine/marine invertebrates (permethrin, resmethrin)

Since then, the modeling approach has been refined, using the spray drift fraction and the “Deposition Tool” from AGDISP
Non-Agricultural (Urban) Uses Exposure and Risk from Indoor Uses - 1

- Exposure estimates from pre-treated clothing, pharmaceutical and pet products which may be released to Publicly Owned Treatment Works (POTWs)
- Used “Down the Drain” module of the Exposure and Fate Assessment Screening Tool (E-Fast)
  - screening model does not include degradation and partitioning
  - includes dilution in pipe and receiving water
  - EECs based on three levels of removal (52, 75, & 94 %) using activated carbon in treatment plants
Major exposure to POTWs was from pre-treated clothing and pet products

Acute RQs for freshwater and estuarine/marine fish exceeded one or more LOCs (permethrin)

Chronic RQs for freshwater and estuarine/marine invertebrates exceeded one or more LOCs (permethrin)
Current and Future Initiatives

- Assessment of SPs on cotton as a class of compounds for full registration
  - address SAP comments
  - integrate exposure and toxicity data developed by PWG
  - use bifenthrin, cyfluthrin, cypermethrin and esfenvalerate as representatives
Current and Future Initiatives

- Re-evaluation of SPs in Registration Review, scheduled in next few years
- Coordination with stakeholders on:
  - implementation of RED decisions
  - review of pyrethroid as a group
  - data needs
- Assessment of ecological impact from outdoor urban uses
  - existing urban models- to estimate exposure
  - monitoring data useful
Current and Future Initiatives

- Assessment of SPs on cotton as a class of compounds for full registration
  - address SAP comments
  - integrate exposure and toxicity data developed by PWG
  - bifenthrin, cyfluthrin, cypermethrin and esfenvalerate were initially selected as representative chemicals for sediment toxicity tests, but full data sets are being required for all pyrethroids in Registration Review

- Re-evaluation of SPs in Registration Review for process started and risk assessments scheduled in next few years
## Current and Future Initiatives

### Rough Schedule

<table>
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<th>Year Docket Opens</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
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<td>PBO</td>
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<td>Zeta-Cypermethrin</td>
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Current and Future Initiatives

- Coordinate with other stakeholders on:
  - implementation of RED decisions
  - review of pyrethroids as a group
  - review of data being generated for CDPR and incorporate in Agency’s risk assessments, including:
    - sediment toxicity studies
    - POTW monitoring
    - sediment persistence (aerobic/anaerobic)
    - Pathway ID Study in urban environments to identify which pathways are contributing most to off site movement
    - Washoff studies (pervious and impervious surfaces) from PWG and from the open literature
Current and Future Initiatives

- Assess ecological impact from outdoor urban uses
  - currently using an impervious scenario for litigation assessments in CA, to estimate exposure in urban use sites, scenario may need further improvements

- Evaluate monitoring data on pyrethroids in water, sediments, and POTW effluents

- Effect of new labeling initiative for pyrethroids in non-agricultural outdoors environments
  - Applications to impervious surfaces were restricted
  - [http://www.epa.gov/oppsrrd1/reevaluation/pyrethroids-pyrethrins.html#eco](http://www.epa.gov/oppsrrd1/reevaluation/pyrethroids-pyrethrins.html#eco)
Current and Future Initiatives

- Evaluate effects of synergists interactions with pyrethroids
  - existing urban models satisfactory to estimate exposure, but seeking refinements at this time
  - ample monitoring data is available and useful

- Review POTW treatability study PWG generated
  - verify whether it can be used to extrapolate to a variety of POTW designs
  - incorporate results in the upcoming reg review risk assessments