Endosulfan

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EHS 201
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Endosulfan

- Background Information
- Fate in the Environment
- Environmental Toxicity
- Human Toxicity
What is Endosulfan?

- Endosulfan is a chlorinated pesticide used on crops like:
  - Coffee
  - Fruits
  - Cereals/Grains
  - Vegetables
  - Cotton
Chemical Properties of Technical Grade Endosulfan

- Color: yellow or brown
- MP: 70-80°C
- Water Solubility: .32mg/L

Endosulfan I (C₉H₆Cl₆O₃S)
Overview of Use

- Endosulfan was first registered as a pesticide in the USA in 1954.
- 94 endosulfan products are currently registered.
- 1.38 million lbs or endosulfan are estimated to be used annually in the USA.
- Considered Priority Pollutant by the EPA
Overview of Use

- Endosulfan is a broad spectrum contact insecticide that controls sucking, chewing, and boring insects.
- Other pesticides can be used with endosulfan.
  - It can be used with other pesticides and may be made in formulations with malathion, parathion, oxine-copper among others.
Fate in the Environment

- Chemical Reactions and Reaction Products
- Transport in the Environment
Important Forms of Endosulfan

- **Parent Isomers:**
  - Endosulfan I(α) and Endosulfan II(β)

- **Degradation Products:**
  - Endosulfan Sulfate
  - Endosulfan Diol
Endosulfan I

- Toxic: 3 times more toxic than endosulfan II or endosulfan sulfate.
- Least persistent form

Endosulfan II

- Toxic
- Slightly more persistent than endosulfan I
Endosulfan Sulfate  
- Toxic  
- Main product in aerobic soils  
- Formed by biological oxidation  
- Much more persistent in the environment than either of its parents isomers

Endosulfan Diol  
- Non-Toxic  
- Main product in anaerobic flooded soils  
- Formed by chemical or biological hydrolysis
Environmental Transport

Major Routes Off Field For Endosulfan

- Volatilization
- Spray Drift
- Runoff
- Degradation
Importance of Routes

- **Spray Drift/Volatilization:**
  - These pathways will contribute to chronic low levels of endosulfan in waterways during the growing season.

- **Runoff:**
  - Most endosulfan in runoff is sorbed to sediment.
  - This pathway will cause temporarily high, potentially acutely toxic levels of endosulfan in waterways after rain events.
Degradation

- After application onto a cotton field, endosulfan sulfate soon becomes the main form present.
- Endosulfan sulfate comprises 60-70% of total endosulfan residues in soil.
- Rate of degradation is dependent on environmental conditions.

Change in constituents of total endosulfan in cotton leaves over time.
Environmental Toxicity

- Toxic Effects
- Routes of Toxicity
- Regulations/Mitigation
Toxic Effects

- Relatively non-toxic to beneficial insects like parasitic wasps, lady bug beetles, and some mites and only moderately toxic to bees.
- Reproductive and developmental effects have been observed in non-target organisms.
- The primary concern for all three toxic forms is on the local scale.
Toxic Effects

- Aquatic fauna are particularly sensitive to endosulfan.
  - Fish are particularly sensitive, some experiencing acute toxicity at 0.3 μg/L.
  - Zooplankton show inhibited growth and reproduction in the presence of endosulfan.
  - Such impacts could potentially have far reaching effects in the ecosystem.
Route of Toxicity

- Adsorption through the water column is the main route to toxicity.
Bioaccumulation

- Unlike other chlorinated pesticides, bioaccumulation is not an issue with endosulfan.
- Endosulfan has a low $K_{ow}$ and can be readily excreted from the body.
- Fish tissue concentrations will reach a plateau that is dependent on water concentration. Once removed from contaminated waters, tissue concentrations quickly dissipate.
Regulations

- **EPA 1991**: Labels need to incorporate 300ft spray drift between treated areas and water bodies

- **Priority Pollutant under the Clean Water Act.**
  - CMC = 0.22μg/L
  - CCC = 0.056μg/L
Mitigation

- Differences in watershed characteristics and the intensity of pesticide use are the best indicators for amount of pesticide found in rivers, not amount of land under agricultural use.

- Important Factors
  - Slope
  - Size and Character of Buffer
  - Time since application
  - Type of Crop
  - Canopy Cover
  - Soil Type
  - Chemical Nature of the Pesticide
Mitigation

- **Ponding**
  - Capturing runoff in ponds before it is released into waterways gives endosulfan more time to degrade

- **Barriers**
  - Tall barriers can be used to minimized spray drift
  - Dense barriers can be used to minimize runoff
Human Toxicity

- Health Effects/Toxicology
- Exposure through Food and Drinking Water
- Occupational Risk
Health Effects

- Endosulfan is a Class I Pesticide

**Acute**
- Seizures
- Death
- More . . .

**Chronic**
- Not much is known
- Liver Damage
- Reduced weight gain
- Possible teratagen
# Acute Health Effects

<table>
<thead>
<tr>
<th>Category</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular</td>
<td>Arrhythmias</td>
</tr>
<tr>
<td>Neurological</td>
<td>Convulsions, Confusion, Loss of Coordination</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>Nausea, Vomiting, Diarrhea</td>
</tr>
<tr>
<td>Renal</td>
<td>Damage</td>
</tr>
<tr>
<td>Dermatological</td>
<td>Irritation</td>
</tr>
<tr>
<td>Eye</td>
<td>Redness, Pain</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>Fetal Death</td>
</tr>
</tbody>
</table>

Instructor Dr. Eckhert EHS201 UCLA 2005
Toxicology of Endosulfan

- Neurotoxin

- Alters electrophysiological and associated enzymatic properties of nerve cell membranes. (changes kinetics of Na$^+$ and K$^+$ ion flow through membrane)

- Antagonizes action of neurotransmitter gamma-aminobutyric acid (GABA). (causes uncontrolled excitation of neuron)
### Lethal Dose

<table>
<thead>
<tr>
<th>Mode</th>
<th>LD&lt;sub&gt;50&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral</td>
<td>30 – 82mg/kg</td>
</tr>
<tr>
<td>Inhalation</td>
<td>0.16 – 0.5mg/L</td>
</tr>
<tr>
<td>Dermal</td>
<td>2g/kg</td>
</tr>
</tbody>
</table>
## Exposure Limits

<table>
<thead>
<tr>
<th>Route of Exposure</th>
<th>Duration of Exposure</th>
<th>NOEL mg/kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dermal</td>
<td>1 day to several months</td>
<td>12</td>
</tr>
<tr>
<td>Inhalation</td>
<td>1 day to several months</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Metabolism and Elimination

- Most metabolites are yet to be determined.
- Endosulfan I and II, endosulfan sulfate, and endosulfan diol are eliminated via feces.
- Only endosulfan diol is eliminated via urine.
Metabolism and Elimination

- Elimination Half Life (Biphasic)
  - 6-14 hrs
  - 33-68 hrs
- Elimination is essentially complete in 1-2 days.
Dietary Exposure

- **Chronic**
  - Risk below EPA level of concern.
  - NOEL: 0.6mg/kg/day
  - LOEL: 2.9mg/kg/day

- **Acute**
  - Risk below EPA level of concern for adults.
  - Small risk for children 1-6 years
    - Mostly associated with succulent beans and peas.
  - NOEL: 1.5mg/kg/day
  - LOEL: 3mg/kg/day
Drinking Water Exposure

- Limited water monitoring data was available, so models were used to estimate risk. Assessment is considered to be unrefined.

- Estimated endosulfan levels in water
  - Ground Water
    - Low levels in areas where soil is acidic to neutral, highly permeable and the GW is shallow
  - Surface Waters
    - Acute: 4.49 – 23.86 μg/L
    - Chronic: 0.53 – 1.5 μg/L
Drinking Water Exposure

- Drinking water levels are below the level of concern for the EPA.
  - Could increase risk associated with dietary exposure in children 1-6.

- EPA

Criteria Concentration = 75μg/L
Occupational Risk

- Routes of Exposure
  - Mixing
  - Loading
  - Applying
    - Endosulfan is applied by handheld devices, tractors, and airplanes
  - Post-Application
Factors that Effect Occupational Risk

- Types of engineering controls used.
  - Closed Cab Tractors
  - Closed Mixing and Loading Systems
- Personal Protective Equipment worn.
  - Gloves
  - Coveralls Over Cloths
  - Respirators
  - Chemical Safe footwear
  - Headgear
Factors that Effect Occupational Risk

- **Time Since Application**
  - Most formulations list Restricted Entry Interval (REI) of 24 hours.

- **Form of Pesticide Used**
  - Wettable powders are generally have a greater post application risk than emulsifiable concentrate

- **Crop type will effect the time before it is safe to work in the fields.**

- **Some crop/formulation combinations make the field unsafe for work for up to 30 days.**
Factors that Effect Occupational Risk

- Duration of Exposure and Amount of Pesticide Handled
- Individual Characteristics
  - Individuals and species with high protein diets tend to be less sensitive to endosulfan exposure.
  - Individuals with higher body weight are at less risk
Regulations

- EPA 2000: Label removed for all residential uses
- Number of possible applications per season limited (1-5)
- OSHA
  - PEL 0.1mg/m³
- ACGIH
  - TLV 0.1mg/m³
- NIOSH
  - REL 0.1mg/m³
Replacement Products

- No plans to phase out endosulfan are in place, but there are other options:
  - Other pesticides
  - Organic Farming
  - Integrated pest management
Summary

- **Background:**
  - Endosulfan in a highly toxic broad spectrum insecticide, commonly used in the USA.

- **Fate in the Environment**
  - Endosulfan travels from the field to water bodies primarily via volatilization and runoff.

- **Environmental Toxicity**
  - Bioaccumulation is not a major factor in toxicity to non-target organisms.
  - Aquatic species are generally most vulnerable to endosulfan toxicity.
  - Mitigation through ponding and creating barriers.
Summary

- **Human Toxicity**
  - Endosulfan is a neurotoxin that is mainly a concern at acute doses.
  - Ingestion through drinking water and food is not considered a major risk.
  - Those most at risk are agricultural workers, but risk can be reduced through the use of personal protective equipment and engineering controls.
References

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