Endosulfan

Jane Curren

EHS 201

Fall 2005

Instructor Dr. Eckhert EHS201 UCLA 2005

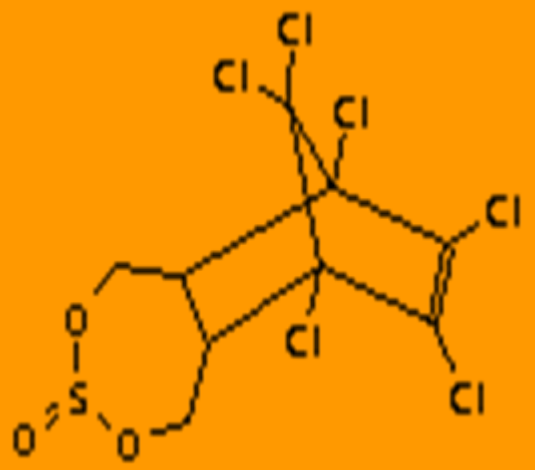
Endosulfan

- 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



Endosulfan I ($C_9H_6Cl_6O_3S$)

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

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

Instructor Dr. Eckhert EHS201 UCLA 2005

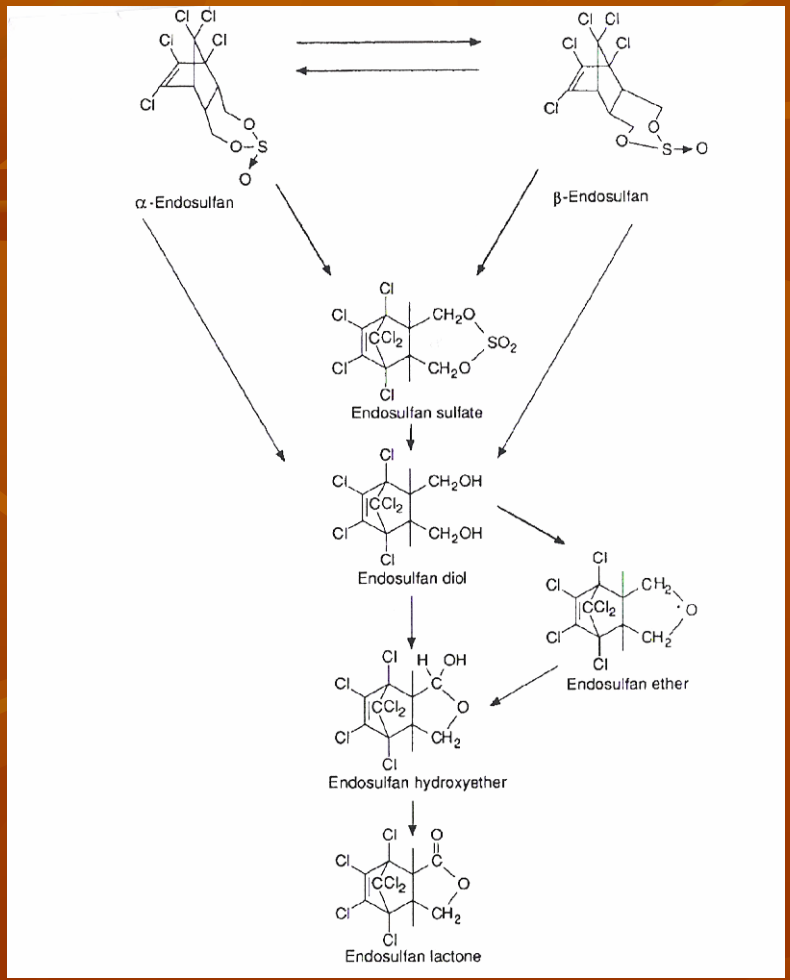
Overview of Use

- 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 and Endosulfan Diol

Endosulfan I

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

Endosulfan II

- Toxic
- Slightly more persistent that endosulfan I

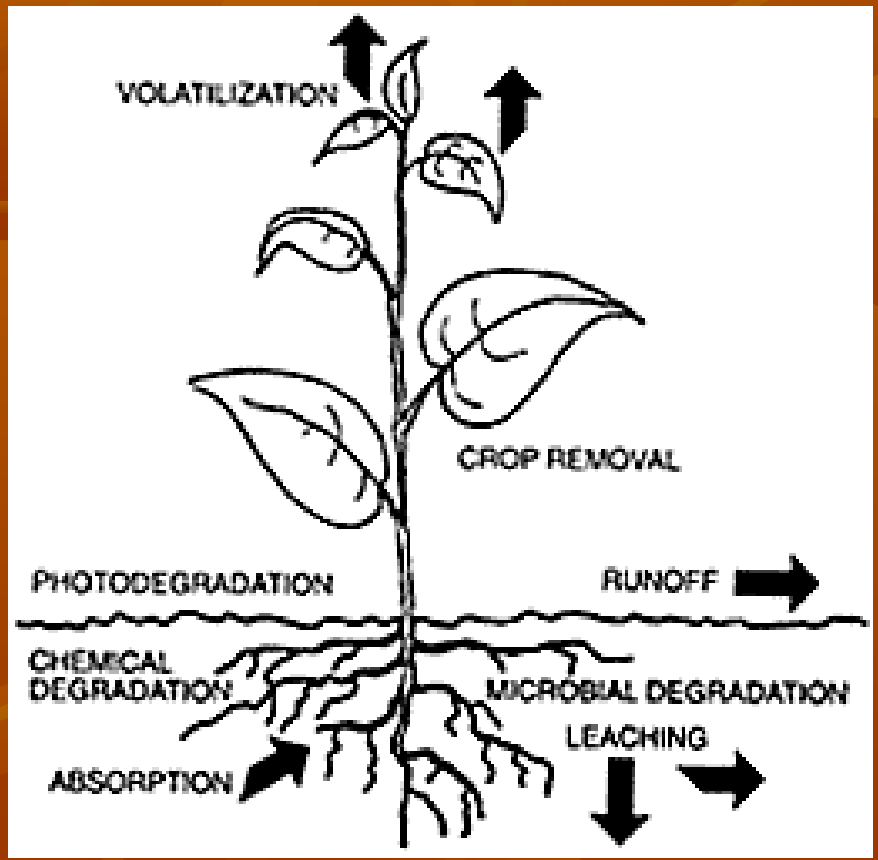
Endosulfan Sulfate

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

Endosulfan Diol

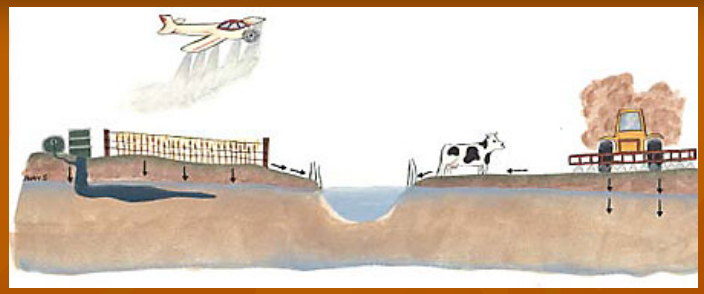
- Non-Toxic
- Main product in anaerobic flooded soils
- Formed by chemical or biological hydrolysis

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

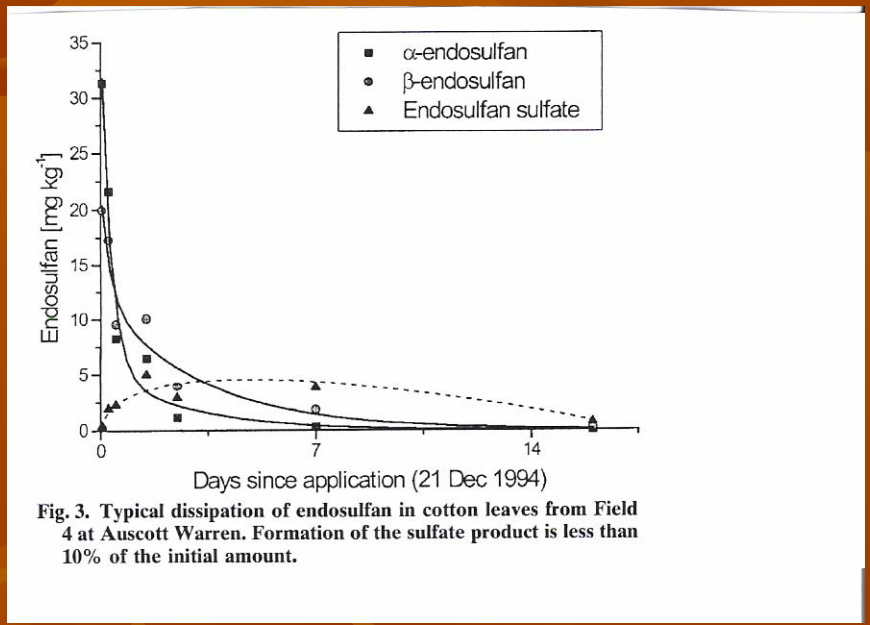


Fig. 3. Typical dissipation of endosulfan in cotton leaves from Field 4 at Auscott Warren. Formation of the sulfate product is less than 10% of the initial amount.

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

- 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.

Environmental Toxicity

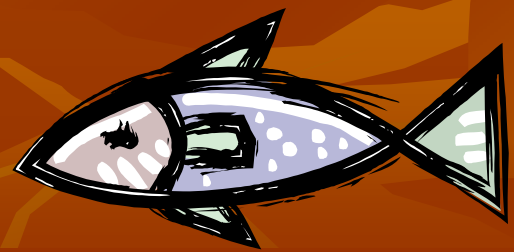
- Toxic Effects
- Routes of Toxicity
- Regulations/Mitigation

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.

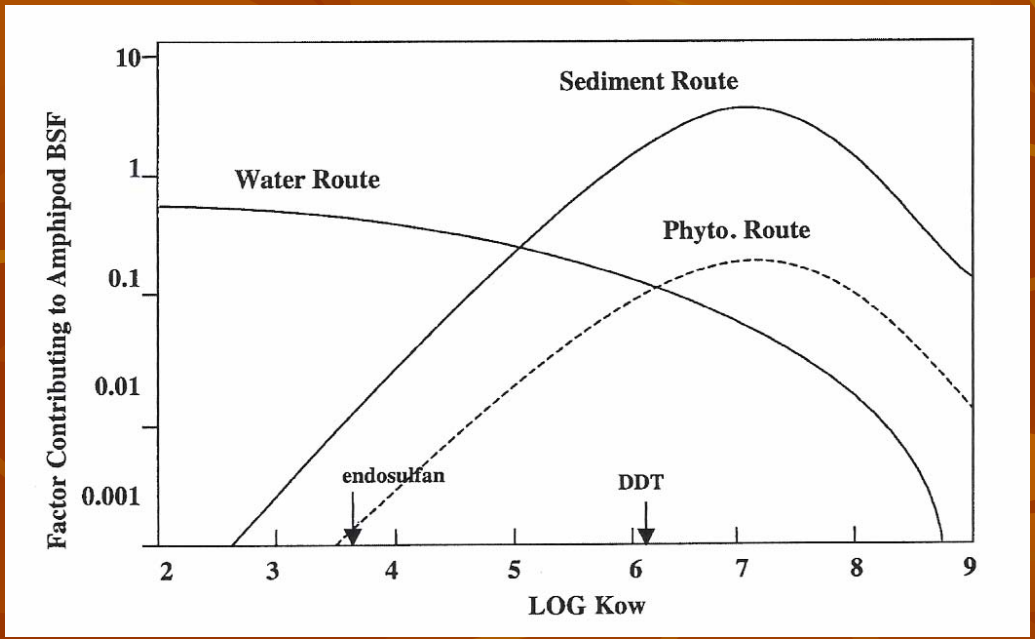
Toxic Effects

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



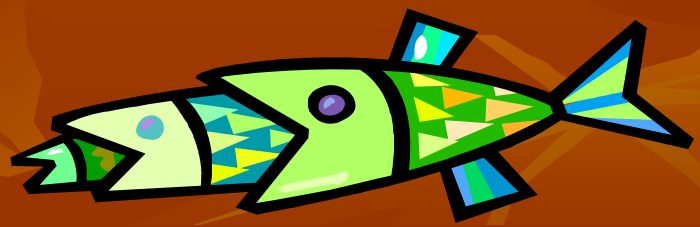
Route of Toxicity

- 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

Instructor Dr. Eckhert EHS201 UCLA 2005

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

Cardiovascular	Arrhythmias
Neurological	Convulsions, Confusion, Loss of Coordination
Gastrointestinal	Nausea, Vomiting, Diarrhea
Renal	Damage
Dermatological	Irritation
Eye	Redness, Pain
Pregnancy	Fetal Death

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)

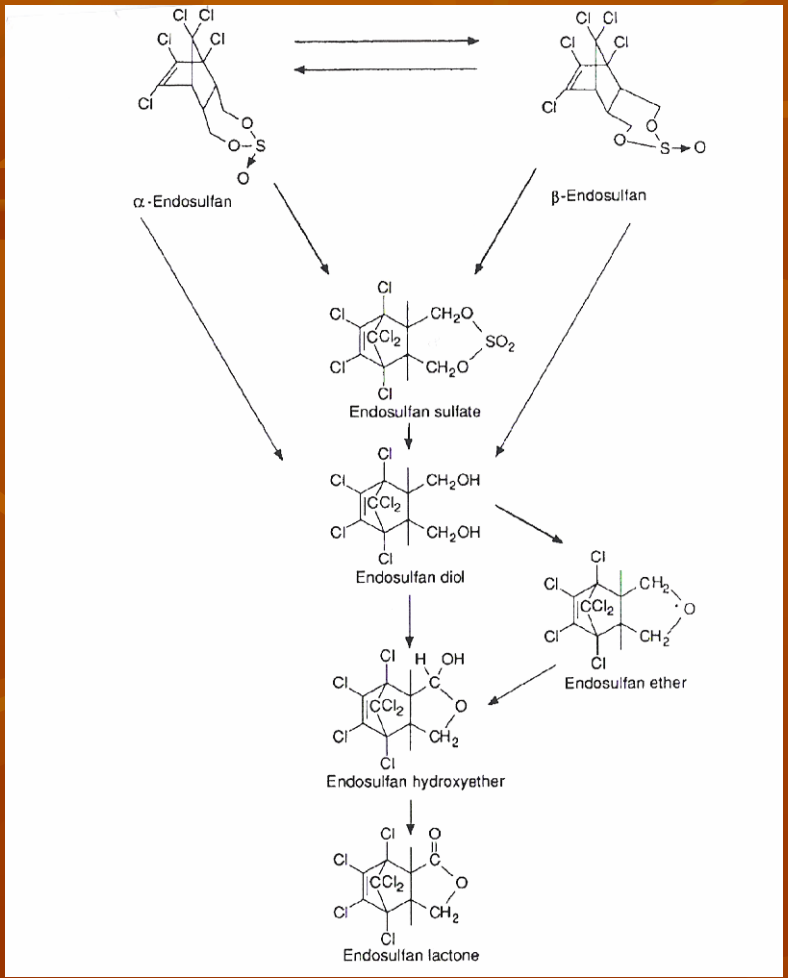
Lethal Dose

Oral	LD_{50} = 30 – 82mg/kg
Inhalation	LC_{50} = 0.16 – 0.5mg/L
Dermal	LD_{50} = 2g/kg

Exposure Limits

Route of Exposure	Duration of Exposure	NOEL mg/kg/day
Dermal	1 day to several months	12
Inhalation	1 day to several months	0.2

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 were 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

Instructor Dr. Eckhert EHS201 UCLA 2005

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/m^3
- ACGIH
  - TLV 0.1mg/m^3
- NIOSH
  - REL 0.1mg/m^3

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

http://www.epa.gov/oppsrrd1/REDs/endosulfan_red.pdf

http://www.epa.gov/ost/pc/ambienttwqc/endosulfan80.pdf

http://www.inchem.org/documents/pims/chemical/pim576.htm

http://www.osha.gov

http://extoxnet.orst.edu/pips/endosulf.htm

Peterson, S. M. and G. E. Batley. 1993. The Fate of Endosulfan in Aquatic Ecosystems. Environmental Pollution 82: 143-152.

Kennedy, I. R., F. Sanchez-Bayo, S. W. Kimber, L. Hugo, and N. Ahmad. 2001. Off-Site Movement of Endosulfan from Irrigated Cotton in New South Wales. Journal of Environmental Quality 30: 683-696.

DeLorenzo, M. E., L. A. Taylor, S. A. Lund, P. L. Pennington, E. D. Strozier, and M. H. Fulton. 2002. Toxicity and Bioconcentration of the Agricultural Pesticide Endosulfan in Phytoplankton and Zooplankton. Archives of Environmental Contamination and Toxicology 42: 173-181.

Naqvi, Syed M. and Chetana Vaishnavi. 1993. Bioaccumulation Potential and Toxicity Of Endosulfan Insecticide to Non-Target Animals. Comp. of Biochemical Physiology 105C(3): 347-361.