Pesticide Fate in The Environment

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Soil and Crop Sciences

Overview
- Pesticide properties
- Site interactions
- Pesticides in Colorado ground and surface water
- Application considerations

What are the Pesticide Characteristics Influencing Movement and Degradation?
- **Volutility** – moving with air
- **Solubility** – moving with water
- **Adsorptivity** – attached to soil
- **Persistence and degradation** (half-life)

Volatilization vs. Drift?
- Change of state vs. physical movement
- Potential depends upon chemical properties and conditions
### Volatility of Common Pesticides

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Common Name</th>
<th>Vapor Pressure (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aatrex</td>
<td>atrazine</td>
<td>$2.89 \times 10^{-7}$</td>
</tr>
<tr>
<td>Banvel</td>
<td>dicamba</td>
<td>0</td>
</tr>
<tr>
<td>Tordon</td>
<td>picloram</td>
<td>$6.2 \times 10^{-7}$</td>
</tr>
<tr>
<td>Roundup</td>
<td>glyphosate</td>
<td>0</td>
</tr>
<tr>
<td>Weedone</td>
<td>2,4-D Acid</td>
<td>0.2</td>
</tr>
<tr>
<td>Weedar</td>
<td>2,4-D Amine</td>
<td>$7.5 \times 10^{-7}$</td>
</tr>
</tbody>
</table>

### Pesticides in Soil System

**Soil Adsorption of Common Pesticides**

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Common Name</th>
<th>Sorption index ($K_{oc}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aatrex</td>
<td>atrazine</td>
<td>100</td>
</tr>
<tr>
<td>Banvel</td>
<td>dicamba</td>
<td>2</td>
</tr>
<tr>
<td>Tordon</td>
<td>picloram</td>
<td>16</td>
</tr>
<tr>
<td>Roundup</td>
<td>glyphosate</td>
<td>24,000</td>
</tr>
<tr>
<td>Weedone</td>
<td>2,4-D Acid</td>
<td>100</td>
</tr>
<tr>
<td>Comite</td>
<td>Propargite</td>
<td>4,000</td>
</tr>
</tbody>
</table>

### Degradation Pathways

- Hydrolysis
- Photodegradation
- Microbial degradation
- Chemical degradation

Modifiers that affect degradation:
- Temperature
- pH
- Moisture

New molecule formation: bacteria and fungi degradation.
Persistence – Half Life

Persistence (Half – Life)

Soil Moisture and Half-life

Persistence of Common Pesticides

Pesticide Environmental Fate Properties and Ratings

http://www.ext.colostate.edu/PUBS/CROPS/xcm177.pdf
Pesticides with Groundwater Advisories

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weed B Gone</td>
<td>2,4-D, salt</td>
</tr>
<tr>
<td>Lasso</td>
<td>Alachlor</td>
</tr>
<tr>
<td>Temik</td>
<td>Aldicarb</td>
</tr>
<tr>
<td>Aatrex</td>
<td>Atrazine</td>
</tr>
<tr>
<td>Abound</td>
<td>Azoxystrobin</td>
</tr>
<tr>
<td>Hyvar</td>
<td>Bromacil</td>
</tr>
<tr>
<td>Furadan</td>
<td>Carbofuran</td>
</tr>
<tr>
<td>Dechal</td>
<td>DCPA</td>
</tr>
<tr>
<td>Casoron</td>
<td>Dichlofluanid</td>
</tr>
<tr>
<td>Imidacloprid 4F</td>
<td>Imidacloprid</td>
</tr>
<tr>
<td>Balance</td>
<td>Isoxaflutole</td>
</tr>
<tr>
<td>Plateau</td>
<td>MCPP, DMA salt</td>
</tr>
<tr>
<td>Dual</td>
<td>Methylchlor</td>
</tr>
<tr>
<td>Sensor</td>
<td>Metribuzin</td>
</tr>
<tr>
<td>Soltica</td>
<td>Norfloxan</td>
</tr>
<tr>
<td>Vantage</td>
<td>Dysonyl</td>
</tr>
<tr>
<td>Tordon</td>
<td>Picroxan</td>
</tr>
<tr>
<td>Princep</td>
<td>Simazine</td>
</tr>
<tr>
<td>Confirm ZF</td>
<td>Tolueneoxide</td>
</tr>
<tr>
<td>Sirin</td>
<td>Terbacil</td>
</tr>
<tr>
<td>Platinum</td>
<td>Thiamethoxam</td>
</tr>
<tr>
<td>Bayleton 50</td>
<td>Triadimefon</td>
</tr>
</tbody>
</table>

Where Do You Find The Ground or Surface Water Advisory?

Environmental Hazards:
Do not apply directly to waters, to areas where surface water is present, or to interstitial areas below the mean high water mark. Do not contaminate water when applying to adjacent surface water or ditches.

Ground Water Advisory:
The active ingredient in [product name] has the potential to leach through soil into groundwater under certain conditions as a result of agricultural use. Use of the chemical in areas where soils are permeable, particularly where the water table is shallow, may result in ground water contamination.

Surface Water Advisory:
The active ingredient in [product name] has the potential to contaminate surface water through ground application of [application method]. Under certain conditions, the active ingredient may also have a high potential for run off. Aquatic plants and other plant growth may be adversely affected. Dimethoate has also been reported to have a high potential for mosquito larval control when used as a larvicide. Care should be taken to prevent drift onto aquatic areas by maintaining proper application rates and directions. Groundwater and surface water quality monitoring should be performed to determine effects of [product name] application.

Web information:  
http://www.cdms.net/manuf/manuf.asp  
http://extoxnet.orst.edu

Site Characteristics?

Leaching
✓ Overlying soil type
  - Permeability
  - Organic matter
✓ Depth to water table
✓ Geology
✓ Recharge rate (precipitation and irrigation)

Runoff
✓ Soil type
✓ Slope
✓ Soil conditions
✓ Irrigation
✓ Vegetation characteristics
✓ Other ground cover

Leaching Potential Factors

Soil characteristics | Numeric guidelines*
---|---
sandy soil | low organic matter | less than 1% OM
microscopic macropores

Pesticide properties
long half-life | greater than 21 days
low adsorption | KOC less than 300-500
high solubility | greater than 30 ppm
Groundwater Monitoring

- Ag Chemicals and Groundwater Protection Program
- 3,359 samples from 1281 wells
- Since 1992
- Analyze:
  - Nitrate
  - Other inorganic
  - ~100 pesticide ai's

Depth to Groundwater

- Time
  - Opportunity for adsorption and degradation
  - Dilution

http://coloradogeologicalsurvey.org

Potential for Recharge

http://coloradogeologicalsurvey.org/water/groundwater-atlas/

Geologic Conditions

- Well-sorted sedimentary material (Mesa Verde, Colorado)
- Poorly sorted sedimentary material (Glenwood Springs, Colorado)
- Hydraulic conductivity
- Slope

Permeability

- Texture
- Sand, silt, clay
- Slope
- Structure

Ground Water Sensitivity to Pesticide Contamination in Colorado

- Aquifer present
- Depth to groundwater
- Soil Permeability & Slope
- Irrigation
**Pesticides Detected in Groundwater (61)**

<table>
<thead>
<tr>
<th>Acetochlor</th>
<th>Dicamba</th>
<th>Metolachlor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetochlor ESA</td>
<td>Diclofop</td>
<td>MCPA</td>
</tr>
<tr>
<td>Alachlor</td>
<td>Diffenoxyflurine</td>
<td>MCPA</td>
</tr>
<tr>
<td>Alachlor ESA</td>
<td>Dimethenamid E</td>
<td>Metolachlor</td>
</tr>
<tr>
<td>Alachlor OA</td>
<td>Dimethenamid OA</td>
<td>Metolachlor ESA</td>
</tr>
<tr>
<td>Aldicarb sulfone</td>
<td>Diuron</td>
<td>Metolachlor OA</td>
</tr>
<tr>
<td>Atrazine</td>
<td>Ethoprop</td>
<td>Motribuzin</td>
</tr>
<tr>
<td>Azauxystrobin</td>
<td>Fenamphos</td>
<td>Nicosulfuron</td>
</tr>
<tr>
<td>Bentazon</td>
<td>Fenamphos sulfone</td>
<td>Oxymethon methyl</td>
</tr>
<tr>
<td>Bromacil</td>
<td>Hexazinone</td>
<td>Phosamidon</td>
</tr>
<tr>
<td>Chlorantraniliprole</td>
<td>Hydroxy Atrazine</td>
<td>Pralleon</td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>Imazamox</td>
<td>Propazine</td>
</tr>
<tr>
<td>Chlorosulfuron</td>
<td>Imazapic</td>
<td>Quinclorac</td>
</tr>
<tr>
<td>Clomazone</td>
<td>Imazaquin</td>
<td>Simazine</td>
</tr>
<tr>
<td>DCPA</td>
<td>Imazethapyr</td>
<td>Tebuthiuron</td>
</tr>
<tr>
<td>Desethyl Atrazine</td>
<td>Imidacloprid</td>
<td>Tetraconazole</td>
</tr>
<tr>
<td>Diclofop Metolachlor</td>
<td>Lindane</td>
<td>Triadimefon</td>
</tr>
<tr>
<td>Diclofop-Methyl</td>
<td>Lindane</td>
<td>Triallate (ESA)</td>
</tr>
<tr>
<td>Diclofop-Methyl</td>
<td>Lixiron</td>
<td>Triazone (ESA)</td>
</tr>
</tbody>
</table>

**Pesticide Detections**

- % of Wells: > Std 1%, BDL 73%
- % Samples: > Std 36%, BDL 64%

**Long List a Concern?**

- 27 compounds detected above 1.0 µg / L (ppb)
- 30 compounds detected fewer than five times
- Detection limits for some compounds as low as 0.003 µg / L (ppb)
- Most detections < 0.10 µg / L (ppb)
- I.e. dose makes the poison

**Above Drinking Water Standard**

- Unusual in Colorado
- Only 20 active ingredients have defined standard or health advisory level
- Often suggest possible spill in area
- All products with leaching characteristics

**West Slope Detections**

- Bar chart showing detections.
Surface Water Sampling

- Less frequent and coordinated as groundwater
- Typically CDPHE, USGS
- Generally focused on basins with use

http://water.usgs.gov/nawqa/pnsp/pubs/pest-streams/

Surface Water Pesticides

- Number of pesticide detections
- Detected pesticide concentration by basin

Monitoring Summary

- Pesticide detection varies widely depending upon area of state.
- Chemicals with leaching properties and higher rates are most frequently detected compounds.
- Detections above drinking water standard are rare.

Application Considerations

- Awareness:
  - Pesticide choice
  - Site Characteristics
- Setback from water sources (Wells)
  - Application
  - Label setbacks
  - Mixing and loading
- Application timing – pending irrigation or rain

Application Considerations

- Most pesticide detections at higher levels (in Colorado) are likely due to point sources
  - Poor mixing and loading
  - Uncontained spills
  - Mixing near wellhead
  - Improper storage and disposal

See newly revised BMPs for Pesticide and Fertilizer Storage and Handling:
http://www.ext.colostate.edu/pubs/crops/xcm178.pdf
**Agricultural Chemicals and Groundwater Protection Program**

Requires secondary containment and mixing and loading pads if you ….

- Store pesticide in bulk containers > 55 gal. (non-DOT approved or >600 gal)
- Mix more than 500 gal product at 1 site annually
- Field mixing and loading is exempt

**Other Resources**

- RUP Recordkeeping
  - Updated Excel Program
    - [http://waterquality.colostate.edu/pestrecordbook.shtml](http://waterquality.colostate.edu/pestrecordbook.shtml)
- Colorado RUP Recordkeeping App (CRURA)
- Available on App Store soon

**Summary**

Certain Colorado waters are vulnerable to pesticide impacts, however …

- Site characteristics
- Chemical selection
- Application/ management practices

Determine actual impacts.

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