

Best Management Practices to Prevent Veterinary Pharmaceutical Contamination of Water Bodies

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and

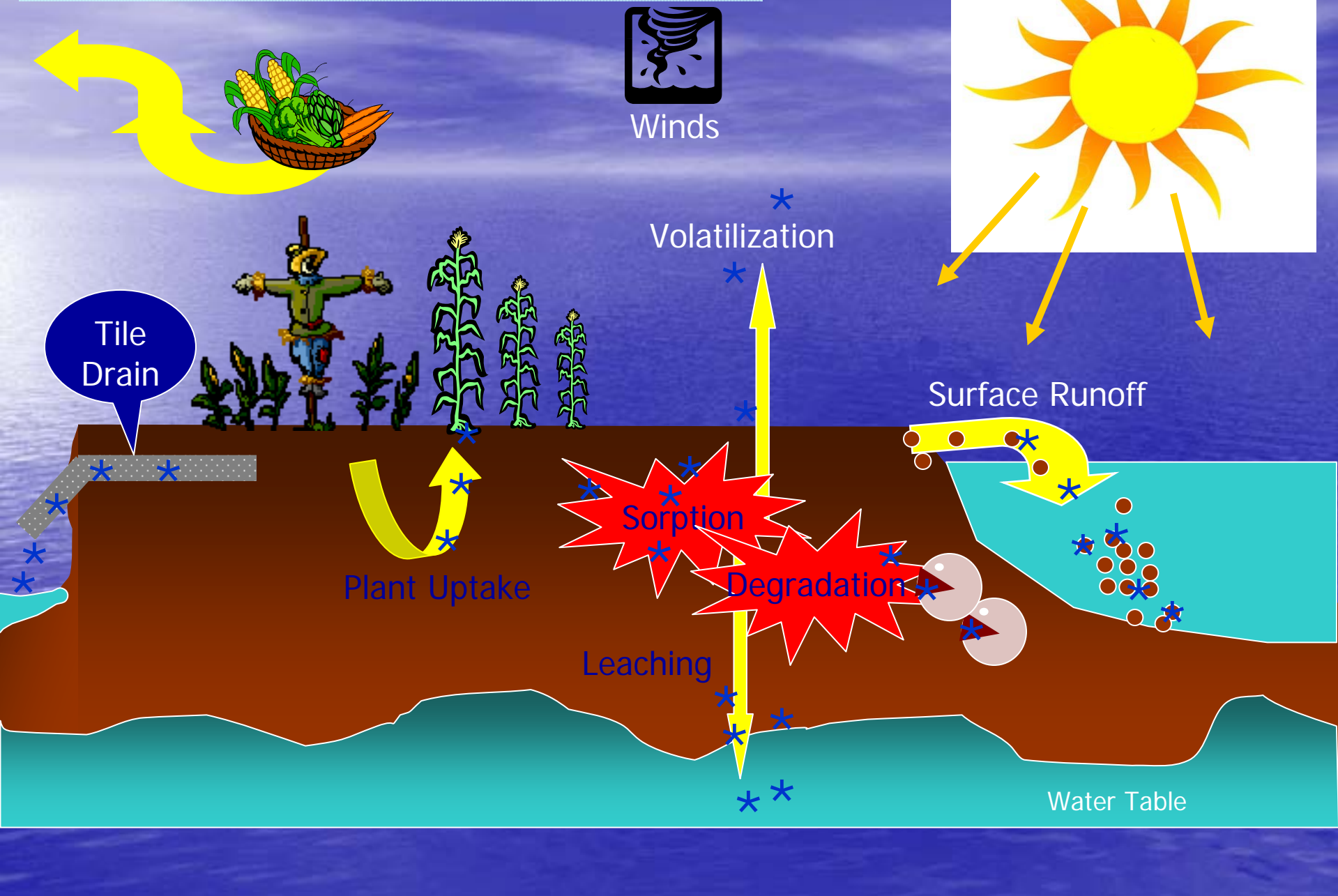
Linda Lee & Paul Ebner, Purdue University

Outline

- 1) Understanding Fate and Transport
- 2) Application of Principles to BMP Development and Selection

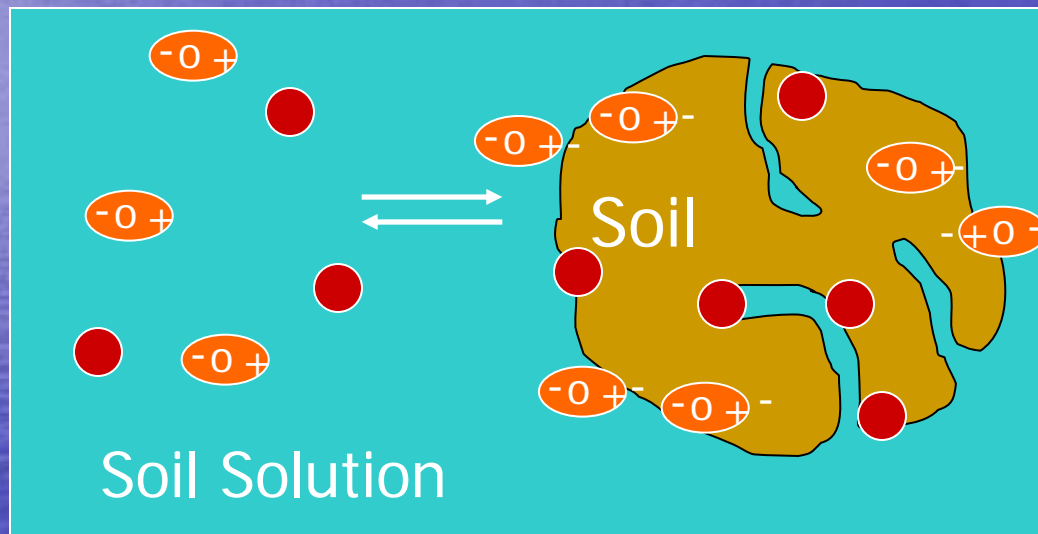


Fate & Transport Processes



Sorption

The **affinity** of compounds such as hormones and antimicrobials **for soil** particles.

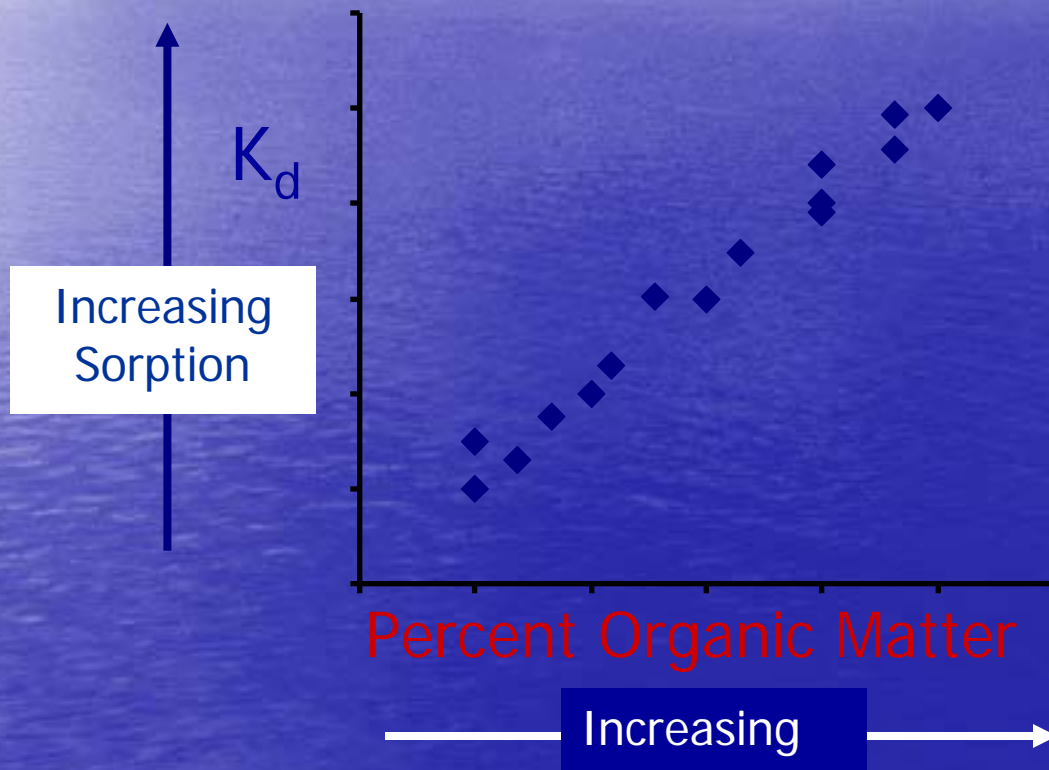


- Higher sorption means less is in the water.
- The soil property that controls sorption varies between hormones and antimicrobials.

The affinity of hormones for soil is primarily controlled by the organic matter in soil.

Soil-water Distribution Coefficient:

$$K_d = \frac{\text{Concentration in Soil}}{\text{Concentration in Water}}$$



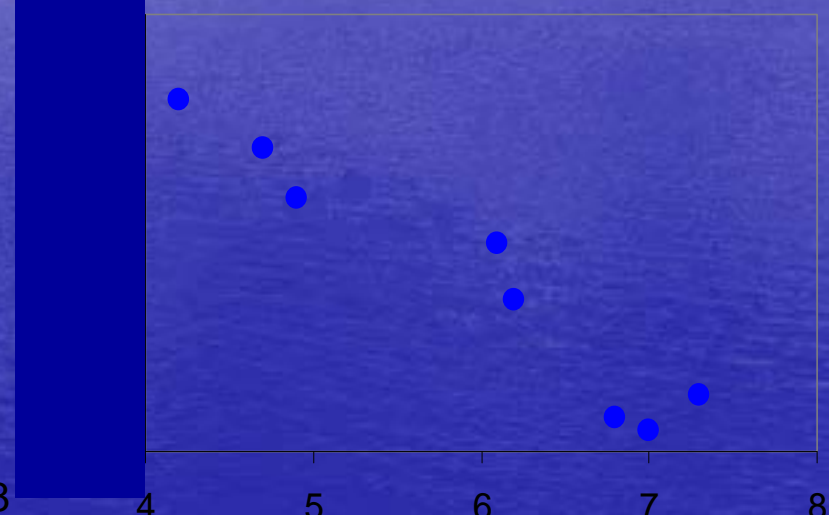
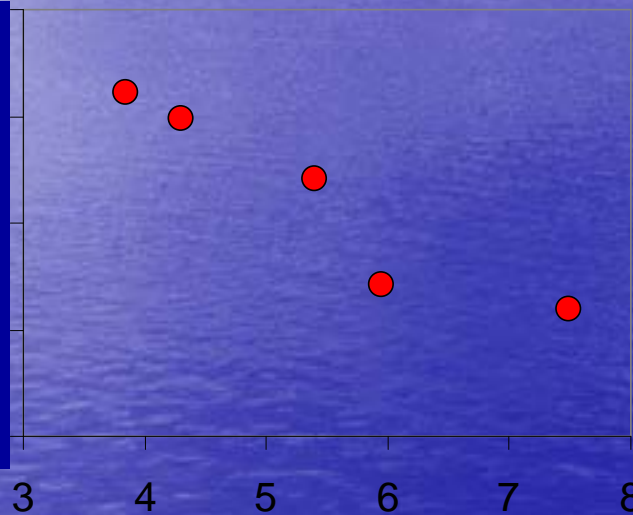
Hormone sorption increases with increasing soil organic matter content.

Sorption is pH-dependent for almost all antimicrobials

Tetracyclines

Monensin

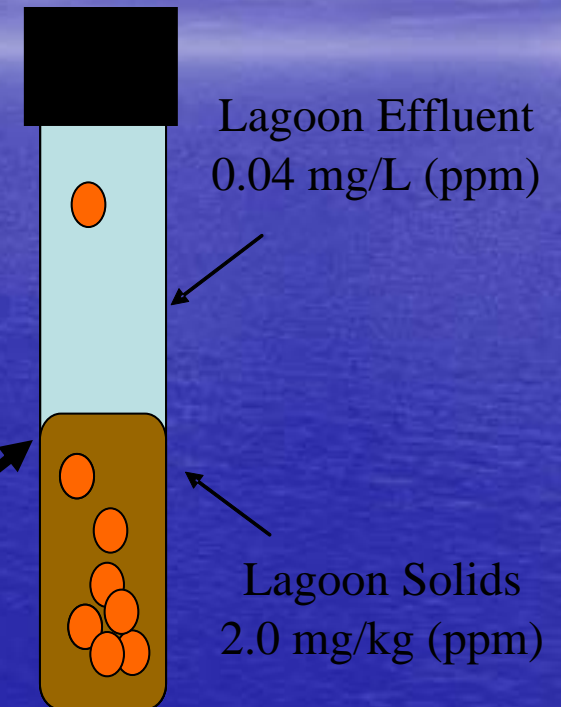
Sorption
Magnitude



pH

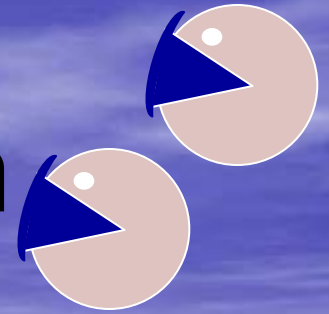
pH

Antimicrobials and hormone distribution in holding ponds



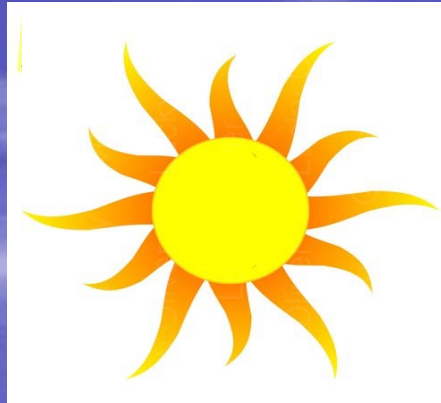
Typically much more antimicrobial or hormone is associated with the solids compared to the liquid

Microbial Degradation



- Conditions that favor activity of aerobic bacteria tend to reduce antimicrobial & hormone persistence
 - Prefer aerobic to anaerobic conditions
 - Preferred Temperature: 20°C to 37°C
 - Preferred Moisture: not flooded; not dry
 - Preferred pH range: 6 to 8

Photolysis



- Photolysis is not dependent on bacteria.
- Nitrates can enhance antibiotic photolysis in water.
- Dissolved humic materials can enhance or hinder antibiotic photolysis.



Leaching

- Leaching is inversely proportional to sorption
- The higher affinity an antimicrobial or hormone has for the soil, the slower it will leach
- The more resistant an antibiotic or hormone is to degradation, the more time it has to leach

Runoff

- Rainfall rate $>$ infiltration rate
- Saturated soils can not hold additional water



What moves with water run-off?

- ✓ Hormone-laden soil
- ✓ Hormone-laden manure
- ✓ Antibiotic-laden soil
- ✓ Antibiotic-laden manure
- ✓ Antibiotic-resistant bacteria*

Tile Drainage

- Excess soil water (and associated constituents) are rapidly moved to surface waterways through tile drain systems
- Preferential flow paths to tiles develop over time reducing the effect of soil attenuation on transport
- Relative contribution not well known yet



Time

Oxytetracycline from Calves*
(fed 60,000 ppb in milk)



Fresh manure	872 ppb
Bedding	367 ppb
Aged manure (1 mo)	19 ppb
Aged manure (4 mo)	2.1 ppb
Soil	0.006 ppb
Tile Drain Water	Not detected

(* Example from study by De Liguoro et al. 2003)

Types of BMPs

- Livestock Management
- Manure Management
- Land and Water Management



Livestock Management BMPs

- Antibiotic BMPs based on recommendations from the American Veterinary Medicine Association
- Two types:
 - 1) BMPs that reduce antibiotic use
 - 2) BMPs for antibiotic use

1) BMPs to Reduce Antibiotic Use

- Limit antibiotic therapy to sick animals.
- Emphasize preventative measures such as
 - Good hygiene
 - Routine health monitoring
 - Immunizations
- Consider other types of therapies before choosing antimicrobial therapy.
- Avoid antimicrobials for uncomplicated viral infections.



2) BMPs to Guide Antibiotic Use

- Only treat animals for as long as is necessary.
- Use narrow spectrum antibiotics whenever possible.
- Maintain accurate records regarding all antimicrobial use.



Manure Management BMPs

- Two types:
 - 1) BMPs that speed degradation of pharmaceuticals
 - 2) BMPs that limit off-site transport



1) BMPs to Speed Degradation of Pharmaceuticals

- Aeration speeds bio-degradation.
 - Lagoon aeration can reduce antibiotic and hormone concentrations in wastewater.
 - Actively composting (including turning as necessary to mix and aerate) speeds antibiotic removal.



1) BMPs to Speed Degradation of Pharmaceuticals

- Exposure to light speeds photolysis.
 - Spreading manure stockpiles out could degrade pharmaceuticals.



2) BMPs to Limit Off-site Transport

- Maintain ability to collect runoff from 25-yr, 24-hr storm at all times.
- Line retention ponds and lagoons to reduce seepage (and maintain liners).



2) BMPs to Limit Off-site Transport

- Site corrals and manure storage areas at least 150 ft from wellheads, creeks, or ponds.
- In humid regions, store manure under roofed areas.



Land and Water Management BMPs

- 1) Manure application BMPs
- 2) Soil conservation BMPs
- 3) Irrigation BMPs



Manure Application BMPs

- Make field-specific application decisions
- For example, avoid
 - Sandy soils over shallow groundwater or tile drains OR
 - Clayey soils on steep slopes near surface water bodies
- Avoid application to saturated or frozen soils if possible
- Incorporate immediately after application



Soil Conservation BMPs

- Many pharmaceuticals are strongly sorbed to soil particles.
- Therefore, preventing soil erosion also prevents pharmaceutical contamination of surface water.
- For example, use:
 - Conservation tillage
 - Cover crops
 - Filter strips
 - Terracing
 - Strip cropping
 - Grassed waterways

Irrigation BMPs

- Avoid over-watering to prevent leaching and runoff.
 - Monitor soil moisture and irrigate based on crop needs
- Manage irrigation systems for optimum uniformity and efficiency



Future Outlook for BMPs

- As our scientific knowledge base expands, we will be able to develop more effective BMPs to protect water bodies from pharmaceutical contamination.

