Runoff and Pollutants in Agriculture

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Agriculture and Natural Resources

Acknowledgments

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What is runoff?

- Runoff- Any water that cannot infiltrate and flows on the ground

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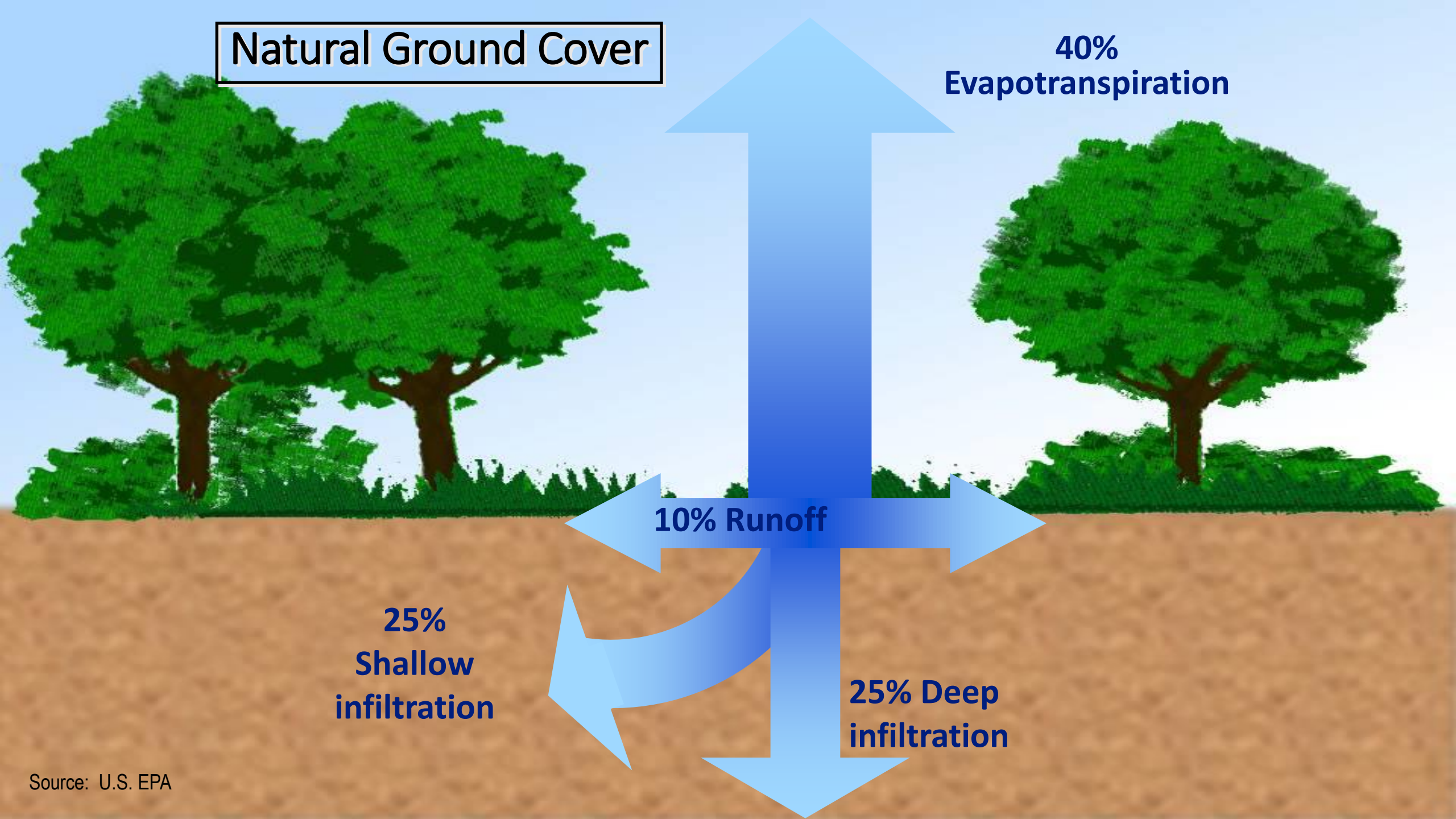


Source: U.S. EPA

What causes runoff?

- Impervious and non-vegetated surfaces (roofs, hoop houses, weed mats, etc.)
- Application rate higher than infiltration rate
- Unvegetated surfaces (including roads)
- Causes erosion (slope, water velocity, soil type, vegetation)

Soil Infiltration Rates	
Soil Texture	in/hr
Coarse Sand	0.75
Fine Sand	0.6
Sandy Loam	0.4
Loam	0.35
Silt Loam	0.25
Clay Loam	0.2
Silty Clay	0.15
Clay	0.1

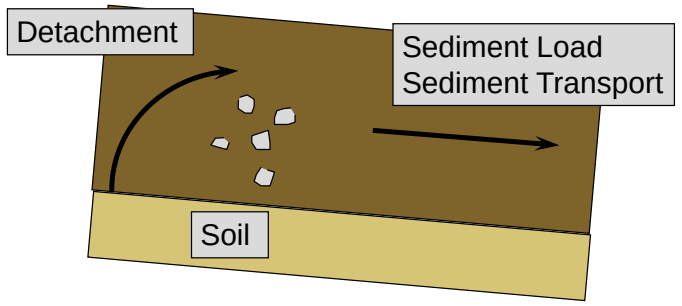
Erosion

- Erosion is the process of detachment and transport of soil particles by erosive agents
- Erosion is a natural geologic process

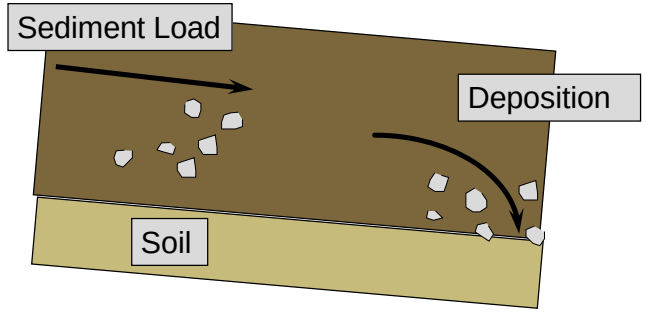
- Water erosion
- Wind erosion
- Tillage translocation

THE SOIL WATER EROSION PROCESS

DETACHMENT



DEPOSITION



Water Erosion

Sheet flow > rill > gully
Concentrated flow

Factors increasing erosion

- High Slope
- Low Vegetation
- Small channel cross section
- Low soil organic matter
- Low soil structure due to high tillage
- Low soil cover (mulch, straw, gravel, weed mat, etc.)

What is Discharge

- Discharge- The release of agriculture water from the property of an agriculture operation.
  - Irrigation runoff
  - Flows from tile drains
  - Stormwater runoff.

Irrigation vs Stormwater

- **Irrigation water:**
  “Keep the water in your property”
- **Stormwater:**

  “Only rain in the storm drain”

Stormwater can leave your property, but…

- No sediment
- No nitrate
- No pesticides
- No other pollutant
- <u>Stormwater cannot be mixed with irrigation runoff</u>

Pollutants

- Pesticides
- Nutrients (nitrogen, phosphorus)
- Sediment (dirt)
- Pathogens
- Salts
- Toxic chemicals
- Metals (mercury, copper, etc.)

Pesticides

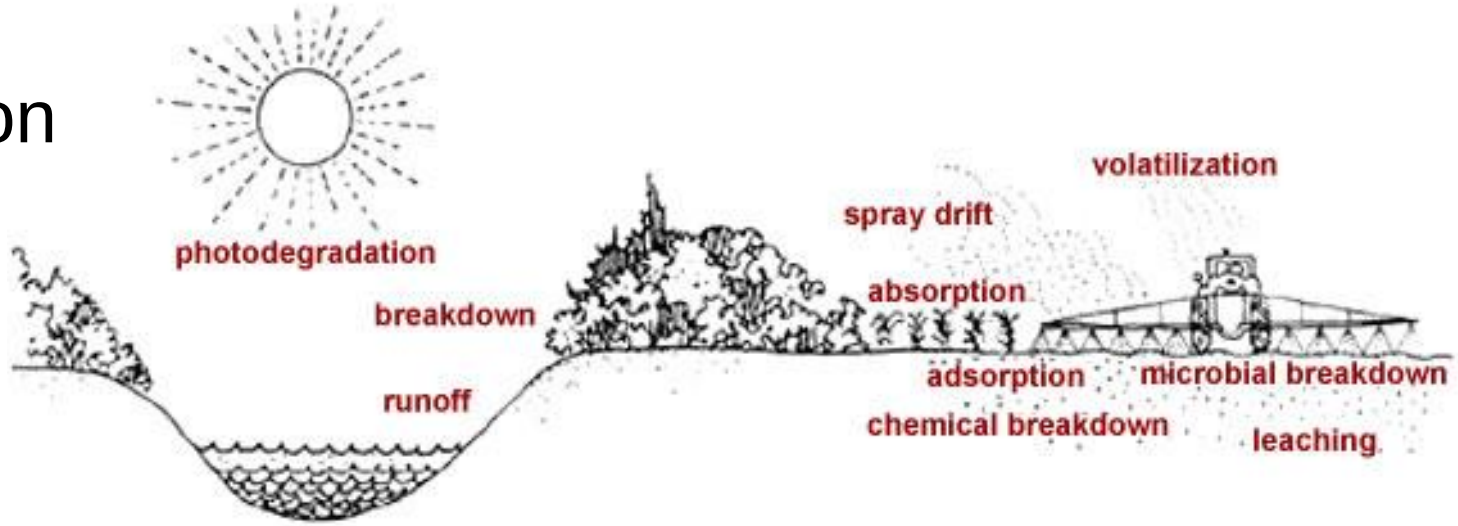
- Toxaphene
- Pyrethroids
- Organophosphate Suite
- Organochlorines Suite

Pesticides

- Factors influencing runoff:
- Soil infiltration rate
  - precipitation or irrigation rate is greater than what the soil or media can absorb
- Pesticide solubility and/or adsorption characteristics
  - material may be carried off-site in runoff water or, if bound tightly to soil particles, it can be carried **with sediment** in runoff water

Pesticide Properties

- Solubility (ppm)
- Adsorption (Koc)
- Persistence or half-life ($T_{1/2}$)
  - affected by biotic and abiotic factors
    - microbes
    - photodecomposition
    - pH
- Aquatic toxicity

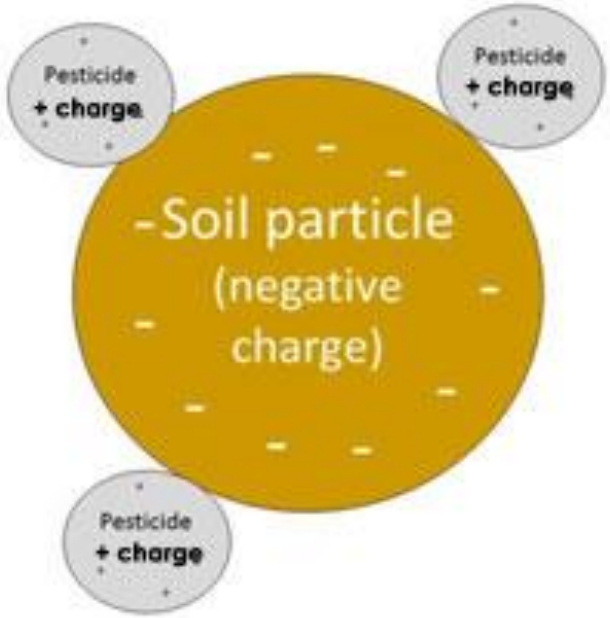


Pesticide Solubility

- Amount of material that can be dissolved
- Reported in ppm or mg/l (same thing)
- The higher the number, the more soluble the pesticide
  - Glyphosate (Roundup) 900,000 ppm
  - Diazinon 60 ppm
  - Oryzalin (Surflan) 3 ppm
  - Bifenthrin 0.1 ppm

Pesticide Adsorption

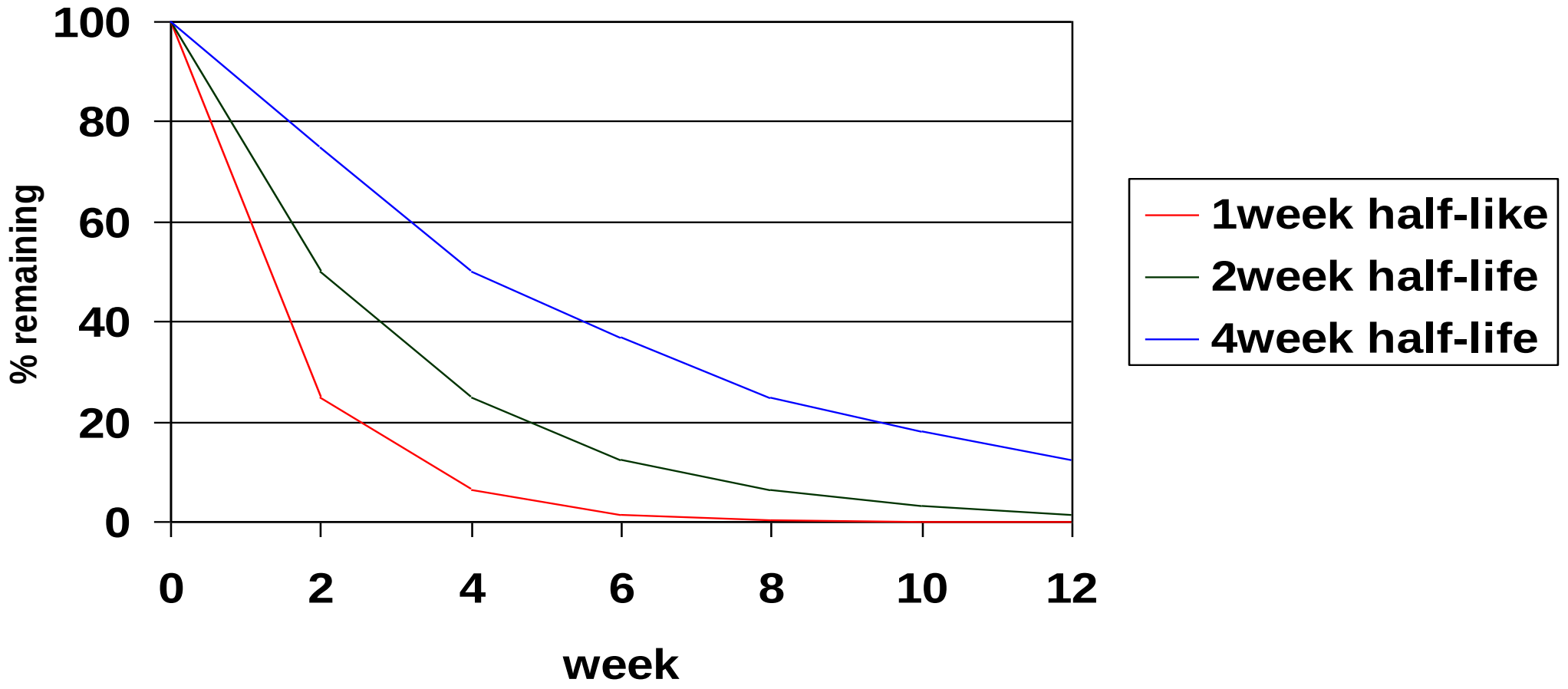
- The process by which a material associates with a surface (“stickiness”)
- Reported as a Koc value
- If pesticide is not adsorbed at all Koc = 0
- Pesticides with a low Koc are more likely to leach all other things being equal



Pesticide Koc

- Koc< 500 tend to move with water; high potential to leach or move off-site with surface water runoff.
  - Atrazine (Attrex) 100
- 500<Koc<1000 potential to move depends on other cultural or environmental factors.
  - Oryzalin (Surflan) 600
- Koc>1,000= pesticide attaches strongly to soil; unlikely to move unless soil erosion occurs.
  - Glyphosate (Roundup) 24,000
- Soil organic matter and clay content will increase adsorption

Pesticide Persistence



Pesticide Properties

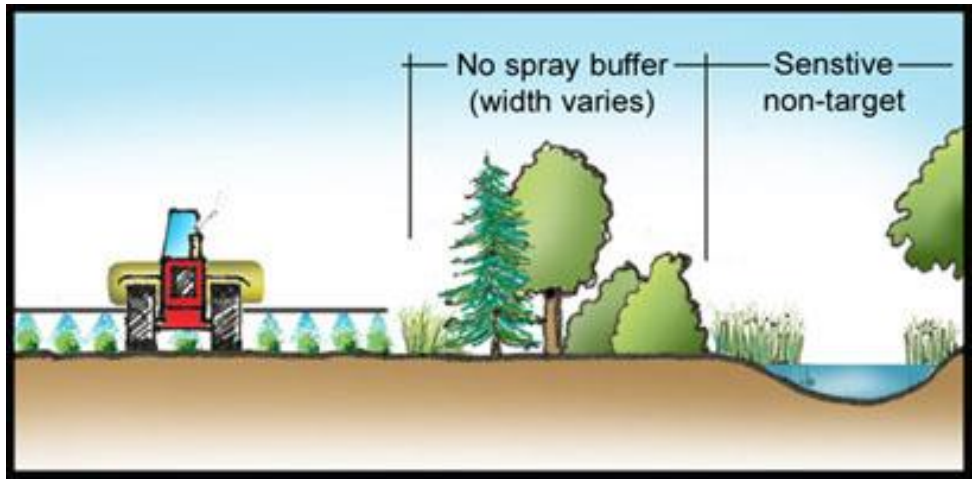
Pesticide	Solubility	Koc	Half-life
Bifenthrin	0.1	302000	345
Chlorpyrifos	1.4	12000	56
Diazinon	60	1800	30
Fenoxycarb	5.7	2600	36
Hydramethylnon	0.9	360000	55
Pyriproxyfen	0.4	34000	86
Atrizine	33	100	130
Glyphosate	900000	24000	47
Oryzalin	3	600	60

Reducing Pesticide Leaching

- USE IPM
- Follow the label
- Select pesticides which have a low solubility and high adsorption rate
- Check irrigation systems for output and uniformity
- Use drip or micro-sprinklers
- Herbicides: For first irrigation after application apply only enough water to move herbicide to active zone

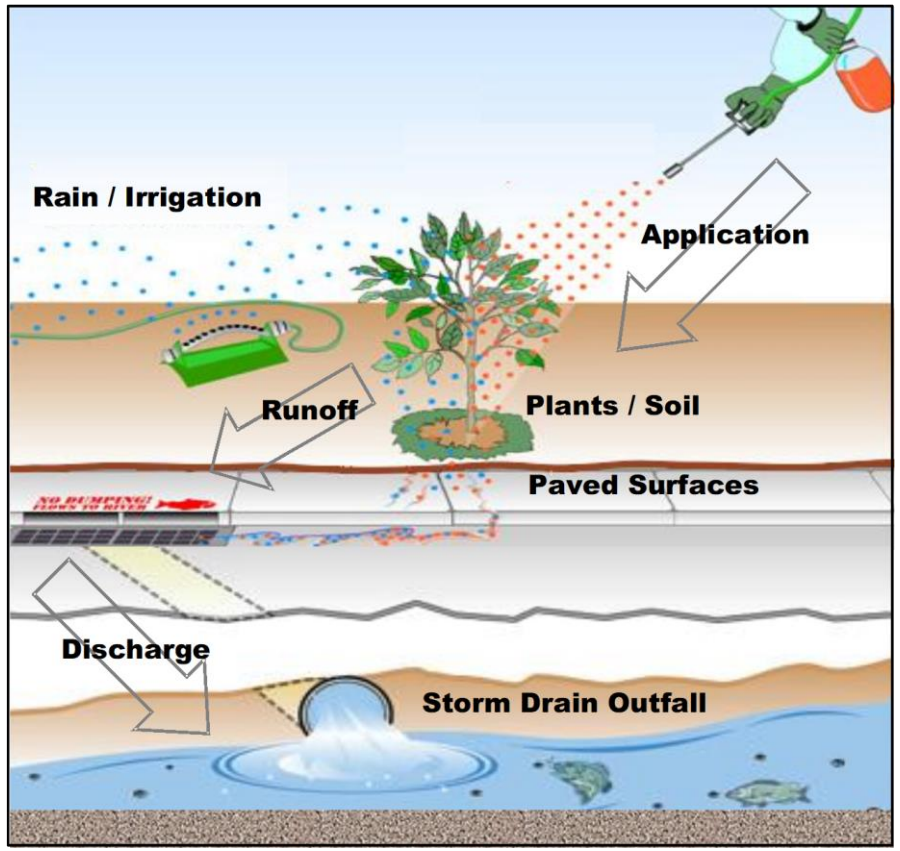
Reducing Surface Runoff

- Do Precision Application
- Timing of application to prevent rain washoff
- Control timing and amount of watering to prevent runoff
- Containment of runoff water
- Recapture tailwater and reuse of water
- Use buffer strips



Greatest Chance of Runoff

- Pesticide
  - High adsorption (high Koc)
  - Persistent (long half-life)
- Soil
  - Fine or easily eroded
  - High soil moisture
- Management
  - Over-irrigation
  - Lack of filter strips or buffers
  - Nursery bed surface (gravel<fabric<plastic)



Aquatic Toxicity

- Select product with lowest toxicity to aquatic organisms
- High LC_{50} (concentration that is lethal to 50% of tested population)
  - Usually in ppm
- Acephate LC_{50} =730, Diazinon LC_{50} =0.09

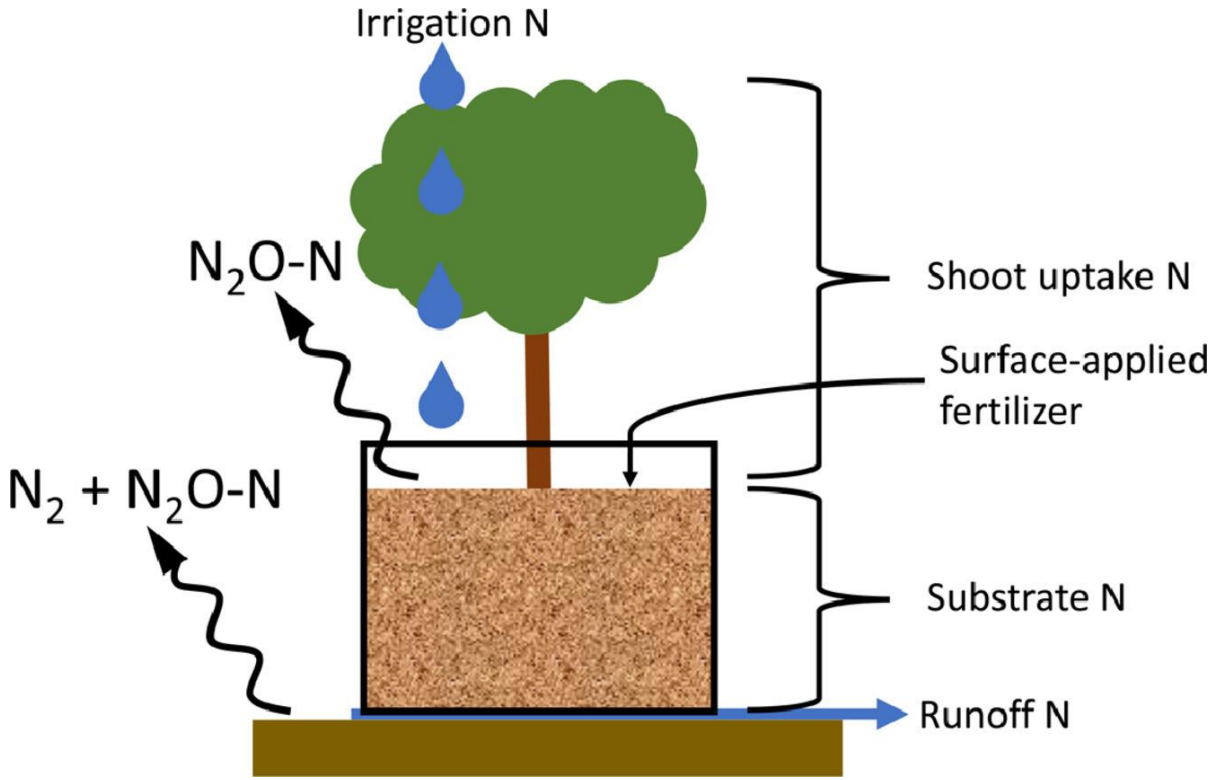
  (based on rainbow trout exposure)

Nutrients

- Ammonia
- Nitrate-Nitrogen
- Total Nitrogen
- Phosphate
- Total Phosphorus
- Sulfate

Case study: Nitrogen leaching from pots

- Goal: Measure the amount of nitrogen leaching from nursery containers



Pitton et al., 2022

Case study: Nitrogen leaching from pots

- Plants were transplanted from a #1 container into a #3 container (fir bark media w/ fertilizer incorporated)
- Half of planting beds lined with plastic, full bed covered w/ gravel
- Topdressed with (20-9-9) 3 days after transplant
- 81 days plants were harvested

Pitton et al., 2022

Case study: Nitrogen leaching from pots

- Inputs
  - Fertilizer incorporated in substrate
  - Nitrogen in irrigation
  - Topdress (20-9-9)
- Outputs
  - Shoot uptake
  - Substrate
  - N2O-N
  - Runoff
  - ? (denitrification)

Pitton et al., 2022

Case study: Nitrogen leaching from pots

- Results

Bed type	Mean plants bed^{-1}	Mean Nitrogen (kg N bed^{-1}) Inputs Substrate[a]	Irrigation	20-9-9 fertilizer[b]	Outputs Shoot uptake	Substrate[c]	N_2O-N[d]	Runoff		Unaccountable
Lined	153	4.680	0.007	1.071	0.296	3.317	0.089	0.521	a	1.683
		81%	<0.1%	19%	5.1%	58%	1.5%	9%		29%
Unlined	151	4.773	0.007	1.057	0.292	3.274	0.087	0.377	b	1.797
		82%	<0.1%	18%	5.0%	56%	1.5%	6.5%		31%

[a] The amount of input N in substrate is based on number of plants per bed and includes fir bark substrate, controlled release fertilizer, and transplant roots.
[b] The amount of input N from 35 g pot^{-1} of surface-applied 20-9-9 fertilizer is calculated based on number of plants per bed.
[c] The amount of output N in substrate includes fir bark substrate, remaining fertilizer, and plant roots and is based on number of plants per bed.
[d] The amount of N_2O-N lost is based on total N_2O-N emitted from substrate during the 81-day production cycle (Pitton et al. 2021) and is based on the number of plants per bed.
*Indicates significant difference at $p < 0.01$.

Pitton et al., 2022

Nutrient BPM's

1. Evaluate irrigation water, soils, growing media, and plant tissue to optimize plant growth and avoid over-fertilization
   - Regularly monitor the quality of your irrigation source water.
   - Regularly test soil/growing media for nutrients, soluble salts, and pH. Along with plant tissue analysis, soil tests are your best guide to effective use of fertilizers
   - Test plant tissue to determine concentrations of macro- and micro-nutrients
   - Use information and recommendations from soil, growing media, and plant tissue analyses in fertilization management
   - Consider nutrients already present in your irrigation water, recovered runoff, composts manures, and previous fertilizer applications in fertilizer management decision-making
   - Periodically test fertigation water to monitor fertilizer levels and ensure injectors are properly operating

Nutrient BPM's

2. Conduct efficient fertilizer and leaching practices
   - Incorporate solid fertilizers in a manner that optimizes nutrient availability to growing roots
   - Ensure that injected fertilizers are carefully mixed and applied at correct rates
   - Utilize slow-release or controlled-release fertilizers to minimize leaching losses
   - Time fertilizers with environmental parameters and growth stage of the plants
   - Flush excess salts from the root systems by using carefully managed leaching practices
   - Use the electrical conductivity (EC) of root media or leachate water to determine leaching practices
   - Set irrigation schedules to perform leaching at specific irrigation events, rather than every time irrigation is performed

Nutrient BPM's

3. Avoid fertilizer material spills during all phases of transport, storage, and application
   - Store fertilizers in a storage structure that complies with local, state, and federal guidelines
   - Locate fertilizer storage and mixing areas as far away from water conveyance (streams, creeks, and storm drains) as possible
   - Conduct fertilizer mixing and loading operations on an impermeable surface such as a concrete floor in areas where potential for runoff is low; perform fertilizer operations at least 100 feet down-slope of a well or other water supply. These are legal requirements
   - Verify regularly that fertigation equipment is properly calibrated and fertilizer solution tanks are free of leaks

Pathogens

- 17 species of Phytophthora
- 26 species of Pythium
- 27 genera of fungi
- 8 species of bacteria
- 10 viruses
- 13 species of plant parasitic nematodes

Phytophthora species found in water (Hong and Moorman 2005)		
Species	Locations	Plants affected
cactorum	Pond, river, canal, runoff	Ornamental, fruit
cambivora	Pond, river, canal	Ornamental, fruit
capsici	Pond, runoff	Ornamental
cinnamomi	Stream, river, pond, runoff, canal, sediment	Forest, ornamental, fruit
citricola	Pond, river, canal, lake, runoff	Ornamental, fruit
citrophthora	Canal, reservoir, pond, river, runoff	Ornamental, fruit
cryptogea	Well, stream, pond, canal, river, runoff, ebb and flow, nutrient film	Ornamental, fruit
drechsleri	River, canal, pond, runoff	Ornamental
gonapodyides	Lake	Ornamental
megasperma	Pond, canal, river, runoff, stream	Ornamental, fruit
nicotianae	Well, stream, pond, canal, reservoir, runoff, ebb and flow, nutrient film	Fruit, tobacco, ornamental
palmivora	Canal	Fruit
ramorum	Stream, watershed, recirculating system	Forest, ornamental
syringae	Canal, reservoir, river, runoff, pond	Ornamental, fruit
tropicalis	Pond, runoff	Ornamental
undulata	Recirculating system	Ornamental
Phytophthora spp	Pond, canal, river, lake, runoff, ebb and flow system	Fruit, vegetable, ornamental

Pathogens

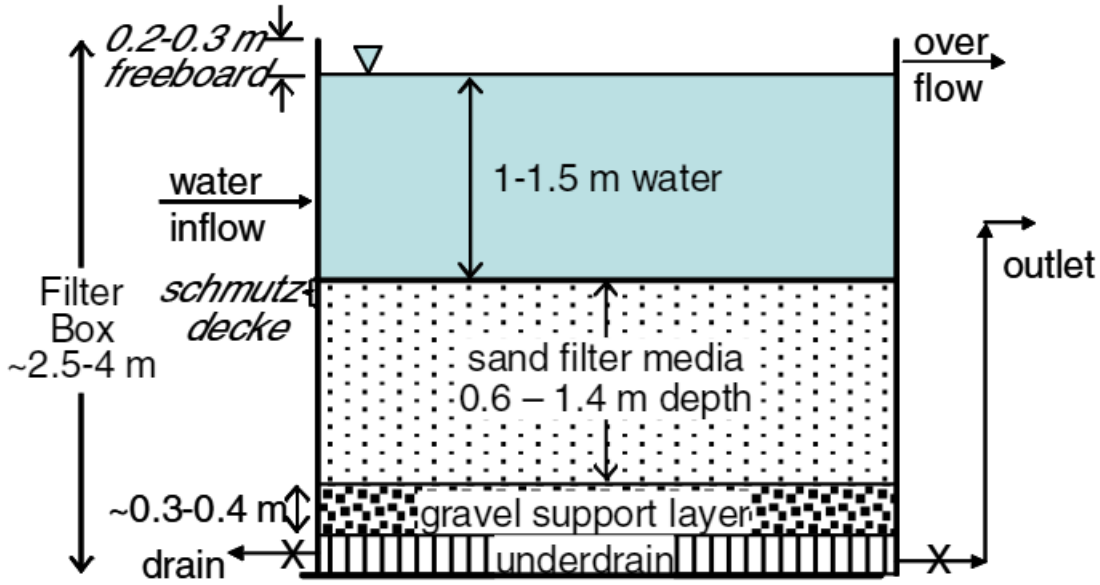
- What to do if a pathogen is suspected
  - Can the pathogen be detected in water (detection threshold)
  - Is it in high enough quantity to pose a threat (biological threshold)
  - What samples to take (clear water, turbid water, sediment, suspended particulates)
  - Where to take samples (at the source, within the crop, at the sprinkler head or other point where water is first applied, as effluent exiting crop area, effluent in drainage ditches, at the intake or return point of the water to the reservoir, from the surface or at some depth)
  - When to take samples (time of year, time of day, time of the irrigation cycle)
  - How to take sample (filters, sieves, water sample, plant trap)

Pathogen Management

- Slow sand filtration
- Ultraviolet light
- Chlorination
- Ozonation
- Heat
- Pressure
- Surfactants
- Sedimentation
- Antimicrobials
- Suppressive potting mixes
- Biological control agents

Slow Sand Filters

- *Phytophthora* spp.
- *Pythium* spp.
- *Xanthomonas campestris*
- *Radopholus similis* nematode
- *Tobacco mosaic virus*



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