

# **Environmental Fate of Herbicides:**

## **The Disappearing Act**

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# GetIPM.com



- ‘Children fall ill after pesticides sprayed -- 2,4-D applied to lawns near family's home’
- ‘Over-the-Counter Herbicides Pose a Significant Threat of Soft-Tissue Sarcoma, Leukemia and Lymphoma’
- ‘50 ill after drinking water from pesticide laden stream’

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# NATIONAL GEOGRAPHIC

HAZARDOUS WASTE  
STORING UP  
TROUBLE 318

VIKING TRAIL  
EAST 278

SUSQUEHANNA:  
SMALL-TOWN  
RIVER 352

MINIATURE  
HORSES 384

...S VOODOO  
...ES 395

# Public Concerns

- **Cause cancer**
- **Not well tested**
- **Hurt animals**
- **Last forever**
- **Not 'natural'**
- **Used carelessly**
- **Contaminate water**
- **Any amount is dangerous**

**TABLE 2**

***Percentage Distributions for General Pesticide Safety Items<sup>a</sup>***

**Q-1.** First I'd like you to tell me how safe you believe pesticides are for our food supply when they are used according to approved directions. Do you believe they are . . .

1. VERY SAFE	98%
2. SOMEWHAT SAFE	45
3. SOMEWHAT UNSAFE	30
4. VERY UNSAFE	15
5. Don't Know	2

N = 436

**Q-2.** Next, when pesticides are used according to approved directions, how safe do you think pesticides are for the environment. Do you think they are . . .

1. VERY SAFE	5%
2. SOMEWHAT SAFE	28
3. SOMEWHAT UNSAFE	41
4. VERY UNSAFE	24
5. Don't Know	3

N = 434

**Q-3.** Some people feel that the residues from pesticides and other agricultural chemicals are contaminating the groundwater and affecting the quality of water supplies. Others do not. I'd like to know the degree to which you are concerned or not concerned that your community's water supply has been or will be contaminated from the residues of pesticides and other agricultural chemicals. Are you . . .

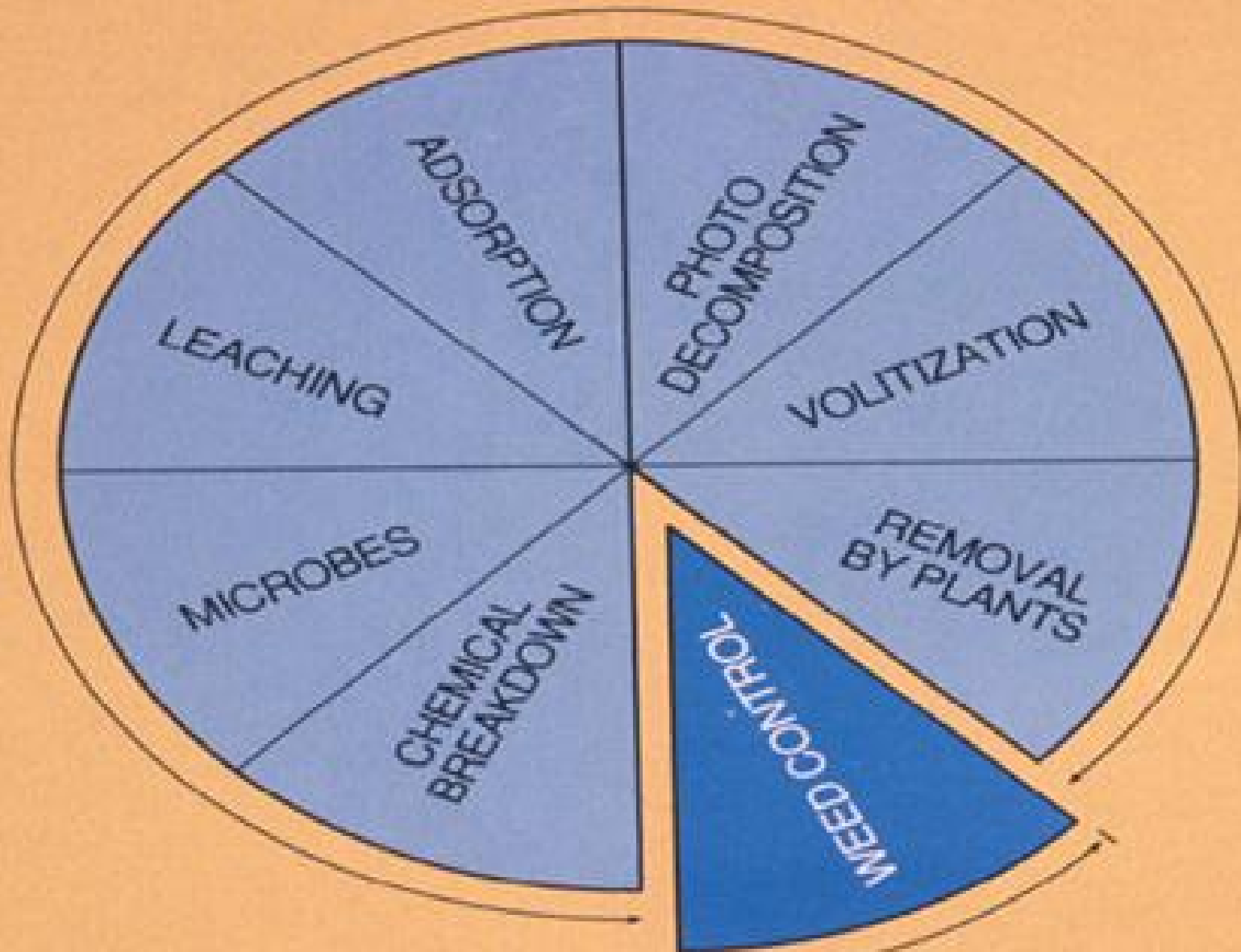
1. VERY CONCERNED	41%
2. SOMEWHAT CONCERNED	38
3. SOMEWHAT UNCONCERNED	14
4. VERY UNCONCERNED	6
5. Don't Know	1

N = 437

<sup>a</sup>Percentages may not equal 100 due to rounding.

# Who regulates pesticides?

- **Regulatory restrictions of pesticide use are usually based on guidelines set forth by the Environmental Protection Agency (EPA)**
- **Standard tests include: aerobic and anaerobic degradation, persistence, leaching, and animal toxicity.**



(THEORETICAL RATE NEEDED)

# What Happens to Pesticides?

- **Solubilization in water**
- **Sorption to clay particles and organic matter**
- **Microbial degradation**
  - Influenced by temperature, pH, moisture, oxygen availability, and microbial population
- **Chemical degradation**
  - Hydrolysis, oxidation, reduction

# What Happens to Pesticides?

- **Photodegradation**
  - Alteration caused by exposure to sunlight
- **Volatilization**
  - Loss due to an increase in temperature, vapor pressure, and wind
- **Plant uptake**
  - Roots, shoots, and leaves



# Pesticide – Chemical Properties

- **Ionic state (+ or – charged)**
- **Water Solubility**
- **Vapor pressure**
- **Hydrophilic or Hydrophobic**
- **Partition coefficient**

# Soil Properties

- **Clay and organic matter levels**
- **Large surface area**
- **Negatively charged surfaces**
  - **Anions (-) repelled**
  - **Cations (+) attracted**
- **Primarily responsible for binding pesticides**

# Persistence in Soil and/or Water

- Pesticide half-life
  - Amount of time it takes the pesticide to reach  $\frac{1}{2}$  of the originally applied concentration. Can be expressed in days, months, or years.

2.0 lb a.i./A  1.0 lb a.i./A  
25 days

# Soils – Living Phase

- **Microorganisms – bacteria, fungi, actinomycetes**
- **Algae**
- **Insects**
- **Earthworms**
- **Vertebrates**
  
- **Microorganisms perform most of the degrading**

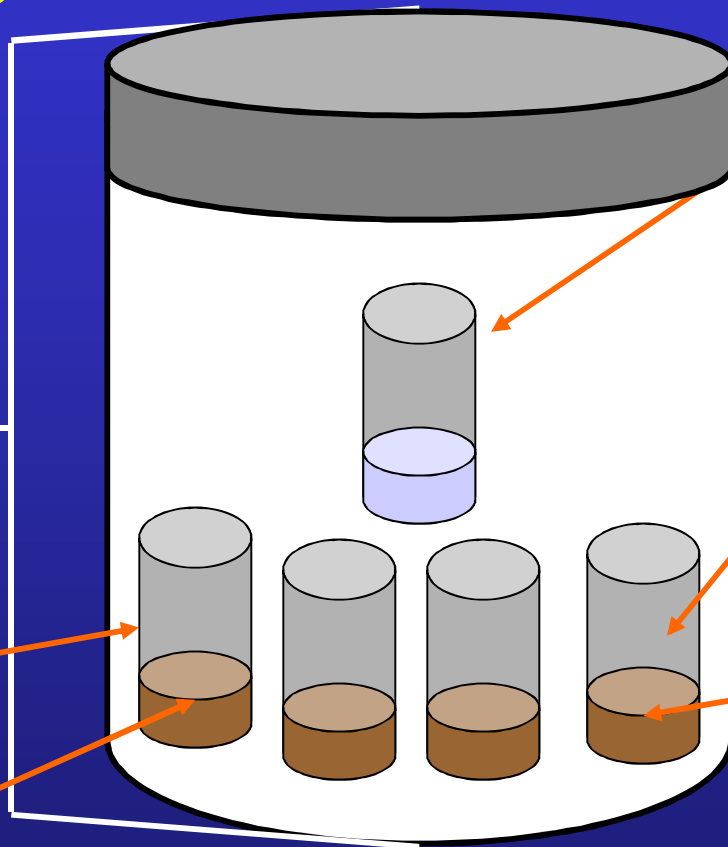
## Incubation periods

(0, 1, 2, 4, 6, 9, 12, 16 wks)

## Soil Microcosm

Extractable  
Pesticide

Bound  
Pesticide

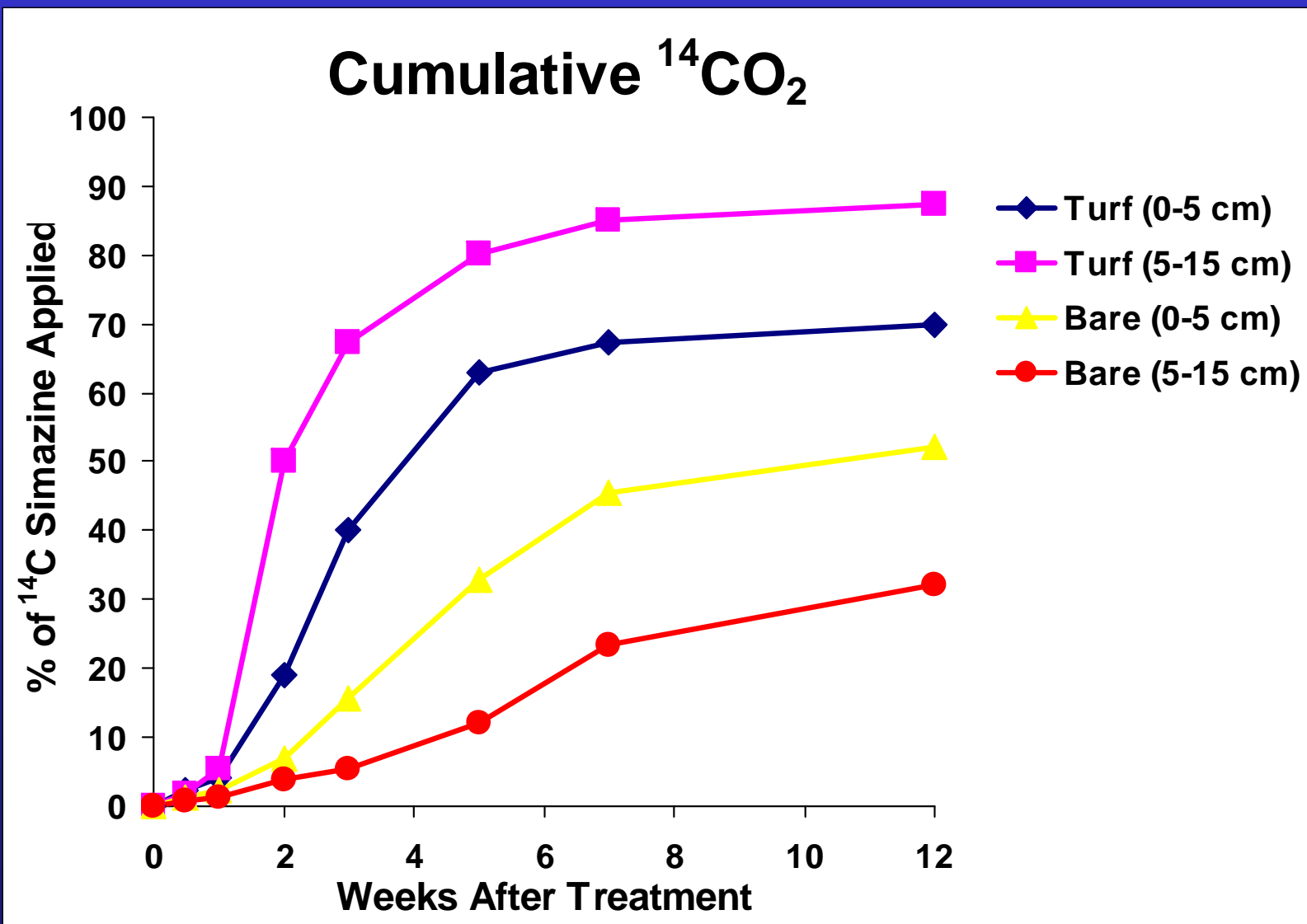


Sodium  
Hydroxide  
(measures  $^{14}\text{CO}_2$   
respiration)

Microbial  
Biomass  
Carbon

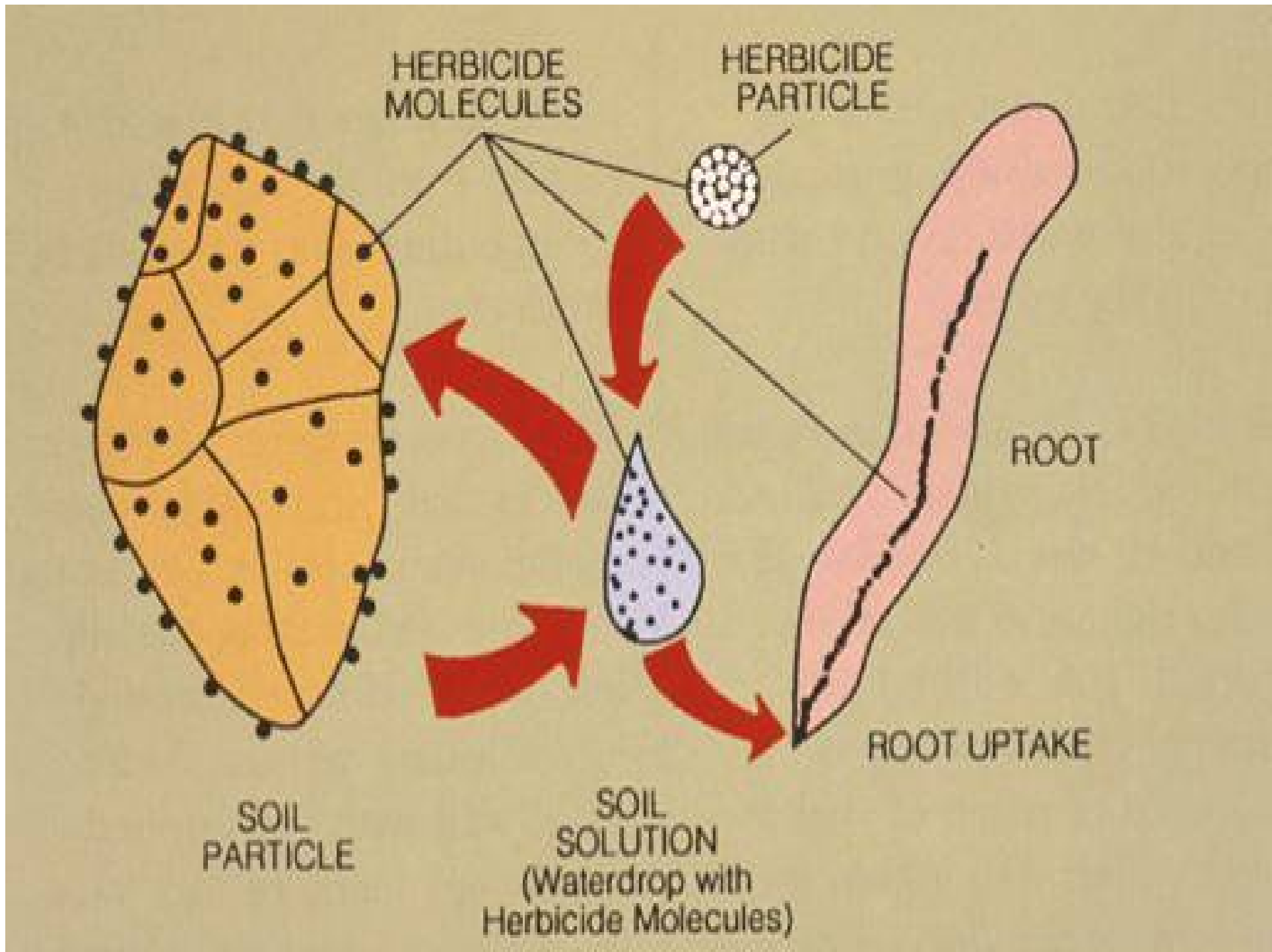
Microbial  
Biomass  
Nitrogen

# Turfgrass vs. Bareground

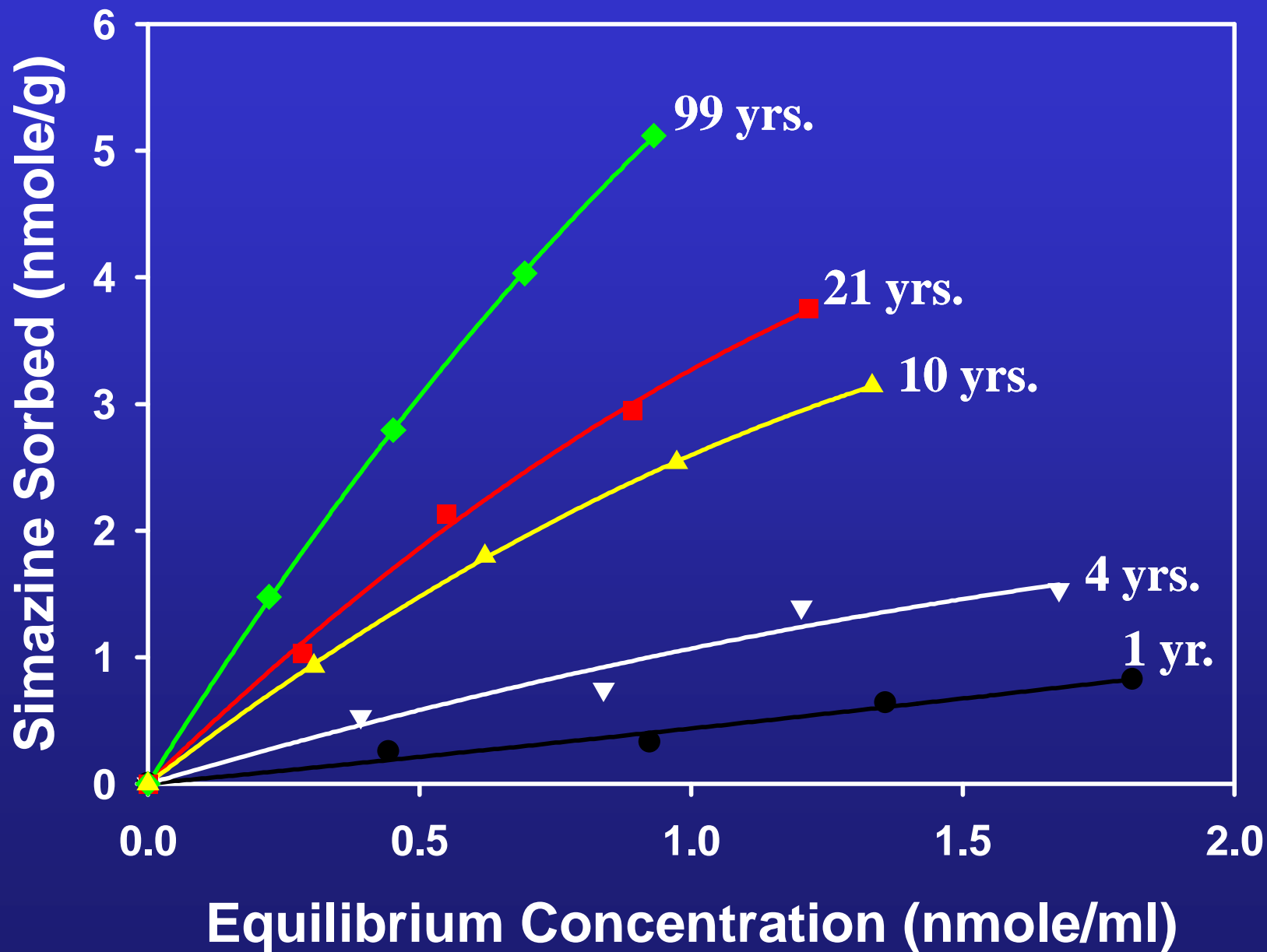


# Pesticide Sorption

- **Soil texture**
  - Coarse sandy soils have few binding sites
  - Fine-textured, high OM have many binding sites
- **Soil OM and clay content**
  - Increase binding
- **Excessive moisture interferes with binding**



# Surface Soil (0-5 cm)



# Factors contributing to leaching

- **Pesticide properties:**
  - High water solubility
  - Low soil adsorption
  - Long environmental persistence
- **Soil characteristics:**
  - Sand and/or gravel with low OM
- **Site conditions:**
  - Shallow depth to groundwater
  - Wet climate or extensive irrigation
- **Management practices:**
  - Poor timing with respect to climate
  - **OVERAPPLICATION!!**

# Atrazine Leaching – Multiple Soils

Check

Candor  
(sub)

Candor  
(6.5)

Candor  
(4.9)

Drummer

Arapahoe

Dundee



# Candor Loamy Sand – Multiple Herbicides

Check

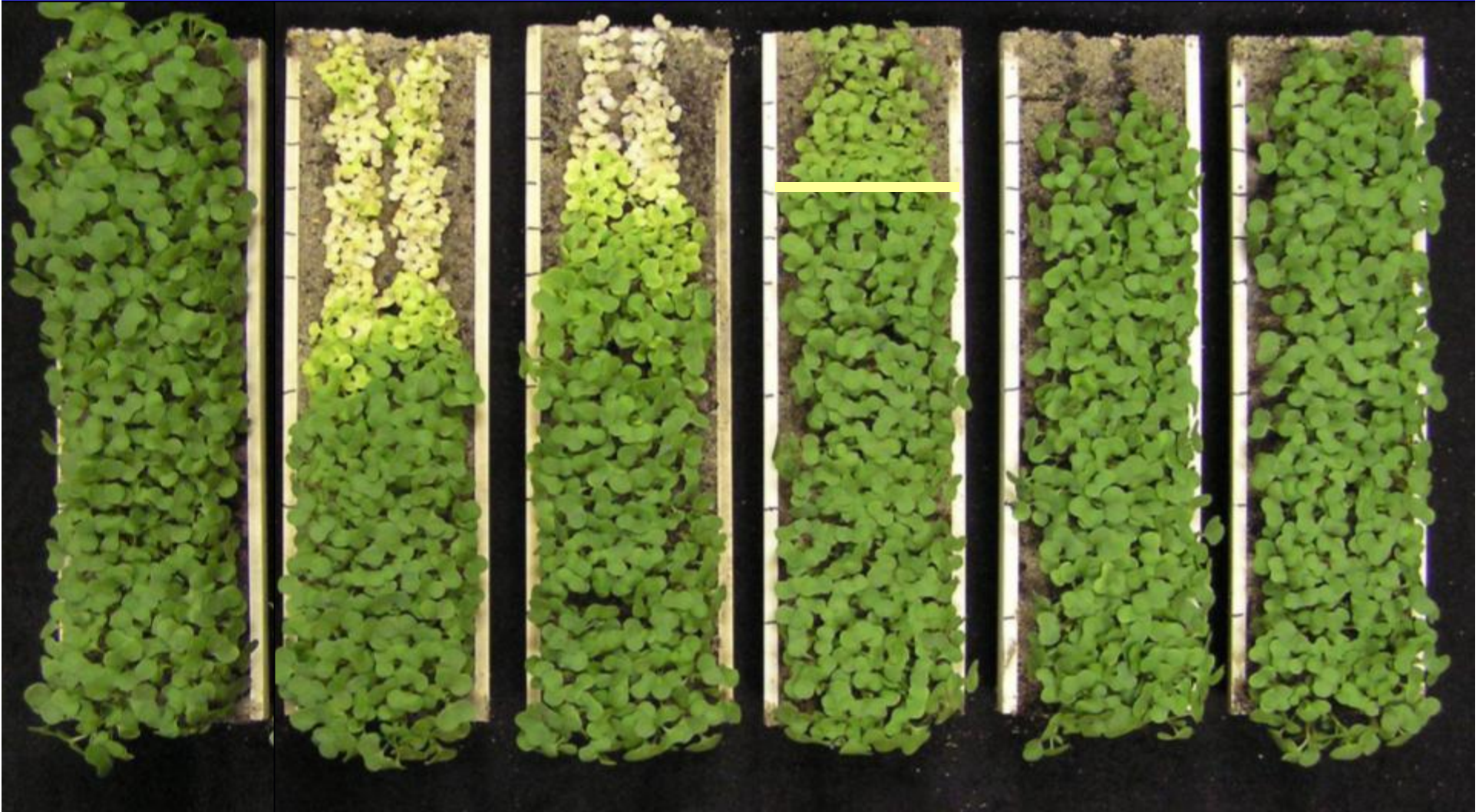
Mesotrione

Isoxaflutole

Atrazine

Flumioxazin

Oxyfluorfen



# Pesticide Selection with PLP/SLP Matrix

		SLP <sup>1</sup> Rating		
PLP <sup>2</sup> Rating		High	Moderate	Low
<b>Groundwater Contamination Potential (GWCP)</b>				
	<b>High</b>	<b>Hazardous</b>	<b>Risky</b>	<b>Safe</b>
	<b>Moderate</b>	<b>Risky</b>	<b>Risky</b>	<b>Safe</b>
	<b>Low</b>	<b>Safe</b>	<b>Safe</b>	<b>Safe</b>

<sup>1</sup> Soil Leaching Potential

<sup>2</sup> Pesticide Leaching Potential



# Best Management Practices

- **Use pesticides with low PLP on high SLP soils**
- **Training of proper application techniques**
- **Spot treat**
- **Always follow label instructions**
- **Calibrate sprayer**
- **Establish a buffer around treated area**

# Fun Facts

- **30 yrs added to lifespan in 20<sup>th</sup> century**
- **8 yrs added since use of pesticides**
- **Only 37% of land farmed in 1950 is cultivated today**

# QUESTIONS



**BACK-UP SLIDES**

# Pesticide Leaching Potential

- **PLP – developed by Warren & Weber, NCSU**
- **Input factors include:**
  - **Sorptive ability ( $K_{OC}$ )**
  - **Half-life ( $T_{1/2}$ )**
  - **Application rate ( $R$ )**
  - **Amount that reaches the soil ( $F$ )**
- **PLP value =  $(T_{1/2} \times R \times F / K_{OC})$**

# Soil Leaching Potential - SLP

- **Factors include:**
  - **Organic Matter**
  - **Soil Texture**
  - **pH**
- **SLP value = OM + Texture + pH**
- **High OM retards movement**
- **High pH can increase movement**
- **Sand increase movement**