

The background is a blue gradient with a wavy line separating a darker blue top section from a lighter blue bottom section. The text is centered in the lighter blue section.

**MASTER GARDENER  
WATER QUALITY  
TRAINING MODULE #2**

# NUTRIENTS AND PESTICIDES IN URBAN ENVIRONMENTS

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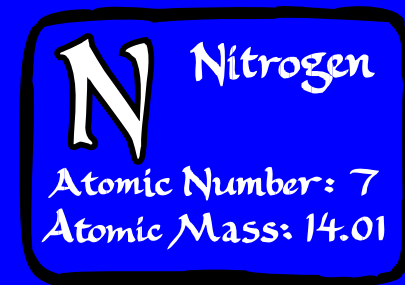
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# Training Module Outline

- ◆ Nutrients
  - ◆ Compounds, Fate, and Transport
    - ◆ nitrogen and phosphorus
- ◆ Pesticides
  - ◆ Mode of Action, Fate, and Transport
    - ◆ organophosphates
    - ◆ synthetic pyrethroids
    - ◆ phenylpyrazoles
- ◆ Indicator Microorganisms
  - ◆ General Overview

# Nitrogen

- ◆ Inorganic forms
  - ◆ Nitrate ( $\text{NO}_3^-$ )
  - ◆ Nitrite ( $\text{NO}_2^-$ )
  - ◆ Ammonium ( $\text{NH}_4^+$ )
  - ◆ Nitrogen ( $\text{N}_2$ )
- ◆ Organic forms
  - ◆ Amino acids
  - ◆ Nucleic acids
  - ◆ Urine



# Transformations of Nitrogen

## ◆ Non-biological

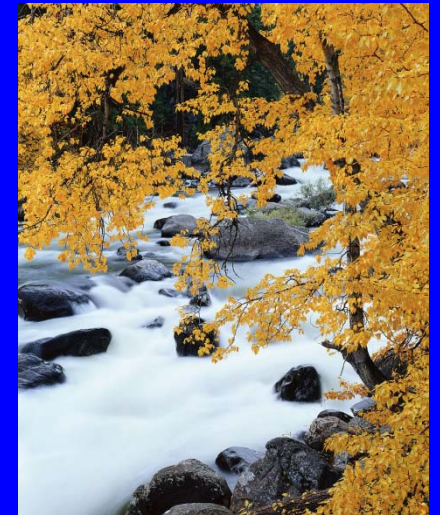
- ◆ Volatilization
- ◆ Sorption
- ◆ Sedimentation

## ◆ Biological

- ◆ Assimilation of inorganic forms of N to form organic forms
- ◆ Reduction ( $\text{N}_2 \rightarrow \text{NH}_4$  or organic forms)
- ◆ Complex heterotrophic conversions
- ◆ Oxidation ( $\text{NH}_4 \rightarrow \text{NO}_3^-$  &  $\text{NO}_2^-$ )
- ◆ Ammonification of organic matter
- ◆ Reduction ( $\text{NO}_3^- \rightarrow \text{N}_2\text{O}$  &  $\text{N}_2$ )

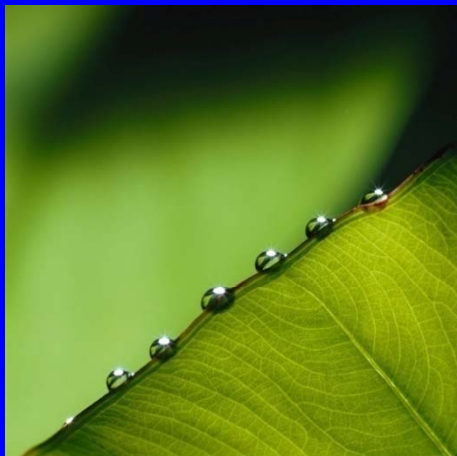
# Ammonia (NH<sub>3</sub>)

- ◆ Occurs naturally in water bodies.
  - ◆ NH<sub>3</sub> exists in equilibrium with NH<sub>4</sub><sup>+</sup>
  - ◆ pH and temperature affects equilibrium
  - ◆ Typically < 0.2 ppm N in surface waters
  - ◆ > 3 ppm N is an indicator of organic pollution
- ◆ Sources
    - ◆ Breakdown of nitrogenous organic and inorganic matter
    - ◆ Industrial waste
    - ◆ Municipal waste
    - ◆ Fertilizers



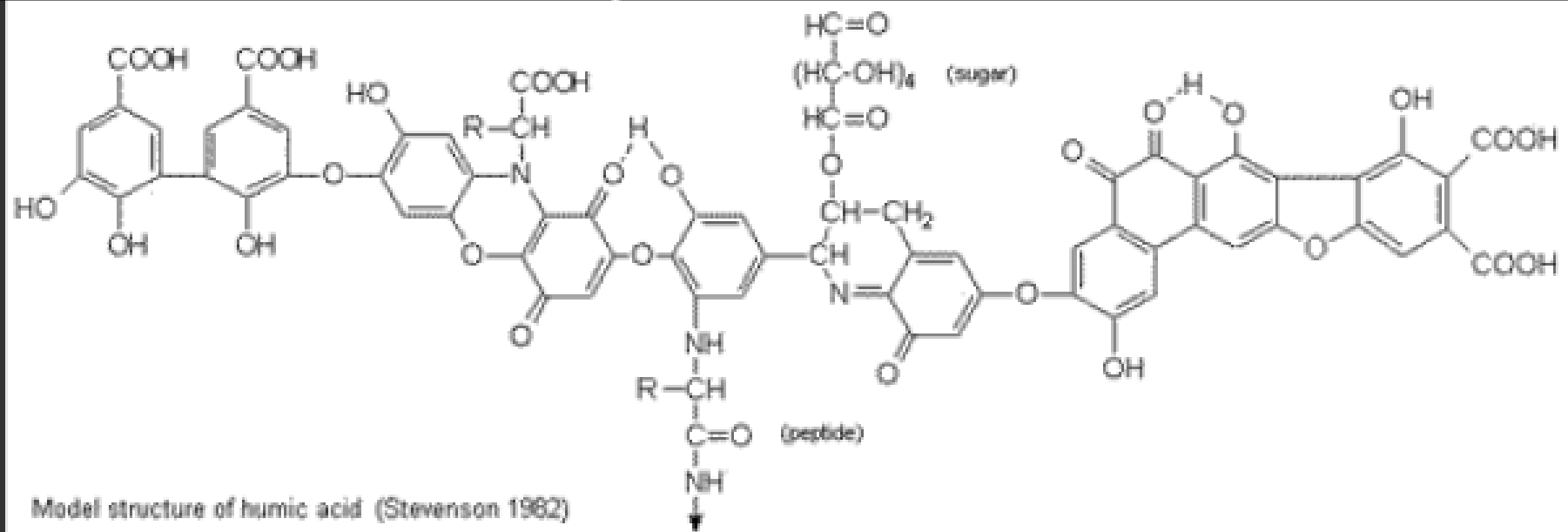
# Nitrate and Nitrite

- ◆ Sources
  - ◆ Municipal waste
  - ◆ Industrial waste
  - ◆ Inorganic nitrate fertilizers
  - ◆ Human or animal waste
- ◆ Commonly found in natural waters
- ◆ Nitrite rapidly oxidized to nitrate (<.001 ppm N)
- ◆ Essential nutrient for aquatic plants
- ◆ Fluctuations caused by plant growth and decay
- ◆ Natural levels seldom exceed 0.1 NO<sub>3</sub>-N



# Organic Nitrogen

- ◆ Sources
  - ◆ Organic fertilizers
  - ◆ Mainly formed in water by phytoplankton and bacteria
  - ◆ Decaying plant material
  - ◆ Organic wastes
    - ◆ Municipal
    - ◆ Industrial
- ◆ Commonly found in natural waters
- ◆ Rapidly converted to ammonia
- ◆ Fluctuates seasonally
- ◆ Humic and fulvic acids are products of organic nitrogen biochemical transformations



Model structure of humic acid (Stevenson 1982)

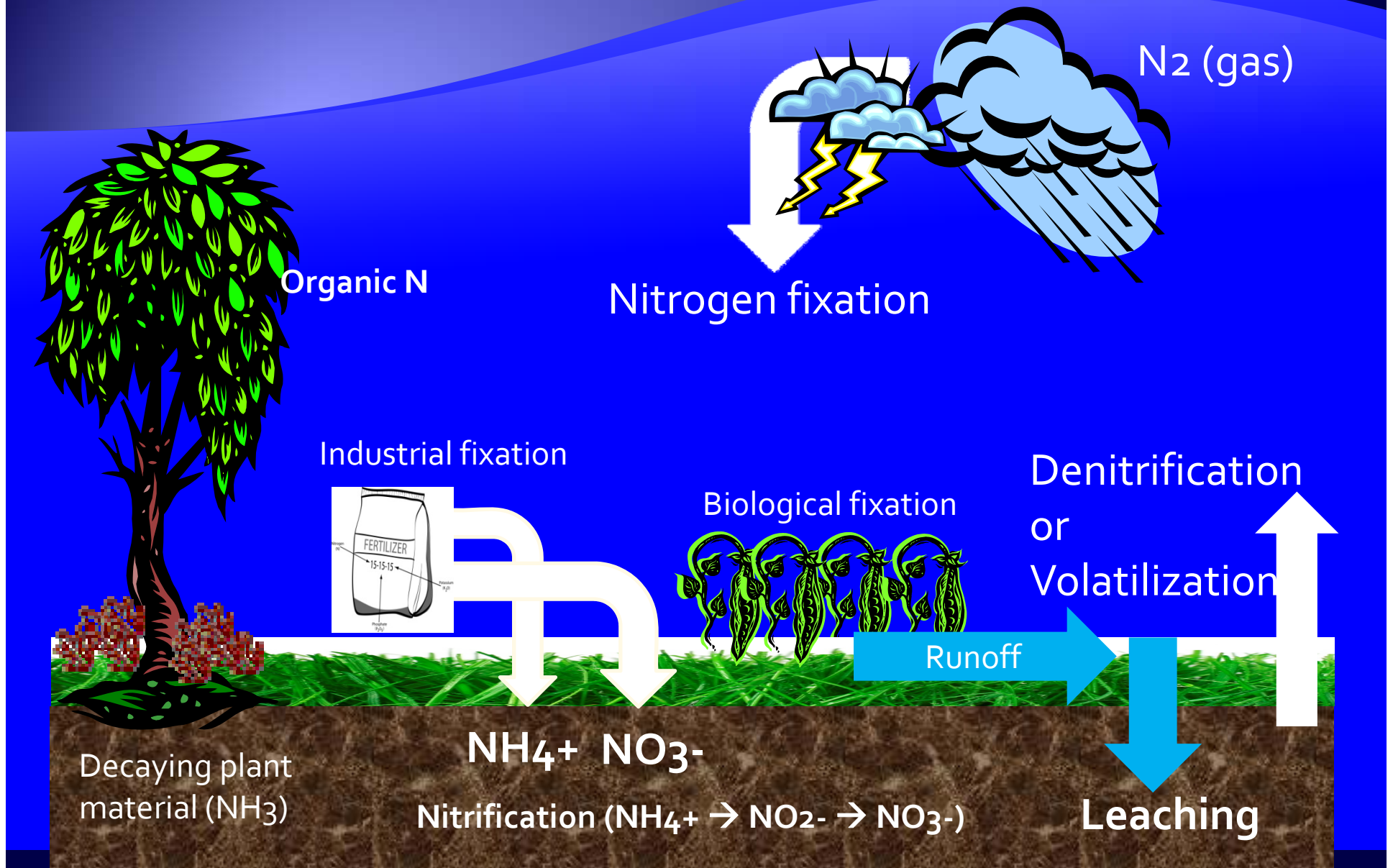
# Nitrogen Sources from Urban Landscapes

- ◆ Inorganic fertilizers
  - ◆ Ammonium sulfate, calcium nitrate, ammonium nitrate
  - ◆ Inexpensive
  - ◆ Manufactured
  - ◆ Readily available to the plant
  - ◆ Easily leached – soluble in water

# Nitrogen Sources from Urban Landscapes cont.

- ◆ Organic fertilizers
  - ◆ Blood and bone meal, manures, nitrogen tied up in proteins
  - ◆ Usually more expensive per pound of N
  - ◆ Naturally occurring compounds
    - ◆ Organic compounds contain carbon
  - ◆ Generally bulky but release nutrients slowly
  - ◆ Require biological activity to transform nitrogen into plant available forms.

# Nitrogen Cycling in the Urban Landscape



# Phosphorus

- ◆ Inorganic forms



- ◆ Organic forms

- ◆ Energy (ATP, ADP)

- ◆ Nucleic acids (DNA, RNA)

# Phosphates (ortho)

- ◆ Occurs naturally in water bodies.
  - ◆ Usually the limiting nutrient for algae growth
  - ◆ Levels in surface waters range from 0.005 to 0.020 ppm  $\text{PO}_4\text{-P}$
  - ◆ Adsorbed to mineral surfaces, clays, iron, etc...
  - ◆ Precipitates to form insoluble iron, aluminum, and calcium phosphates
- ◆ Sources
    - ◆ Rocks and minerals
    - ◆ Industrial waste
    - ◆ Municipal waste
    - ◆ Fertilizers
    - ◆ Manures



# Phosphorus in the Urban Landscape

- ◆ Only 1% or less of the total P in the soil is available to plants
- ◆ Excessive soluble P increases chances of P runoff
- ◆ Phosphorus fertilizer 22-3-8 versus 5-3-1



# Pesticides

- ◆ Organophosphates
- ◆ Synthetic pyrethroids
- ◆ Phenylpyrazoles



# Organophosphates

- ◆ Irreversibly inactivate acetylcholinesterase
  - ◆ enzyme is essential to nerve function in insects and humans
- ◆ Varying activity on enzyme
  - ◆ Parathion more toxic than malathion
- ◆ Degrade rapidly when exposed to sun, air, and soil
- ◆ High acute toxicity
- ◆ Most are readily soluble in water

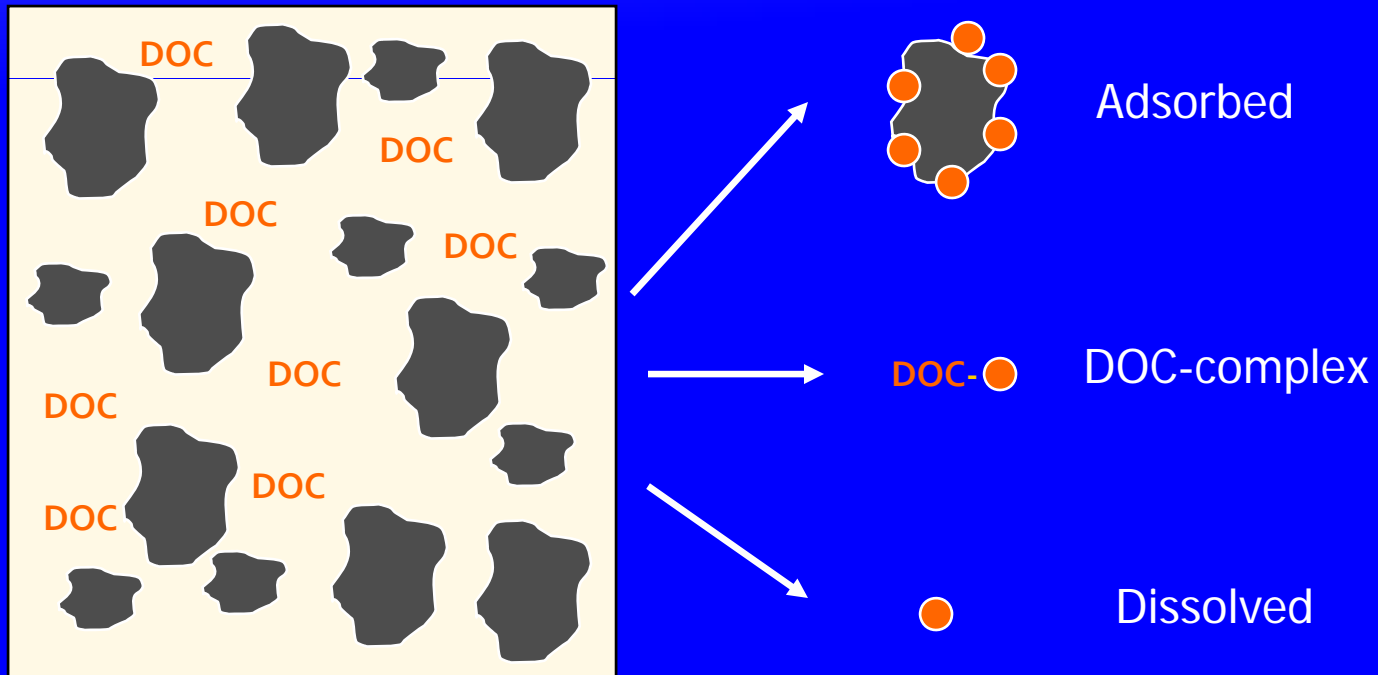
# Current Sources of Organophosphates from Urban Landscapes

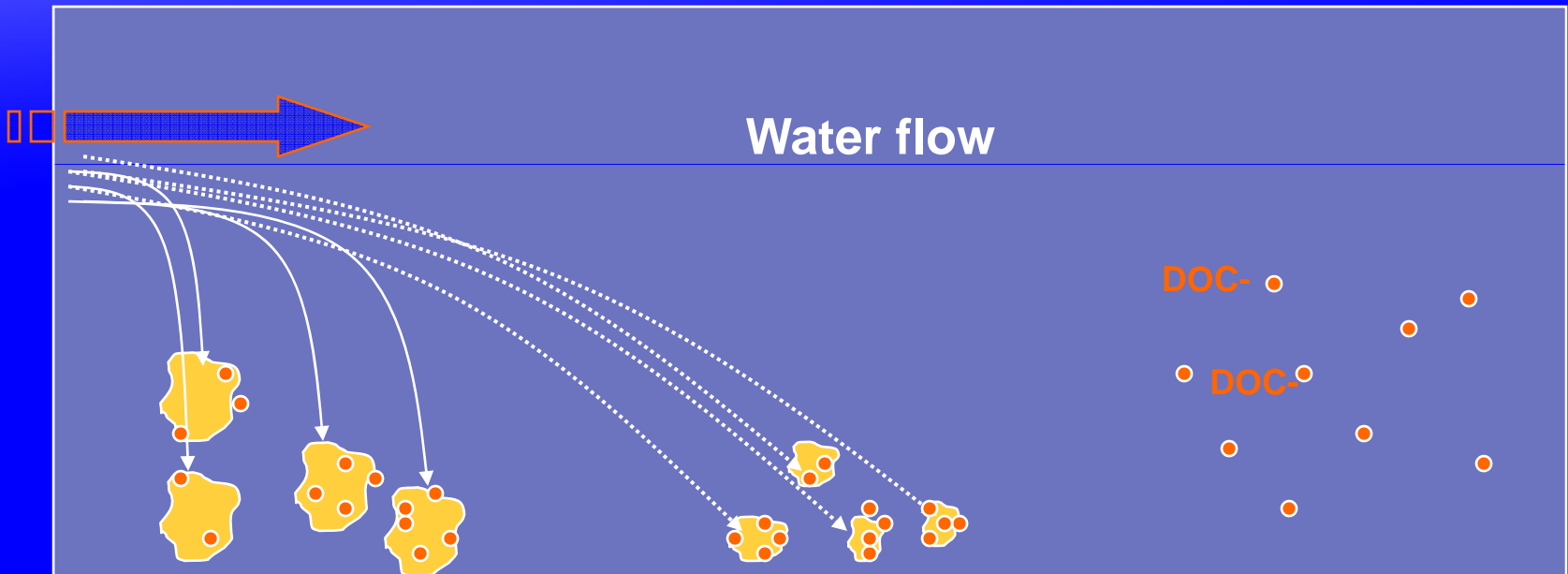
- ◆ Diazinon – residential sales ended Dec. 31, 2004
- ◆ Chlorpyrifos – residential sales ended Dec. 31, 2001
- ◆ Malathion – majority of remaining OP use in residential setting
- ◆ Detection in urban surface waters is declining since residential sales ended.

# Synthetic pyrethroids

- ◆ Based on natural pyrethrum (active ingredient pyrethrin extracted from chrysanthemum)
  - ◆ Some synthetic pyrethroids are safer than the natural pyrethrins.  
Ex. Oral LD<sub>50</sub> of Pounce (pyrethroid) is 4,000 mg/kg  
Oral LD<sub>50</sub> of pyrethrin is 1,500 mg/kg
- ◆ Synthetic forms are more resistant to environmental breakdown (half-life of days to weeks versus minutes)
- ◆ High aquatic toxicity
- ◆ Strong absorption to particles (organics, sediment, etc..)

# Absorption of Synthetic Pyrethroids in Water





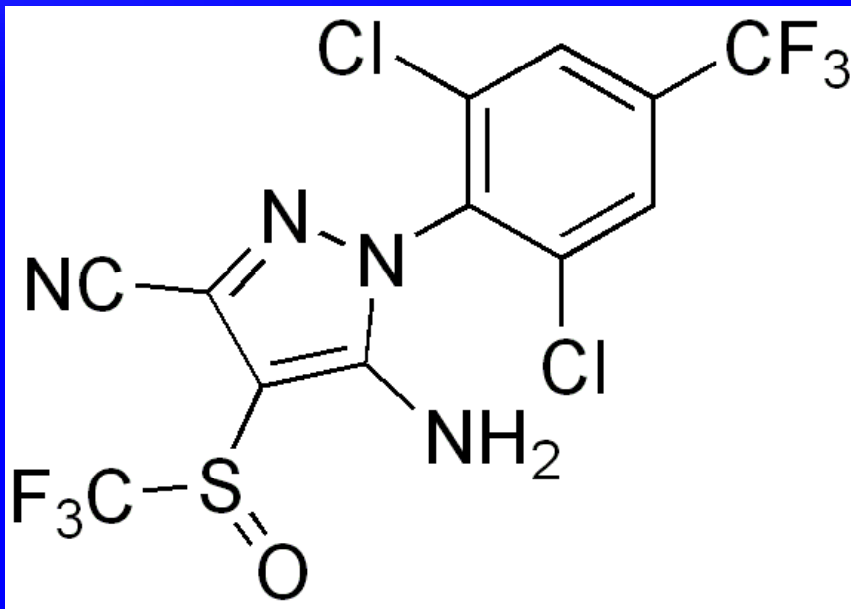
# Current Sources of Synthetic Pyrethroids from Urban Landscapes

- ◆ Detection in urban surface waters is increasing since residential sales ended of diazinon and chlorpyrifos.
- ◆ Broad spectrum insecticides
  - ◆ Bifenthrin
  - ◆ Cypermethrin
  - ◆ Cyfluthrin
  - ◆ Permethrin
  - ◆ Lambda-cyhalothrin

# Phenylpyrazoles

- ◆ Fipronil is currently the only pesticide in this class
- ◆ US registration in 1996
- ◆ Works on the insect's central nervous system
  - ◆ Specificity to insects is due to lack of a specific receptor in mammals
- ◆ Slow acting poison
  - ◆ Ants, termites, etc... carry poison back to colony or nest

# Characteristics of Fipronil



- ◆ Highly toxic to fish and aquatic invertebrates
- ◆ Low water solubility and absorption to sediment may reduce toxicity
- ◆ Toxic to bees
- ◆ Two metabolites are more toxic than parent
- ◆ Non-toxic to earthworms and microorganisms

# Environmental Fate of Fipronil



- ◆ Half-life of 0.7 to 1.7 months in various field situations
- ◆ Low mobility in soil as it binds to soil
- ◆ Degradation is slower in anaerobic soil and water conditions
- ◆ pH of water greater than 7.0 increases degradation

# Sources of Fipronil in Urban Landscapes

- ◆ Frontline
  - ◆ Flea control for pets
- ◆ Maxforce and Combat
  - ◆ Gels and baits for cockroach and ant control
- ◆ Termidor
  - ◆ Termite and ant control sprays and granular baits
  - ◆ Registered for use by Pest Control Operators for treatments around structures and spot treatments