CHEMICALS AND SOILS: INTERACTIONS AND TRANSPORT

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WATER TRANSPORT
MANY CHEMICALS!

Fe$^{+3}$

Zn$^{+2}$

As$^{+3}$
THE “OLIVE THEORY” OF THE BEHAVIOR AND TRANSPORT OF CHEMICALS IN THE ENVIRONMENT

Properties of the Environment
- temperature
- pH
- salinity
- kind of solids
- amount of solids
- amount of water
- bacteria

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Properties of the Chemical
- water solubility
- vapor pressure
- Henry’s Law
- acid / base
- charge
- size
- reactivity

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SOILS ARE COMPOSED OF SOLIDS, AIR, AND WATER
SOIL AGGREGATE

- Mineral surface
- Organic matter
- Pore
- Roots
SOIL-CHEMICAL INTERACTIONS

Photo: Karnok, 2003, Australian Turfgrass Management
CHEMICAL CONTROLS ON SOIL-CHEMICAL INTERACTIONS

- Henry's Law constant (~V/S)
- Vapor pressure (V)
- Water Solubility (S)
- Charge and reactivity
EQUATIONS – FOR THE ENGINEERS!

Solids-Water Distribution

\[ K_d = \frac{\text{concentration of the chemical on solid (mg/kg)}}{\text{concentration of the chemical in water (mg/L)}} \]

Air-Water Distribution

\[ K_{aw} = \frac{\text{concentration of the chemical in air (mg/m}^3)}{\text{concentration of the chemical in water (mg/L)}} \]
EQUILIBRIUM DISTRIBUTIONS OF CHEMICALS AMONG SOLIDS, WATER, AND AIR
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CHEMICALS ALSO UNDERGO TRANSFORMATIONS

Microorganism-induced
Plant-induced
Chemical-induced
Light-induced

“Half-life”: time for 50% to be transformed

“Environmental lifetime” of a chemical = 6 half-lives (~1% remains)
GLYPHOSATE

Competes with phosphorous for solid interactions
Strongly interacts with mineral surfaces (Ca, Mg, Fe, Al)
Weakly interacts with organic matter
$K_d$ ranges from 1 to $>1000$ L/kg (depending on soil)
GLYPHOSATE IN AN AGRICULTURAL STREAM

Transported largely in runoff associated with soil particles

Coupe et al., 2012, Pest. Manage.
GLYPHOSATE IN AN AGRICULTURAL DRAIN

→ Quickly transported through soil after rain after application ???

Velkoverh and Capel, in review
GLYPHOSATE: COMPLEX INTERACTIONS WITH SOIL
EXTENT OF GLYPHOSATE ASSOCIATED WITH SOLIDS

- Streams
- Runoff
- Soil
VOCs IN PRINCIPAL AQUIFERs – DETECTION FREQUENCY

Zogorski et al., USGS Circular 1292
TRANSPORT OF VOCs THROUGH THE SOIL TO GW

Pankow et al., 1997, ES&T
CHEMICAL LIFETIME AND DISTRIBUTION

Legacy Chemicals

Capel et al., USGS, in review
Similarities: soil foundation, same transport processes water and solids, sometime similar engineering, ...

Differences: permanent vegetation, tillage, exposed soil, ...