

US EPA ARCHIVE DOCUMENT

Inorganic Leaching Science

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Acknowledgements

■ Sponsors

- Gulf Coast Hazardous Substance Research Center
- Texas Advanced Technology Program

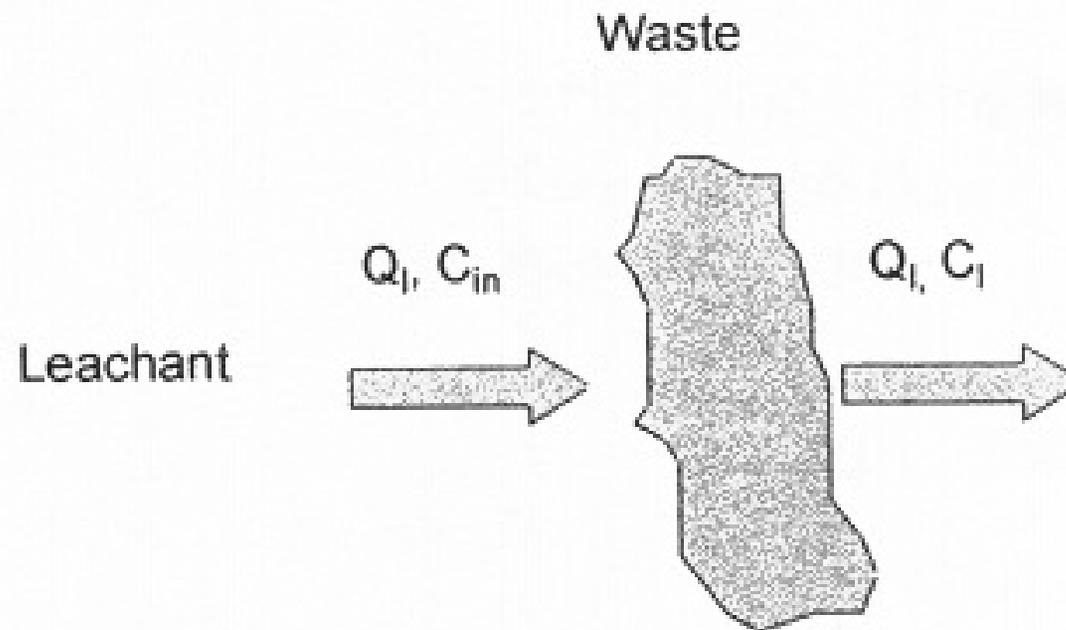
■ Students

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Overview

- Equilibrium/Kinetics (mixed)
- Equilibrium (Fundamental, Applications)
- Kinetics (Fundamental, Applications)

Equilibrium/Kinetics



Equilibrium/Kinetics

■ Leachate Concentration

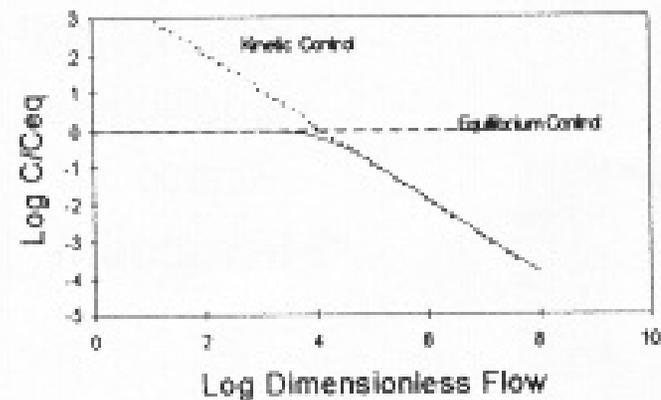
– Equilibrium control

- low Q_1, t
- $C_1 = C_{eq}$

– Kinetic Control

- high Q_1, t
- $C_1 = m_{dot}/Q_1$

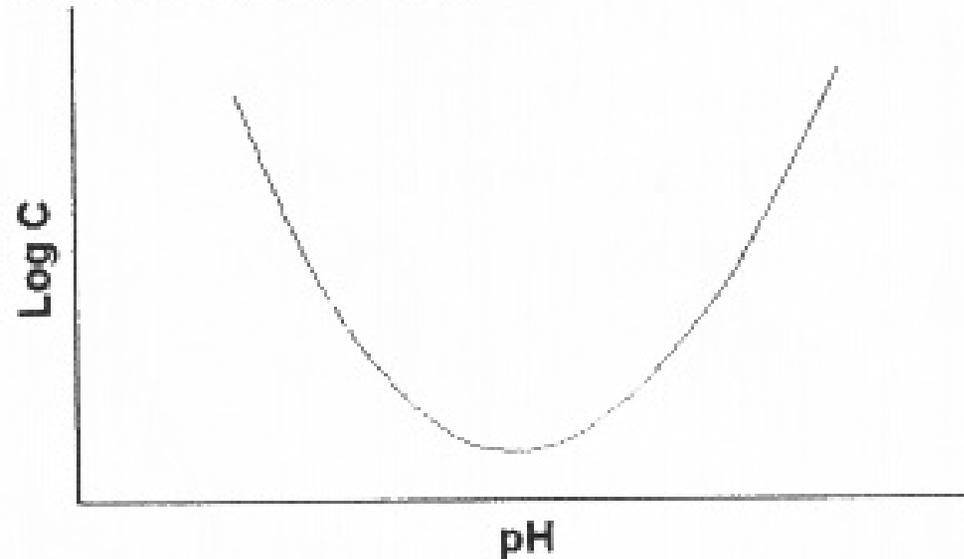
– Mixed Control



Equilibrium-Fundamentals

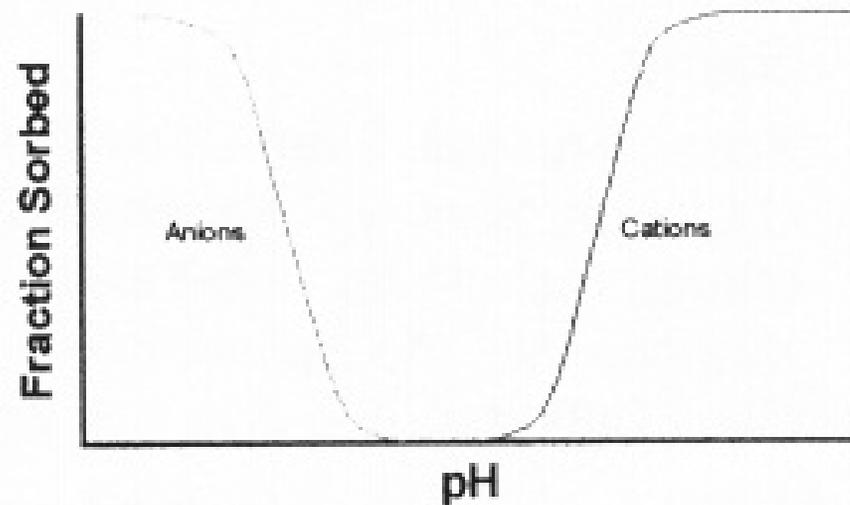
■ Key Factors - pH

- affects speciation reactions
(mobile \leftrightarrow immobile)



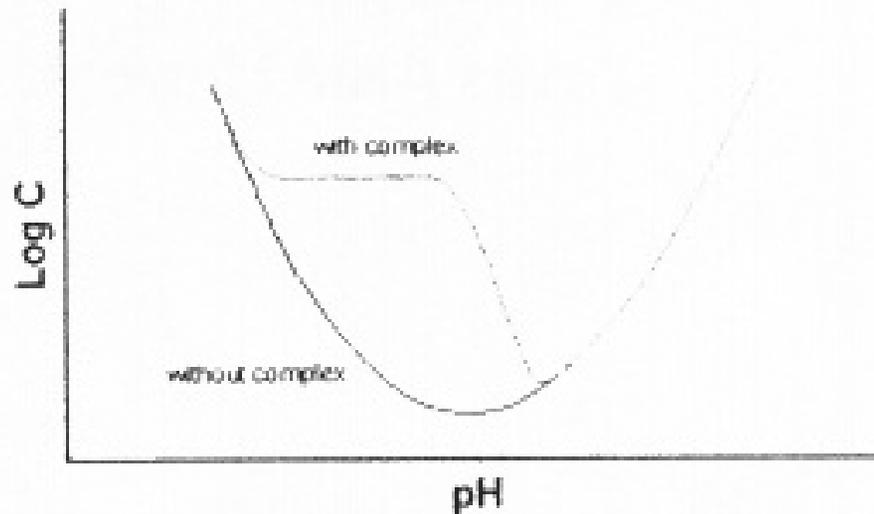
Equilibrium-Fundamentals

- Key Factors - pH
– sorption



Equilibrium-Fundamentals

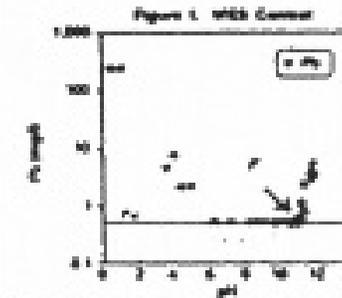
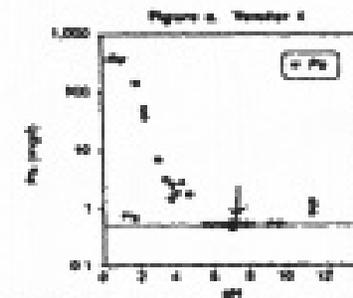
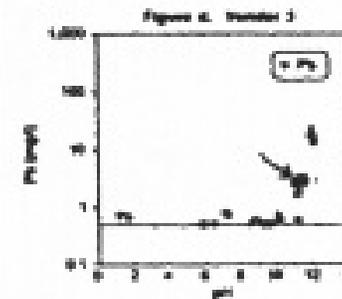
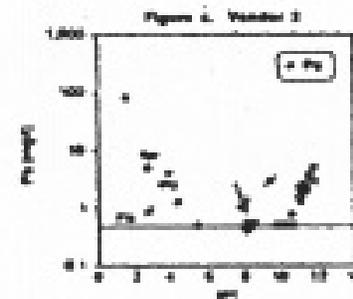
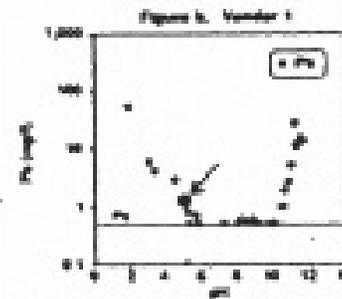
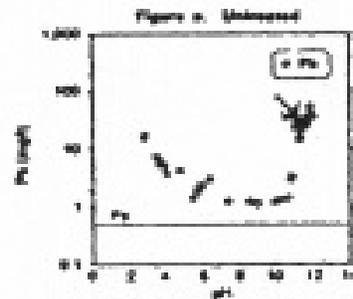
- Key Factors - pH
 - redox transformations
 - complex formation



Equilibrium-Fundamentals

- Key factor - pH
 - pH determined by
 - strength/amount of a/bnc
 - waste
 - leachant
 - L/S

Lead Concentrations as f(pH)

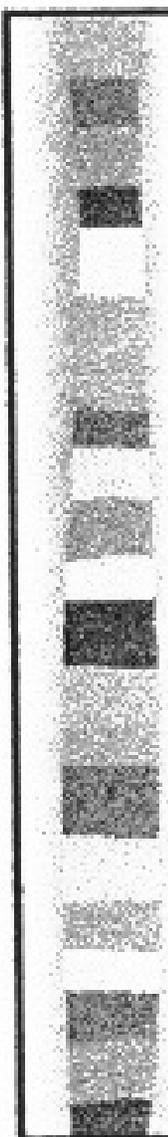




Equilibrium-Fundamentals

■ Other factors

- pe (Eh, redox potential)
- surfaces
- ligands (e.g. citrate)
- metals (e.g. PbCrO_4)



Equilibrium-Applications

■ Leach Test Philosophies

– Fundamental Data

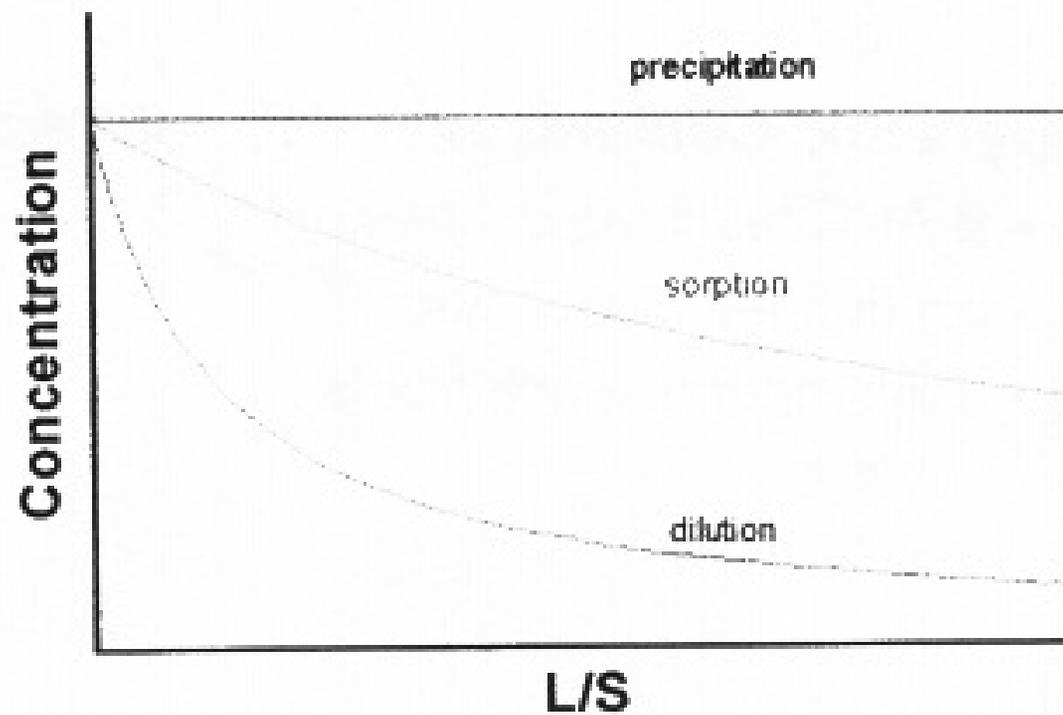
- Equilibrium
- Kinetic

– “Microcosm” (possibly mixed eq/kin)

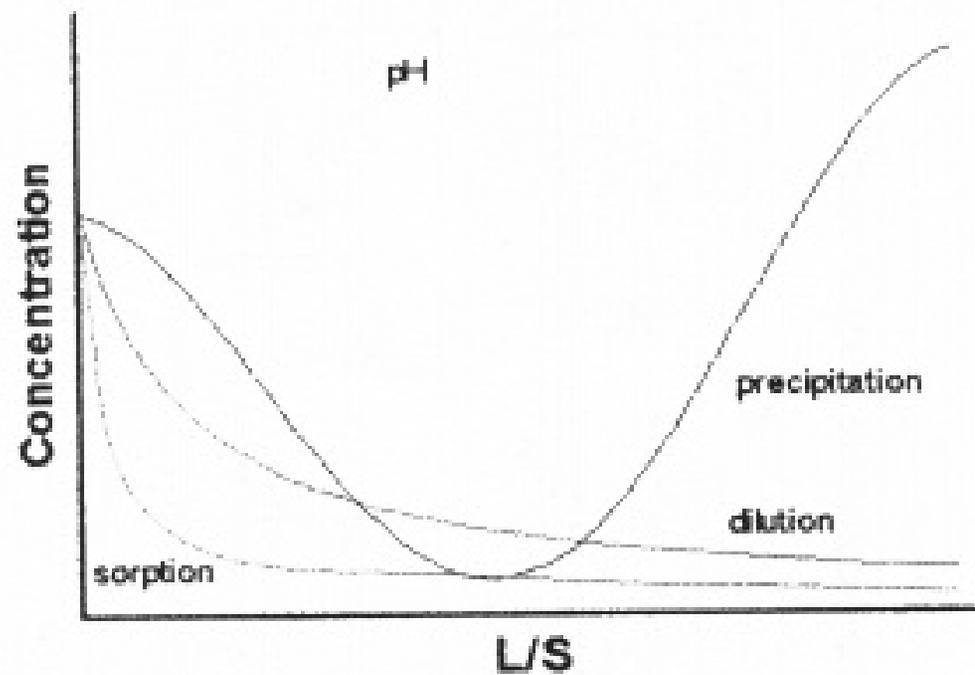
Equilibrium-Applications

- Equilibrium Leach Test - Contaminant Concentration
 - Test characteristics
 - leachant
 - distilled/deionized water
 - simulated (e.g. TCLP, SPLP)
 - series of acid/base solutions (GANC)
 - small particles, long times (speed kinetics)
 - low L/S (avoid dilution)

Effect of L/S (no pH effects)



Effect of L/S (pH effects)



Equilibrium-Applications

■ Equilibrium Leach Test - Available Contaminant

– Test characteristics

- leachant - constant pH (pH 7, pH 4)
- small particles, long times (speed kinetics)
- high L/S (maximize release)

– Result - available contaminant/waste

Equilibrium-Applications

■ Acid Neutralizing Capacity of Waste

– Test Characteristics

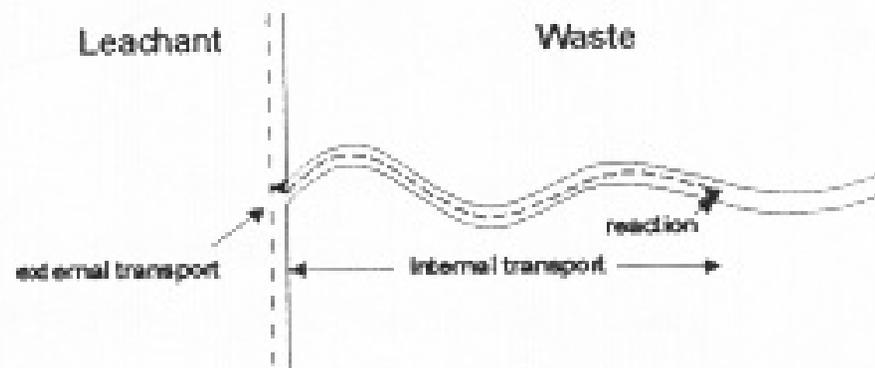
- small particles, long times (speed kinetics)
- high L/S (maximize release)
- leachant (acid/base solutions)

– Results

- A/BNC - amount neutralized as f(pH)
- GANC - contaminant concentration as f (pH)

Kinetics - Fundamentals

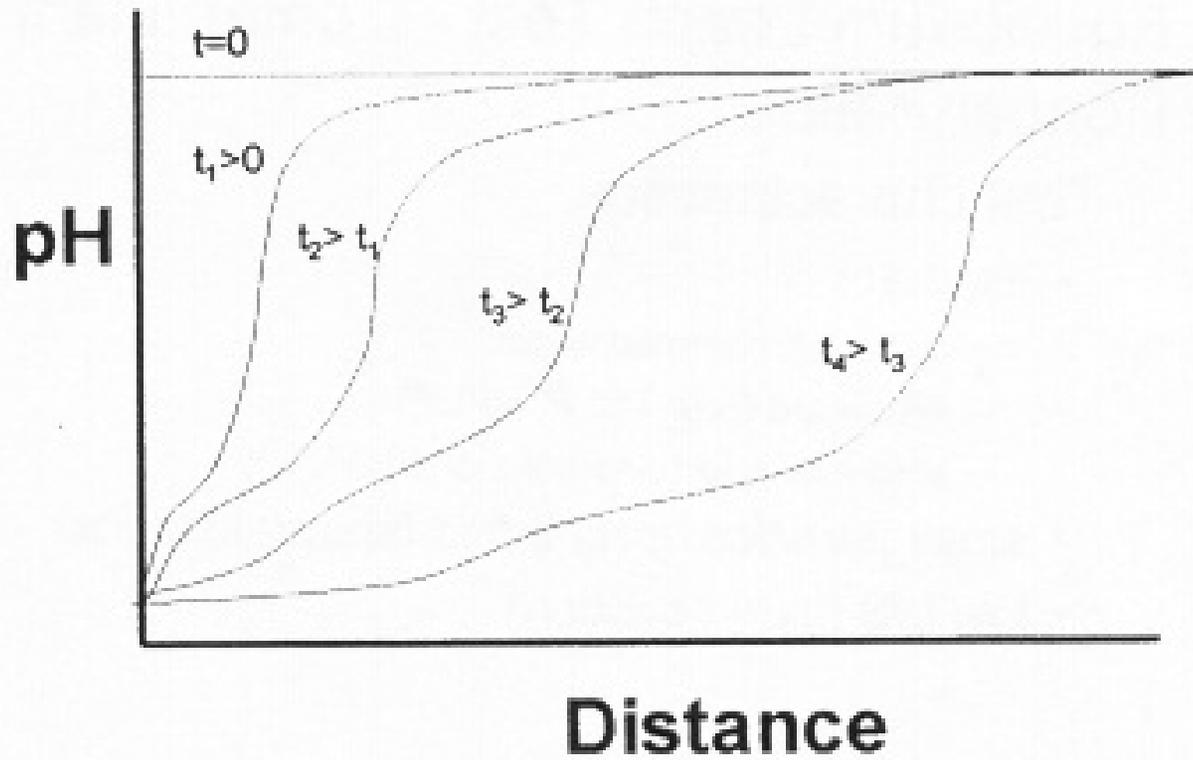
- Kinetics = study of rate processes
 - chemical (speciation)
 - mass transfer (internal/external)
 - combined (controlling step?)



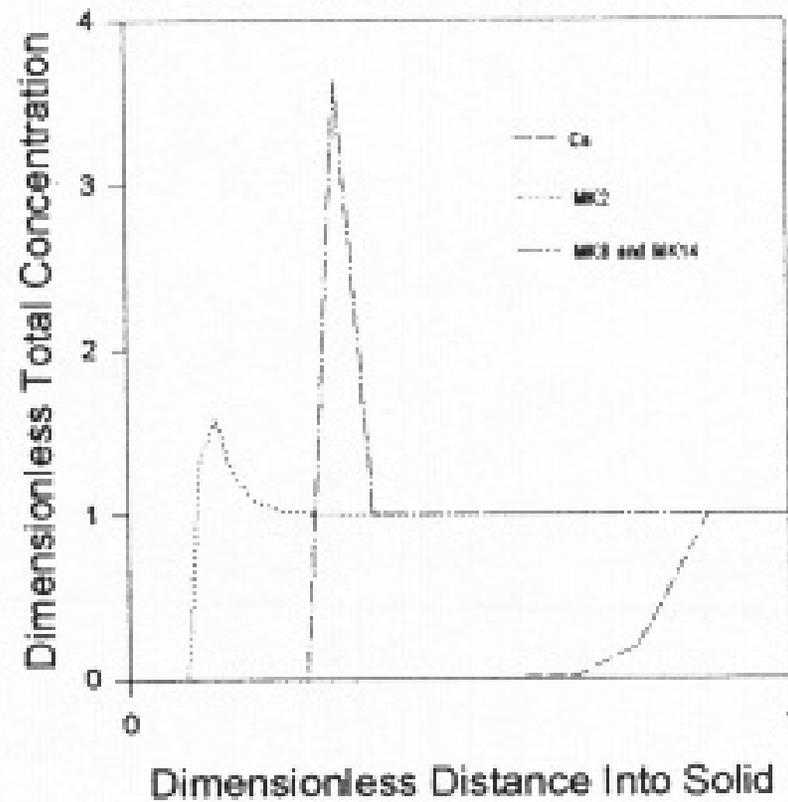
Kinetics - Fundamentals

- Dynamic Contaminant/ANC Interaction
 - B/ANC leaching defines pH
 - pH defines speciation
 - movement of leach fronts
 - b/anc
 - contaminant

pH Profiles



Concentration Profiles



Kinetics - Applications

■ Leach Tests

– Types

- continuous flow
- semi-continuous (leachant replenishment)

– Results: $LI = -\log(D_{obs})$

$$\frac{M_t}{M_0} = \left(\frac{4 D_{obs}}{\pi L^2} \right)^{0.5} t^{0.5}$$

Kinetics - Fundamentals

■ Simple Leach Model

- assume: infinite bath, semi-infinite solid, homogeneous, slab geometry

$$\frac{M_t}{M_0} = \left(\frac{4 D_{obs} t}{\pi L^2} \right)^{0.5} \quad C_{l,kin} = \frac{\dot{m}}{Q_l} = \frac{M_0}{Q_l L} \left(\frac{D_{obs}}{\pi t} \right)^{0.5}$$

M_t = amount leached at time t

M_0 = initial amount available to leach

D^{obs} = observed diffusivity (chemical/physical)

L = volume/external area

Kinetics - Applications

■ Leach Tests

– Types

- continuous flow
- semi-continuous (leachant replenishment)

– Results: $LI = -\log(D_{obs})$

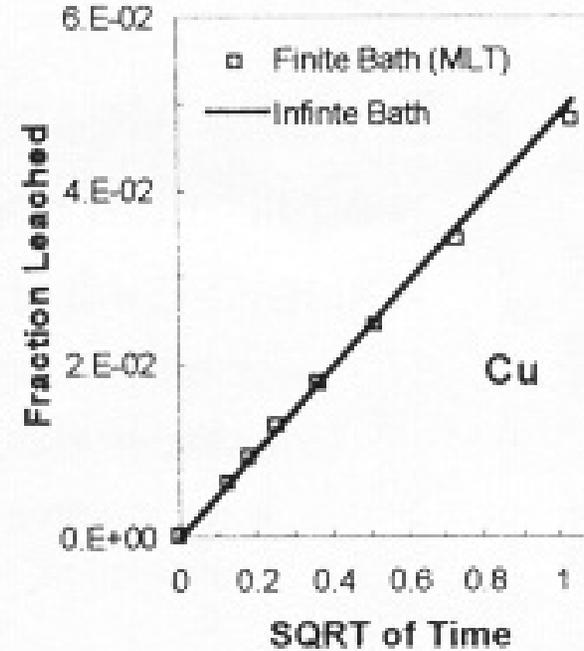
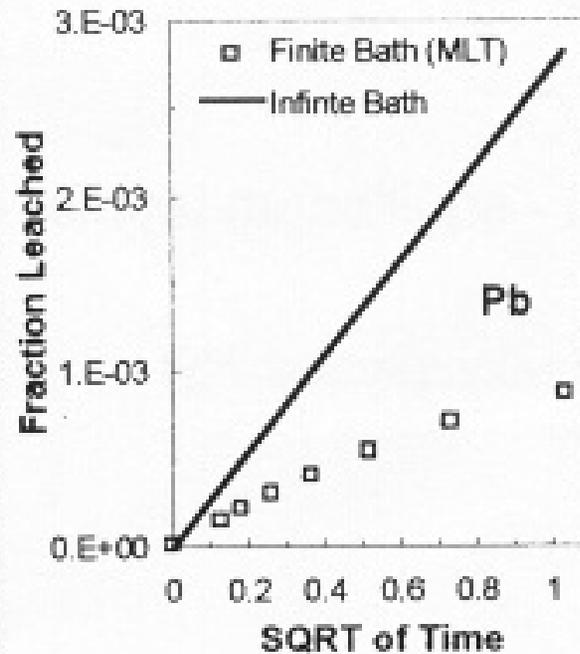
$$\frac{M_t}{M_0} = \left(\frac{4 D_{obs}}{\pi L^2} \right)^{0.5} t^{0.5}$$

Kinetics - Applications

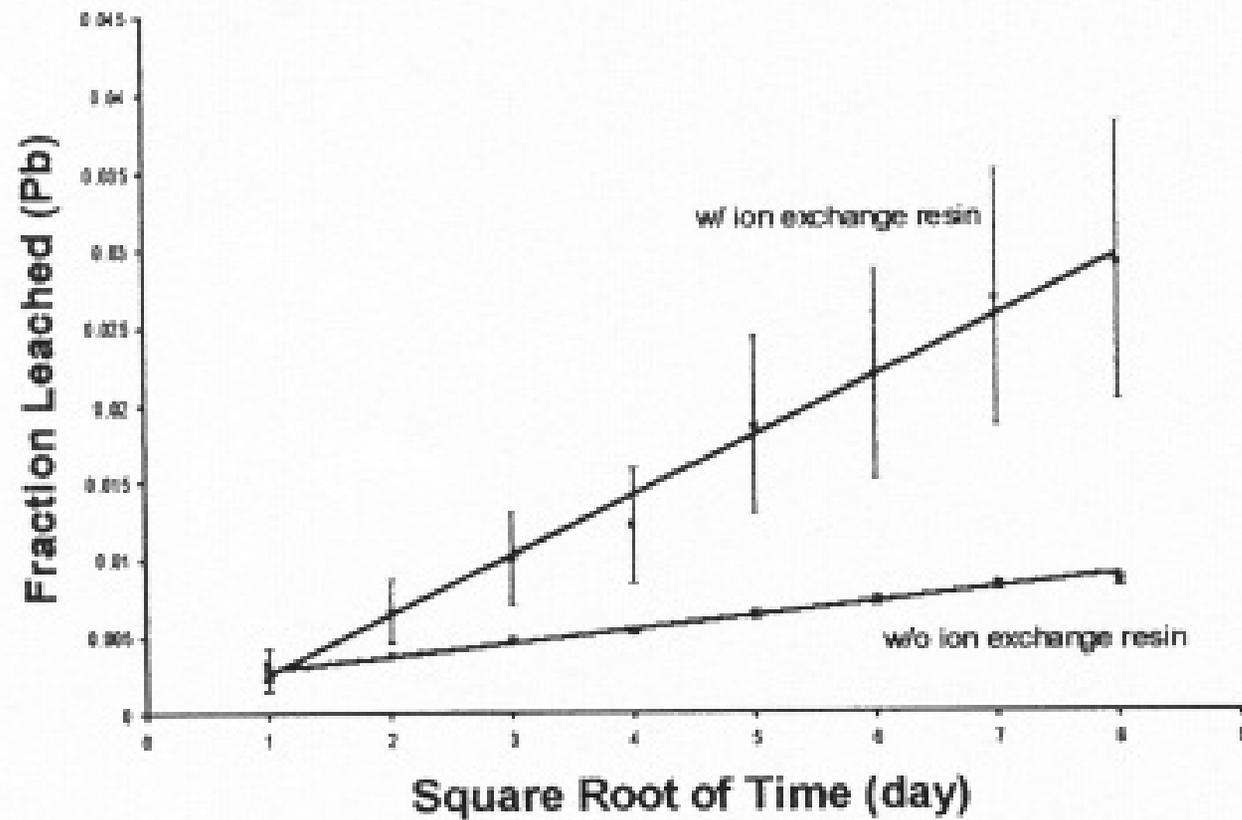
■ Leach Test design

- Q or L/S and t
- Contaminant concentration
 - low for infinite bath (high Q or high L/S, low t)
 - high for analysis (low Q or low L/S, high t)

Effect of L/S (kinetic tests)

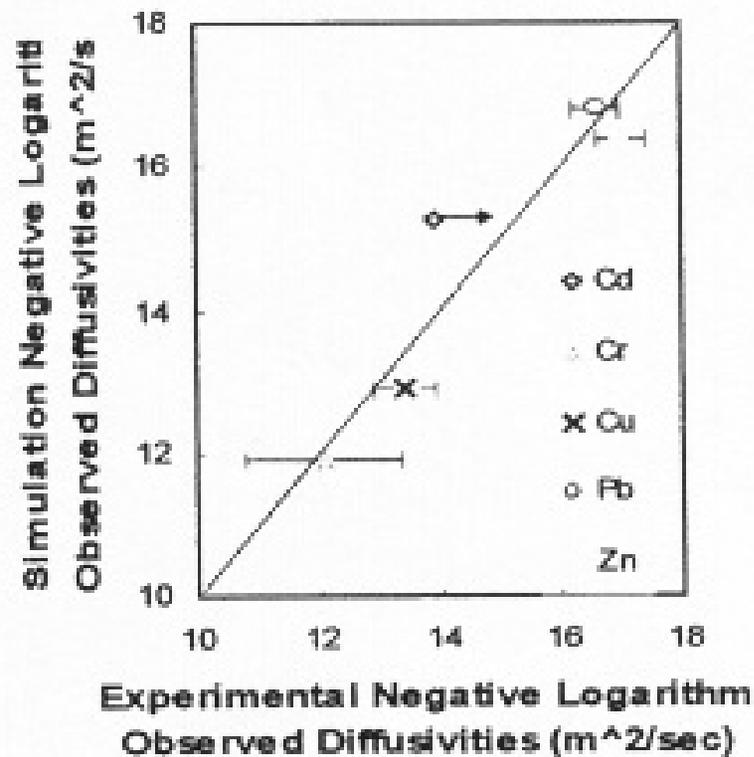


Modified Kinetic Leach Test

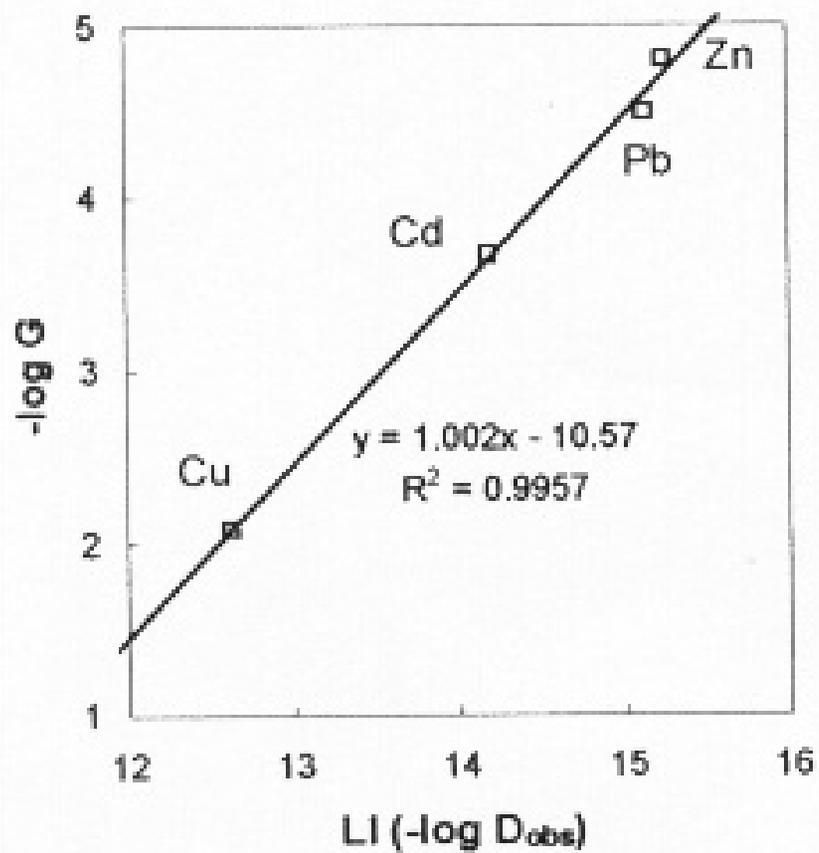


Kinetics - Applications

■ Simulations as Test Replacements



Correlations with D_{obs}





Summary

- Equilibrium/Kinetics
- Importance of pH
- C_1 links test to field

Summary

■ Tests to Measure C_l

- equilibrium control - equilibrium test for C_{eq}
- kinetic control
 - leachable concentration (availability)
 - observed diffusivity
 - measurement
 - simulation