US EPA ARCHIVE DOCUMENT

Adsorption and Release of Contaminants onto Engineered Nanoparticles

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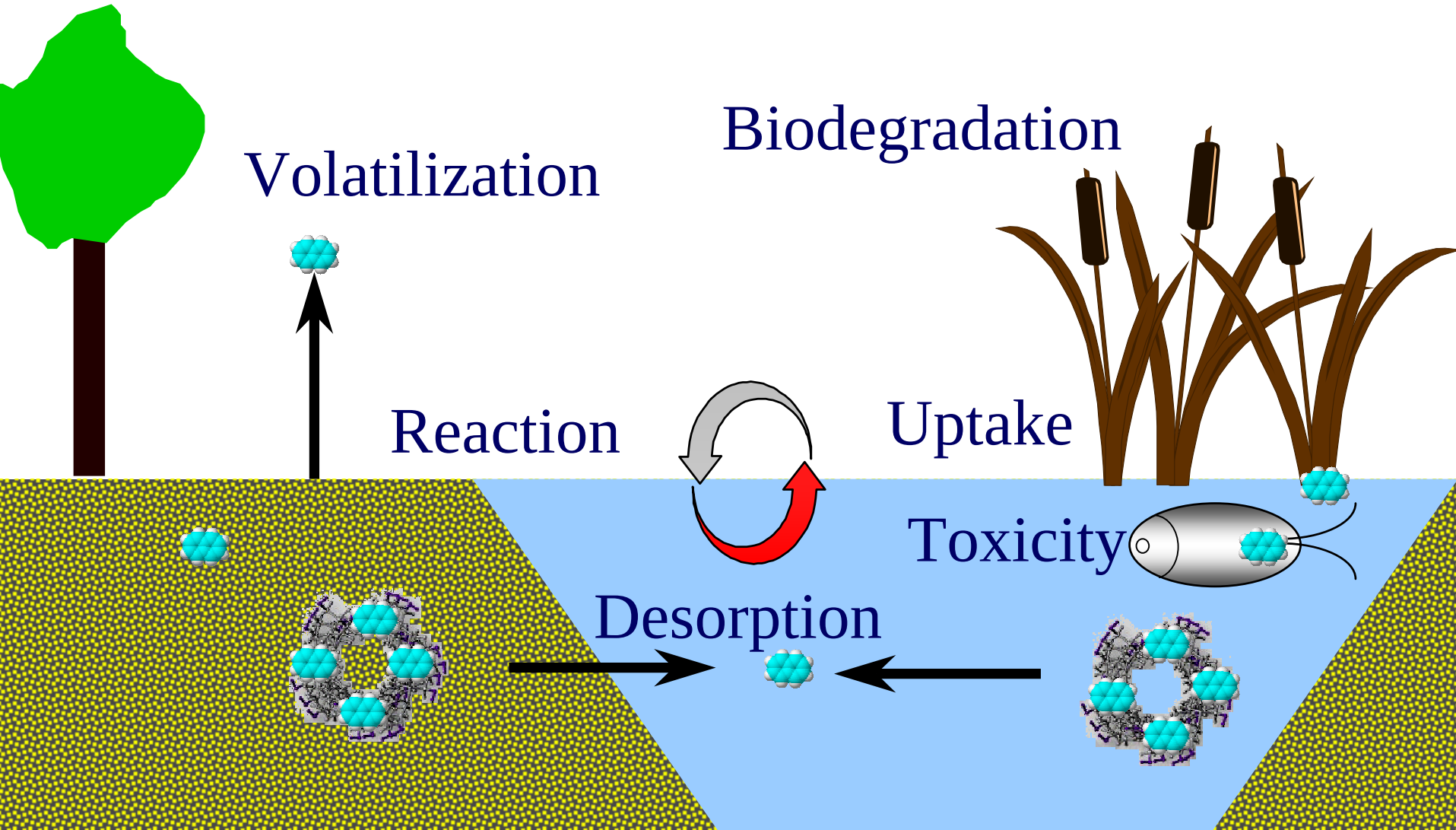
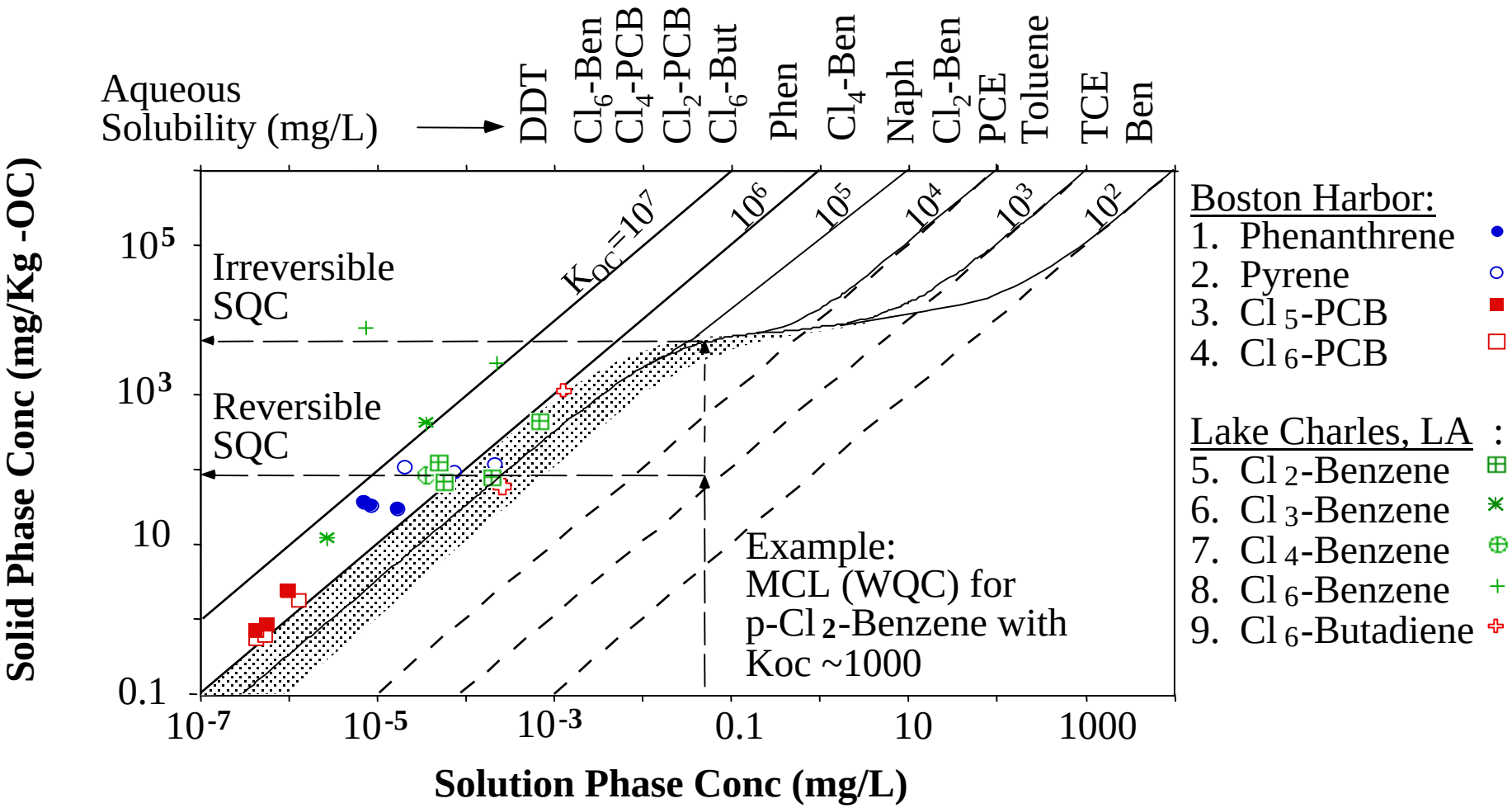
Objective and Benefit

- **Largely Avoidable**: The overarching goal of research proposed is to create the information needed to insure that avoidable deleterious outcomes of nanomaterial production and use never materialize.
- Develop the information needed to predict the risk of nanomaterials.
  - Adsorption and desorption of contaminants.
  - Impact of naturally occurring sorbents, NOM, heavy metals, surfactants.
  - Fate of nanoparticles in soil and water.

Adsorption/Desorption Hysteresis

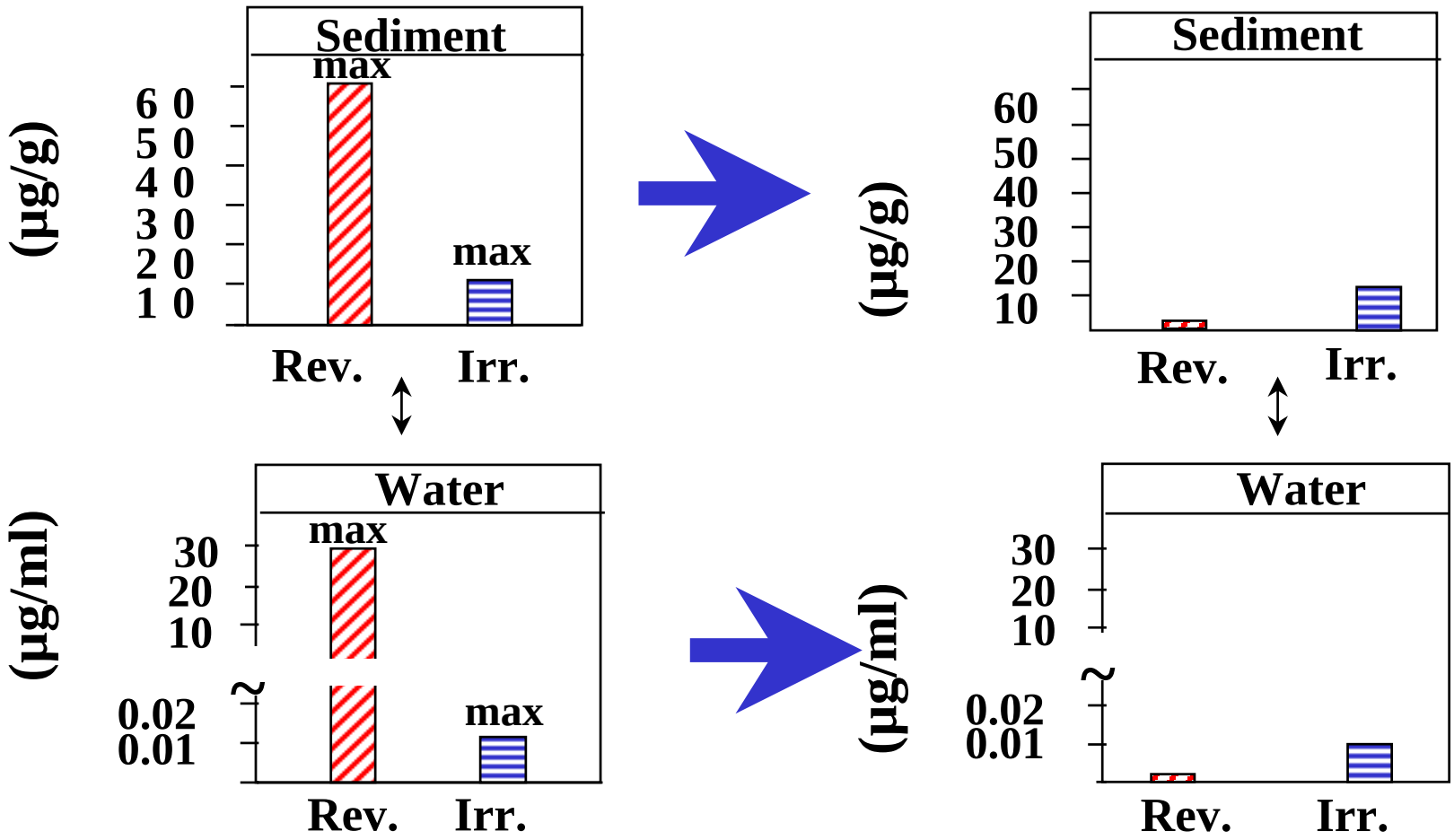


Adsorption/Desorption Hysteresis



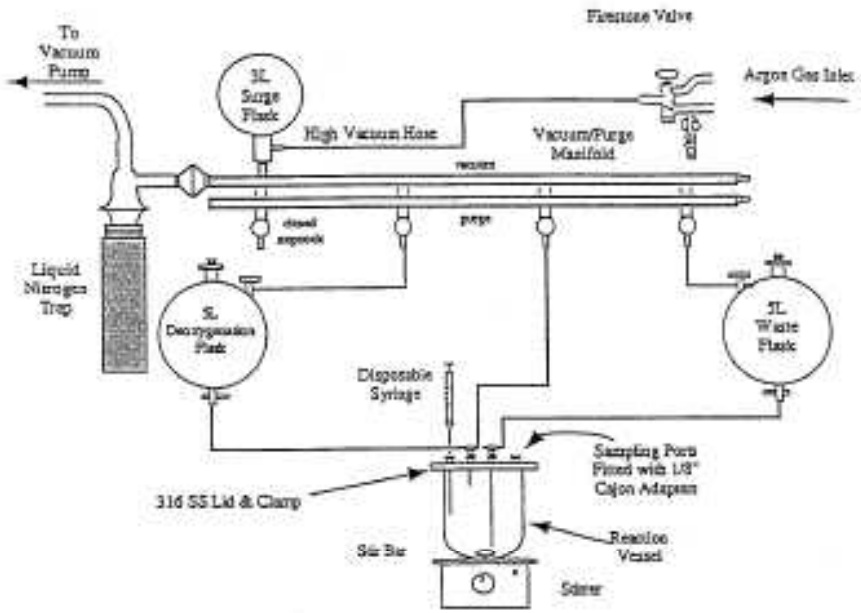
"**Unweathered**, non-remediated, or freshly contaminated"

"**Weathered**, remediated, or aged"

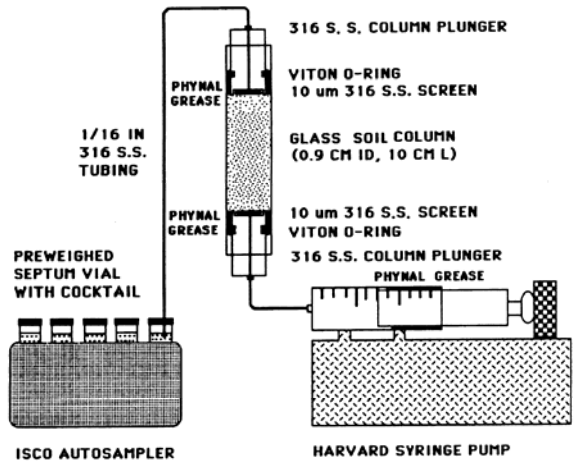


Approach and Methodology

Oxic/Anoxic Batch Apparatus



Column Apparatus



Adsorption of Organic Contaminants from Solution to C_{60} Fullerene

Batch Adsorption/Desorption Study:

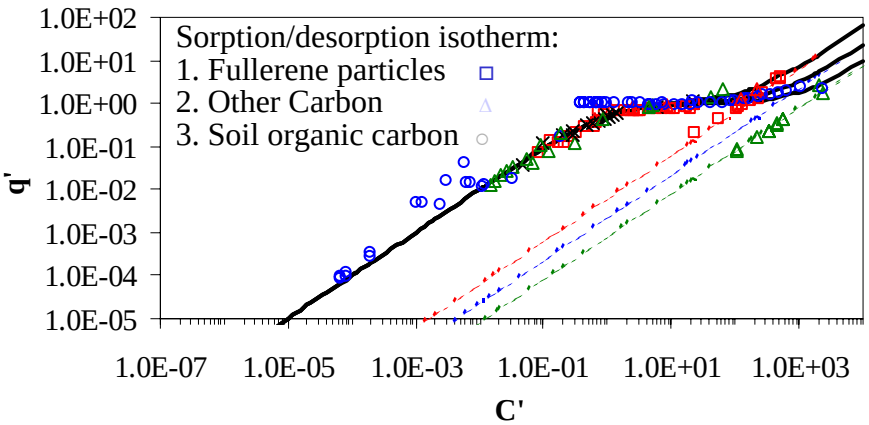
C_{60} large aggregates

C_{60} small aggregates

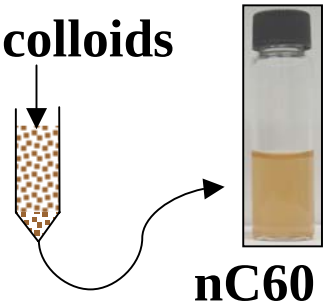
C_{60} colloidal particles

Fate of Contaminants Adsorbed to Carbon Nano-Particles

Will the sorption and desorption of organic compounds to fullerene particles cause enhanced environmental contaminant transport?



nC60 colloids



nC60 is hydrophilic, mobile & nonextractable

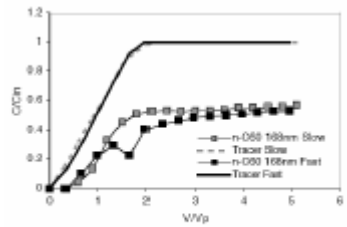
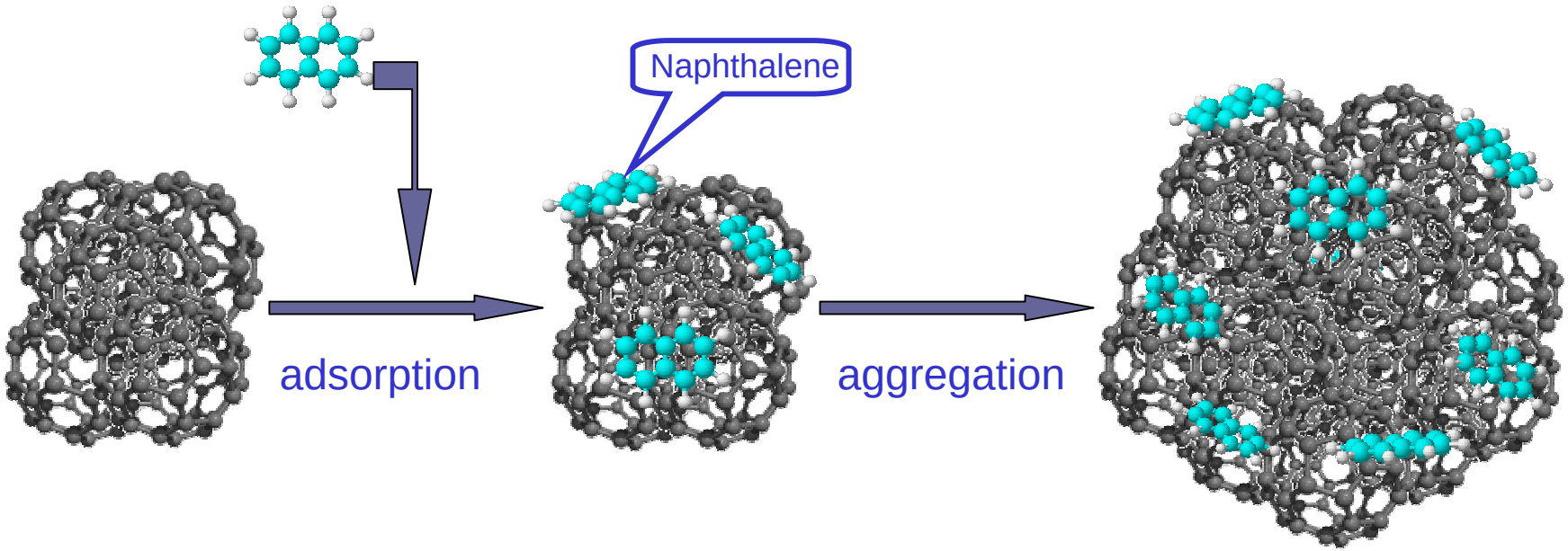


Figure 5.3.21: Breakthrough curves for nano-C_{60} aggregates at two Darcy velocities.

Sorption of organic contaminants to fullerene particles is the same as to soil organic matter and to activated carbon. When fullerene particles migrate, contaminant transport will be enhanced.

(Wiesner, 2004)

What Happened During Adsorption?

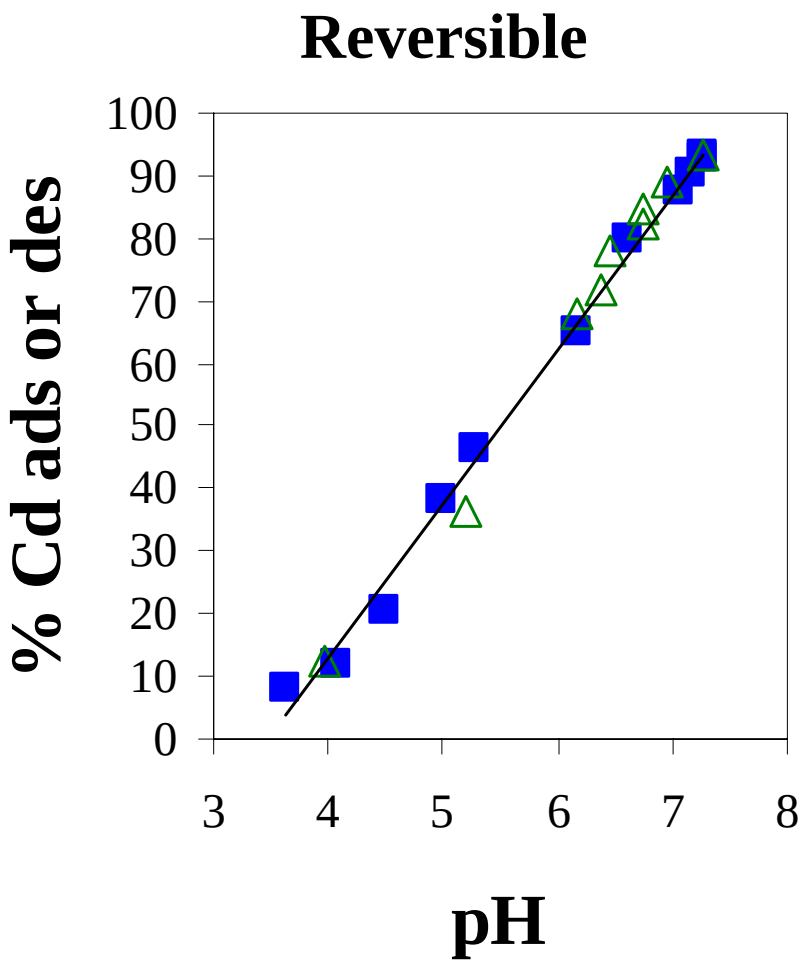


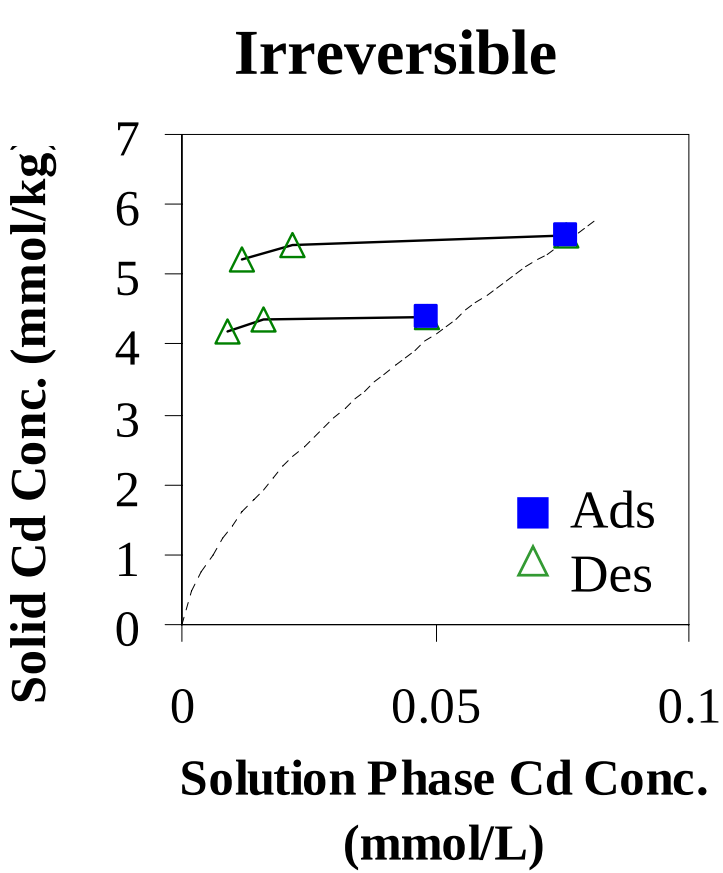
Small Fullerene Aggregates

Naphthalene Adsorption

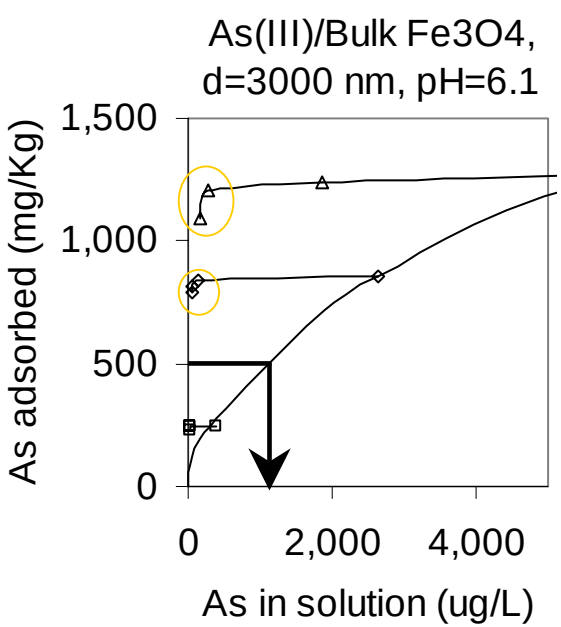
Clusters Aggregation & Naph. Entrapment

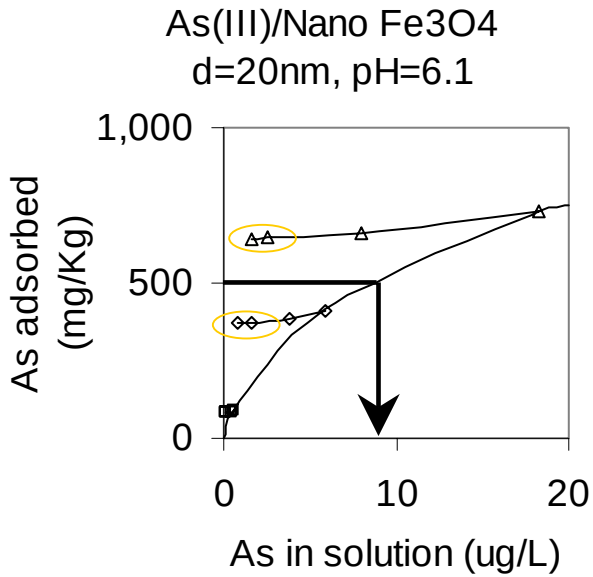
Adsorption/Desorption of Cd to Soil





Sorption/Desorption of As to Magnetite

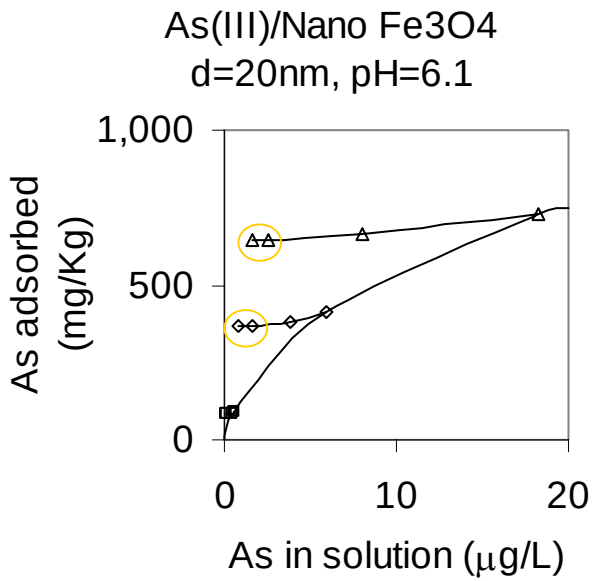




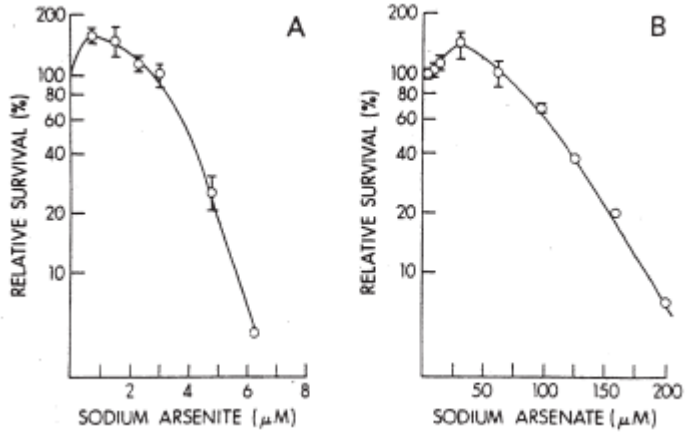
Nano Advantage: Disposal, no desorption bleed-off at low concentration.

New Standards: USEPA (10 μg/L); State of N. J. (5 μg/L)

Hysteretic Desorption and Below Dose No Toxicity Effects



Hormesis Effect: No toxicity at low dose



(Calabres, 2003)

Hysteretic contaminant releases from sequestrated nano-particles may not harmful to the ecological environment.

Nano Advantages: Related to Contaminant Removal and Solids Disposal

- Between 10 and 30 times less solid to remove As (III/V) from water.
- Virtually no bleed-off: Once As (III/V) is adsorbed to nano-magnetite, desorption is orders of magnitude less than from bulk magnetite. This is an enormous disposal advantage.

Mass of Magnetic Needed For Similar Total As Removal

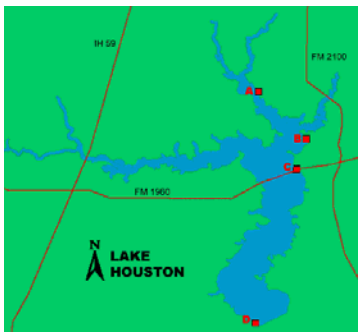
4 nm

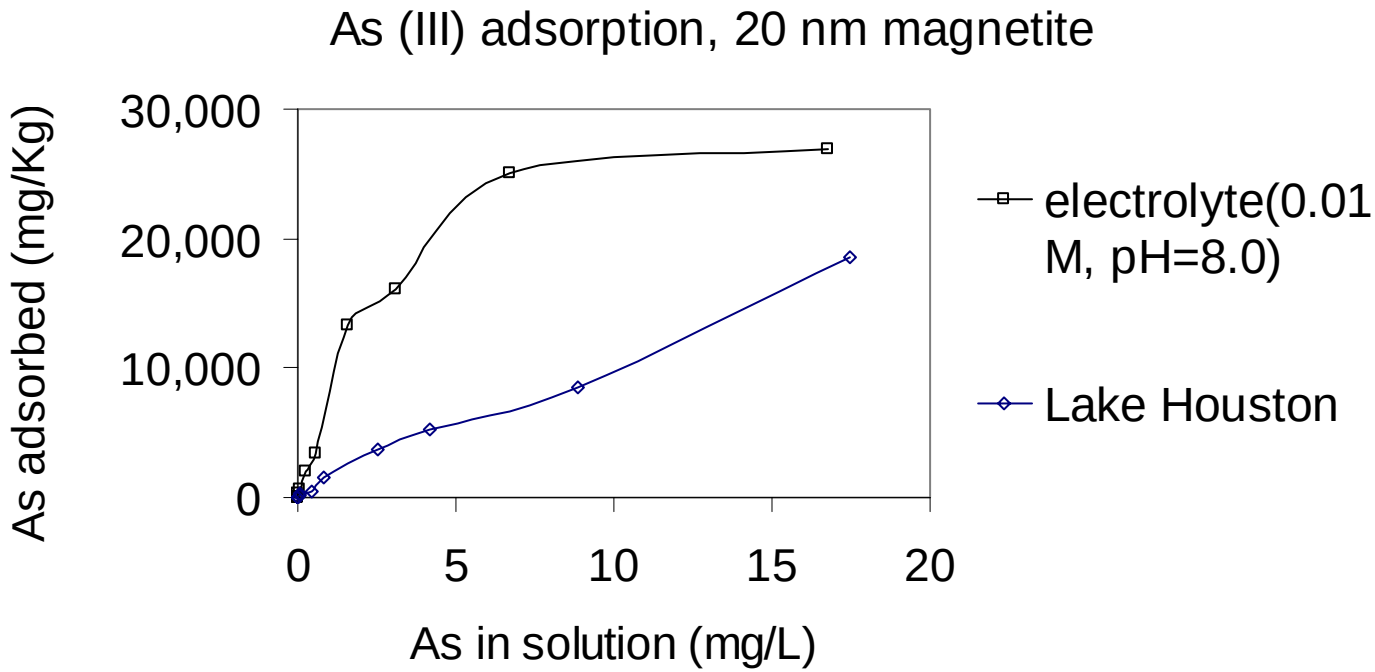
20 nm

3000 nm

Competitive Adsorption - Natural Water

Lake Houston: Drinking water reservoir for Houston





Future research direction: Importance of competative processes, organic matter, other heavy metals, silicates, and various forms of phosphates

Expected Benefits

- Provides the information needed to assess whether this risk is substantial for nanoparticles disposed of in groundwaters.
- Yields the necessary parameters to understand the fate of engineered nanoparticles in the environment.
- Yields the necessary parameters for future development of risk assessment of the engineered nanoparticles.