GeoPractical

GEOPRACTICAL COURSE OUTLINE
ARSENIC CONTAMINATION IN NEW ENGLAND SOIL AND GROUNDWATER

I. Classroom Portion (5 hr):

-Background information, instruction, field examples, and exercises (5 hours total; time estimates for each section given below in *italics*)

We will facilitate four classroom exercises in which course participants will evaluate data in light of the history and geology unique to each site. In small groups, they will plot these data, discuss trends, and evaluate their observations in the context of each site's characteristics. Last, each group will decide on a hypothesis regarding the source of arsenic and propose plans for further data collection if necessary. We will discuss ideas as a class and the instructors will reveal what actions were taken and what was learned.

- Health effects – why the concern for As? (*0.25 hr*)
    - Field examples: Bangladesh; Granite Falls, WA
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- Regulatory standards (*0.25 hr*)
    - Federal: Maximum Contaminant Limit (MCL) for groundwater
    - MA and CT: MCP and RSR standards for soil and groundwater
    - Other states: NH, ME, NY, RI summaries

- Geochemical controls on As mobility (*1 hr*)
    - Speciation in solution (oxidation states, organoarsenic complexes)
    - Adsorption by hydrous ferric oxide and other mineral surfaces, desorption, reductive dissolution
    - Precipitation/dissolution of arsenic-bearing solids and mechanisms responsible for both
    - Redox (oxidation-reduction potential or ORP) conditions, natural and anthropogenic influences on redox conditions
    - Field example: Massachusetts landfill site
    - Classroom exercise: Participants will be given a set of groundwater arsenic and ORP data. They will be asked to construct a plot with these data and develop conclusions regarding the influence of redox conditions on arsenic mobility. Based on the classroom discussion and this exercise, they will acquire some understanding of the geochemical processes that affect arsenic behavior, particularly under strongly oxidizing or reducing conditions.

- Sampling and analysis: analytical methods (including potential pitfalls); detection limits; interferences (*0.5 hr*)
    - Field example: Connecticut coastal site with seawater intrusion.
    - Classroom exercise: Participants will examine a data set from a coastal site and construct plots from which they will formulate a defensible explanation for apparent exceedances of regulatory standards.

- Transport (*0.25 hr*)
  - Ensure familiarity with processes and terminology (advection, dispersion, reactions, etc.)
  - Application of transport modeling to arsenic contamination scenarios.

- Sources of contamination (*1 hr*)
  - Naturally occurring: Geology -- the "New England Arsenic Belt," sulfide mineralization in bedrock; occurrence in overburden due to glacial comminution, oxidation, aqueous transport/dissolution/precipitation
    - Field example: Eastern Massachusetts school site
    - Classroom exercise: Given what participants know at this point regarding arsenic geochemistry, they will develop a conceptual model that is consistent with the site history and local geology. As a group, we will discuss why the MA DEP concurred that the soil As was naturally occurring.
  - Anthropogenic releases (pesticides, rodenticides, manufacturing, mine tailings, smelters, coal ash, widespread historical agricultural use in New England)
    - Field example: Massachusetts manufacturing site
  - Indirect anthropogenic effects: e.g., creation of reducing groundwater conditions by addition of electron donors from release of organic contaminants; consequent mobilization of naturally occurring As.
    - Field example: large chlorinated solvent plume undergoing remediation
    - Classroom exercise: Participants will receive long-term monitoring data and highlights of the site history. In small groups, they will propose cause(s) of arsenic contamination and additional analytes that should be collected to support their hypothesis.

- Site-to-Background Comparisons (*1 hr*)
  - What is background (soil, groundwater)?
  - How to discriminate anthropogenic contributions
    - Field example: Devens soil background study
    - Classroom exercise: Massachusetts landfill site (As in groundwater w/excess Fe); Southeast U.S. former cattle grazing site (As in soil, excess As). Data sets from both sites will be provided; participants will discuss and develop plausible explanations for the anomalous concentrations.

- Remediation (PRBs, excavation, ISCO, foster sulfide precipitation, iron sulfate addition, etc.) (*0.75 hr*)

LUNCH (0.75 hr)

II. Field Trip to Shepley's Hill Landfill (SHL) (3 hours total; subtotals given below in italics)

- Stop 1: Shepley's Hill (*1.5 hr*)
  - Observation of bedrock
  - Discussion of fracture network and groundwater flow and discharge beneath landfill

- Stop 2: Overview of monitoring well network

- Stop 3: Slurry wall preventing groundwater discharge to Plow Shop Pond

- Stop 4: Red Cove sediment remediation. Discussion of SHL hydrology (water discharging to the cove, "hinge line" and recharge to downgradient groundwater)

- Stop 5: Tour of arsenic treatment plant (*0.75 hr*)

- Stop 6: Moore Army Airfield ("induced arsenic") (*0.75 hr*)

COURSE DESCRIPTION

The purpose of the proposed course is to educate participants on the topic of arsenic contamination in New England. We will examine sources and processes resulting in mobilization to groundwater and surface water. The course content will focus broadly on three key areas involved in arsenic contamination at sites across the northeastern states:

- Naturally occurring arsenic, derived from arsenic-bearing minerals in bedrock, distributed through overburden sands and gravels by glacial and post-glacial physical and geochemical processes;

- Anthropogenic arsenic, resulting from historic use and/or disposal of arsenic in agricultural and industrial applications;

- Arsenic that has a naturally occurring source but is mobilized by anthropogenically induced geochemical processes (e.g., impact of landfill leachate).

Course structure will consist of classroom instruction, a field trip to local arsenic-contaminated sites, and in-class activities based on these and other locations that will facilitate participants' ability to develop strategies for site characterization, interpretation of data, and formulation of an appropriate site-specific conceptual model. Participants will need to bring a laptop with Excel or a similar spreadsheet program.

INSTRUCTORS

Carol L. Stein, PhD: Carol has over 30 years of experience in a range of environmental investigations. She was a research scientist for Sandia National Laboratories on the nation's radioactive waste isolation programs, and subsequently was on the faculty of the School of Oceanography at the University of Washington. She has worked for environmental consulting firms, with emphasis on geochemical aspects of soil and groundwater contamination. She holds graduate degrees in geochemistry (MA, PhD: Harvard).

David F. McTigue, PhD: Dave has over 30 years of experience in environmental research and applications. He worked on US radioactive waste isolation programs at Sandia National Laboratories, and taught hydrogeology at the University of Washington. He then entered the environmental consulting field, where he focuses primarily on groundwater flow and contaminant transport. He holds graduate degrees in engineering (MS: Stanford) and geology (PhD: Stanford).