Team Science in a Summer Undergraduate Fellowship: Field Sampling for Metal Contamination in the Raritan River

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Abstract

Summer internships provide undergraduate students with intensive one-on-one training experiences in the laboratory. At Rutgers University, we sought to extend this training to promote scientific collaboration and networking through team-based field sampling. During the 2019 Summer Undergraduate Research Fellowship (SURF) Program, twelve undergraduate students collected surface water from the Raritan River aboard the R/V Rutgers following completion of interactive classroom sessions on heavy metal contamination. The river has a history of extensive pollution from industrial facilities and includes multiple Superfund sites along its shore. In collaboration with the Marine and Coastal Sciences program, surface water was collected in duplicate at 6 sites between New Brunswick, NJ and the Raritan Bay. Students kept field notes on sample characteristics as well as weather and water conditions. ICP-MS analysis revealed a large range of metals concentrations in the sampled surface water. Lithium (mean: 33.0 ppb), barium (mean: 20.8 ppb), and arsenic (mean: 16.2 ppb) were the most abundant metals analyzed, while lead (mean: 0.06), cadmium (mean: 0.02 ppb), and cobalt (mean: 0.48 ppb) were the least abundant. Notable changes in metal concentrations were observed in relation to whether samples were collected near and away from industrial and landfill sites, and may provide clues on the primary sources of contamination. Concentrations of lithium, vanadium, chromium, cobalt, nickel, copper, arsenic, cadmium, cesium, and uranium increased up to 14-fold in samples collected between the Edison landfill and Sayreville brownfield, with an overall trend of increasing concentrations toward the Raritan Bay. By comparison, barium decreased toward the Raritan Bay, while lead was highest upstream from the major contamination sites, but remained constant throughout the remaining the stretch of river. Participants rated the surface water sampling activity highly (mean rating = 4.6, SD 0.5) on a Likert scale of 1-5. The students' overall impression of fieldwork was that it was fun to perform research outside, and that the experience provided tangible relevance of toxicology to their lives. *Supported by the SOT Intern Program, R25ES020721, P30ES005022, and T32ES007148.*

Objectives

- Engage undergraduate students in a community-based environmental health project through fieldwork and community outreach.
- Establish a connection between sampling site selection and the outcomes of laboratory analyses.

Background

Pollution in the Raritan River:

Landfill along Raritan River: This image shows the notorious Kin Buc Landfill where pesticides began to seep into the river in the 1970s.

- The Raritan River is the longest river solely in New Jersey
- Over 200 contaminated sites including abandoned industrial sites, Superfund sites, and landfills are adjacent or drain into the river
- These sites contribute to the Raritan River being recognized as the 12th most polluted river in the U.S.
- Twelve undergraduate students collected surface water from the Raritan River following completion of interactive classroom sessions on heavy metal contamination

Project Goal:

- Foster scientific collaboration and networking among undergraduate students participating in the Summer Undergraduate Research Fellowship Program and field scientists through team-based field sampling

Acknowledgements

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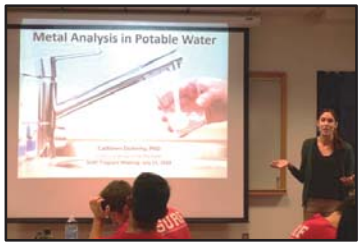
Field Sampling



Fieldwork training: SURF students learned how to analyze water samples for metal contamination from Rutgers EOHSI analytical chemist, Dr. Doherty (left) and how to measure salinity, oxidation reduction potential, and temperature in real-time from Rutgers Center of Ocean Observing Leadership Marine and Glider technician, Nicole Waite (right).

History Lesson: Captain of the R/V Rutgers (left), Chip Haldeman of the Rutgers Center for Ocean Observing Leadership Marine Operations team provided a history lesson about contamination of the Raritan River (right). Photo of the R/V Rutgers courtesy of Rutgers School of Environmental and Biological Sciences (https://marine.rutgers.edu/about-us/facilities/r-v-rutgers/).

Water quality assessment: Students worked in teams to measure water quality parameters including salinity, oxidation reduction potential, and temperature using a portable meter.

Water sample collection: Students collected surface water samples in duplicate at six locations along the Raritan River between New Brunswick, NJ and the Raritan Bay. Students kept field notes on sample characteristics as well as weather and water conditions

Analytical Methods

Classroom Instruction: Dr. Cathleen Doherty explaining analytical chemistry techniques for metals analysis.

Sample Prep: Acid leaching samples in nitric acid (HNO_3) to mobilize and extract metals from the samples

Microwave digestion system: used to enhance the leaching of metals from the collected samples.

Sample Analysis: Metal concentrations were quantified via Inductively Coupled Plasma Mass Spectrometry (ICP-MS) using a Nu Instrument Attom.

Results

Abundance	Element	Mean (ppb)
Most	Lithium	33.0
	Barium	20.8
	Arsenic	16.2
Least	Lead	0.06
	Cadmium	0.02
	Cobalt	0.48

Metals Concentration along Raritan River:

- We observed a large range of metals concentrations in sampled surface water (left).
- Notable changes in metal concentrations were observed in relation to whether samples were collected near and away from industrial and landfill sites and may provide clues on the primary sources of contamination.
- Concentrations of lithium, vanadium, chromium, cobalt, nickel, copper, arsenic, cadmium, cesium, and uranium increased up to 14-fold in samples collected between the Edison landfill and Sayreville brownfield, with an overall trend of increasing concentrations toward the Raritan Bay.
- Barium decreased toward the Raritan Bay, while lead was highest upstream from the major contamination sites but remained constant throughout the remaining the stretch of river.

Participant Response:

- Twelve undergraduate students participated in this fieldwork experience and rated the activity highly (mean rating = 4.6, SD 0.6, Likert scale of 1-5).
- Overall response was that it was fun to perform research outside, and that the experience provided tangible relevance of toxicology to their lives.