Analysis of Selected Metals in Groundwater and Soil on Byers Island near Sunbury, Northumberland Co., PA

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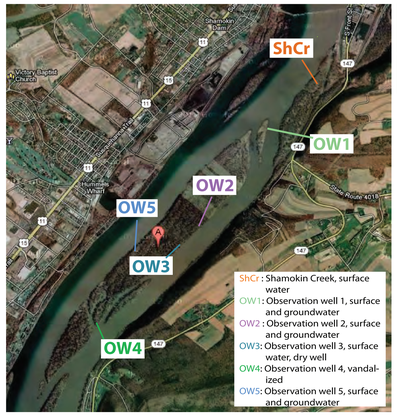
Abstract

A group of faculty and students at Bloomsburg University have been sampling the Susquehanna River near the confluence of the West and North Branch for the past several years. During the first round of sampling, elevated concentrations of metals were documented in Susquehanna River water samples collected near Byers Island—a large island in the Susquehanna between Sunbury and Selinsgrove, Northumberland Co., PA. Additional work indicated that the island was the most likely source of these metals, but confirmation in the form of groundwater and soil analyses was lacking. In late summer 2012, soil, groundwater, and surface water samples were collected in and around Byer's Island to identify what could be causing the elevated levels. Due to concerns with nesting bald eagles, the sampling process could not begin until after the nesting season ended on August 1. Travelling by canoe, we collected water and soil samples on Byers Island and adjacent surface water samples. Using a hand auger, 5 wells were installed along the shore of the island; one well was placed above the low-head dam and the subsequent 4 were placed below the dam, three on the east side of the island, where metals level had been elevated, and one on the west side. Soil samples were collected from each well drilled; selected samples were sent to Hawk Mountain Laboratories for further analysis. Surface water samples were also collected at the mouth of Shamokin Creek, and soil samples were collected on the ridge that rises above the east bank of the river, near entrances to the long abandoned Doughty Lead-Zinc Mine. Analyses were run for metals, anions and cations in the lab, as well as alkalinity and acidity using the Hach 8203 and 8201 respectively. The soil samples were all analyzed by X-ray Fluoresence (XRF) in the field. A few minor complications were faced when we went out to sample from our well, especially for the second round of sampling. One well was vandalized before we could sample (OW4) and another was too dry to pump a useful sample from it. Our search found no obvious sources for elevated levels of lead or copper in the Susquehanna River. Field and lab soil analyses, however, as well as groundwater samples from Byer's Island do show moderately elevated levels of manganese.

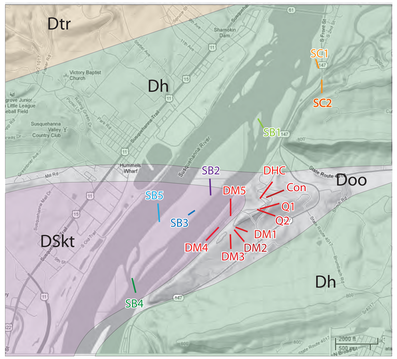
Background Information and Objectives

Transporting equipment over the low-head dam

The Susquehanna River Heartland Coalition for Environmental Studies has, for the past several years, funded collection and analysis of water from the Susquehanna River to determine levels of dissolved constituents and help establish a baseline against which surface water affected by hydraulic fracturing or flowback water may be identified. Drs. Christopher Hallen and Cynthia Venn of Bloomsburg University, along with several undergraduate summer research students, have conducted this sampling in the North Branch, West Branch, and Main Stem Susquehanna since summer 2009. During their first round of sampling, elevated concentrations of metals including lead, manganese, and copper were documented (Eyerly et al., 2010) in Susquehanna River water samples collected near Byers' Island—a large island in the Susquehanna between Sunbury and Selinsgrove, Northumberland Co., PA . Additional work indicated that the island is the most likely source of these metals, but confirmation in the form of groundwater and soil analyses was lacking (Kaldon et al., 2010, Ochal et al., 2011, Reed et al., 2012). A variety of potential sources of metals were evaluated for this study. In the initial survey, lead levels were highest along the east bank of the Susquehanna river south of its confluence with Shamokin Creek . Aerial photos going back to the 1930s suggest that input from Shamokin creek may stay relatively unmixed near the east bank of the river along the length of the island. Recent analyses of fish in Shamokin Creek (Cravotta and Kirby, 2004), however, did not detect elevated lead levels. A literature review turned up documentation of an old (mid-late 1800s) lead-zinc mine on the east side of the river, across from Byer's Island (Rogerson, 1976). Exploration of the ridge revealed several locations that may be related to mining, and soil samples were collected and screened for metals using a handheld ThermoScientific Niton XL2 Series handheld X-ray Fluorescence instrument.



Soil Samples



Dtr: Trimmer's Rock Fm.
Dh: Hamilton Gp.
Doo: Onondaga and Old Port Fms.
DSkt: Keyser and Tonoloway Fms

DHC: Downhill Concrete
Con: Concrete Structure
Q#: Quarry
DM#: Doughty Mine
SB#: Soil boring
SC#: Shamokin Creek

Soil Conditions

Silt bank at OW3 (source of high manganese?).

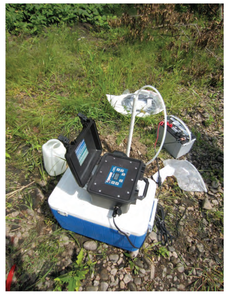
The soil type found on Byer's Island as described in the Soil Survey of Northumberland County Pennsylvania is Uf, or Udifluvents and coal overwash (Eckenrode, 1985). Uf soils are generally deep, have a slope of 0-3 percent and are excessively drained to moderately well drained. There are 20 to 40 inches of black, sand/silt size coal particles overlying 1 to 6 inches of silt or sandy loam. The substratum is composed of loam or sandy loam and descends to a depth of 60 inches or more. Uf soils have a moderate to rapid permeability but the available water capacity is moderate to low. Historical records (Brainerd et al., 1798) indicate the island was part of a large native american settlement and aerial photos indicated that the north half of the island was used as farm land at least through the late 1930s. Shallow soil in the farmed area was analyzed in the field with XRF. On the banks of the island, a three-layer stratigraphy was observed, a steep, silt bank underlain by a 6-12-inch dark clay-rich layer, followed by more silty sand underlain by a poorly sorted mix of sand and rounded gravel to cobbles.

Top: Looking at Southwest end of ridge where Doughty Mine samples were collected.
Right: Heavily vegetated area where Quarry samples were collected

Methods

Sampling

A hand auger was used to drill sample wells on the shoreline of Byer's Island. Soil borings were placed on plastic sheeting as they were removed from the boerehole, logged, and screened with a hand-held XRF to determine whether any intervals had elevated metals. At least one soil sample was collected from each boring, with preference given to those intervals showing elevated metals. Three representative samples were sent to Hawk Mountain Labs for further analysis. Soil not collected for sampling was returned to the borehole. Plastic sheeting was bagged and properly disposed on shore. One-inch diameter PVC pipe with a PVC piezometer was placed in the hole. The piezometers were located within 2 m of the shoreline, extended below ground up to approximately 1m, projected up to 1/2m above the ground surface, had non-locking PVC caps, and were located by GPS so they would not require flagging. Groundwater samples (4L, conditioned) were collected by the use of a peristaltic pump and placed on ice in the field. Surface water samples were also collected at every well and placed on ice. Samples were analyzed for dissolved oxygen, pH, temperature, and conductivity in the field. Filtering (GFF 0.7µm effective pore size) took place upon returning to the lab. Nonfiltered and filtered metal samples were acidified and refrigerated for later testing, and cation/anion samples were frozen until analysis. A surface water sample was also collected in Shamokin Creek following the same preparations and procedures. Soil samples from the adjacent SE ridgeside near the Doughty Pb-Zn mine were also collected for XRF analysis.



Peristaltic pump set-up.

Analytical

D.O., pH, T, and Conductivity (Hach HD40)
In situ

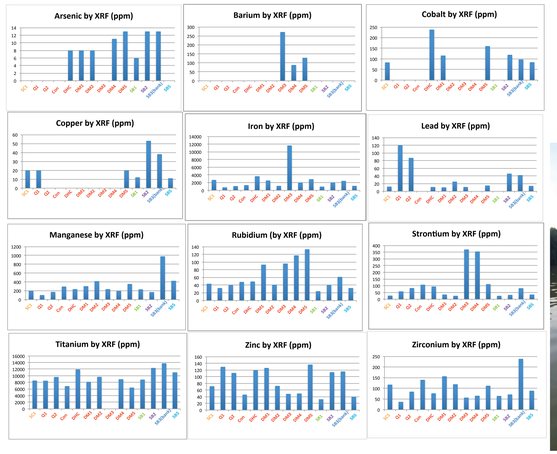
Alkalinity and Acidity:
For filtered samples using the Hach 8203 and 8201methods respectively

Ion Chromatography (Dionex ICS 2000):
Anions: Fluoride, Chloride, Nitrite, Bromide Nitrate, Sulfate, Phosphate

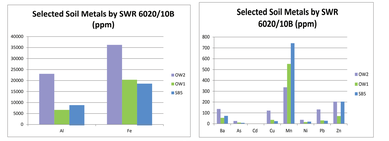
Profile ICP-OES:
Metals: Aluminum, Barium, Arsenic, Iron, Cadmium, Manganese, Nickel, Zinc, Copper, Lead

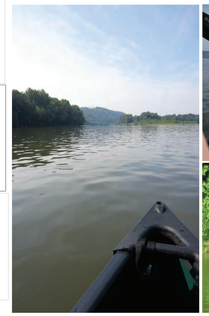
X-Ray Fluorescence (ThermoScientific Niton XL2 Series handheld XRF):
Any detected constituents

X-Ray Fluorescence

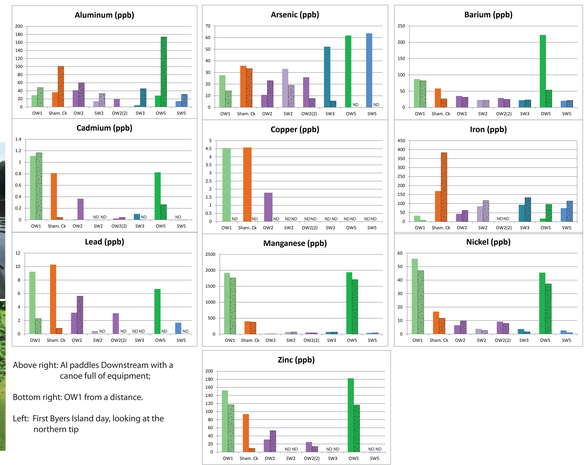


Hawk Mountain Labs





Metals Profile ICP-OES



Above right: Al paddles Downstream with a canoe full of equipment;

Bottom right: OW1 from a distance.

Left: First Byers Island day, looking at the northern tip

Results and Discussion

1. Observation well 4 was vandalized before we could collect our samples, so surface water samples were collected only from observation wells 1, 2, 3 and 5, with a duplicate at OW3. Observation well 3 was too dry to pump a 4L sample, so groundwater samples were collected only from observation wells 1, 2 and 5, with a duplicate from OW2.
2. To better assess the impact of groundwater, an effort was made to sample during a period of low discharge with maximum contribution from groundwater baseflow. This goal was not achieved, however, as during our first round of samples collected (8/23-8/24), groundwater samples from OW1 & OW2 and surface water from Shamokin Creek were collected during the initial stages of fiberdam deflation, so discharge on those days was variable. The second round of samples was collected 9/29/12 when discharge was somewhat higher than average. Due to time constraints from the bald eagle nesting season and the ensuing Fall semester, we could not be more selective about our sampling days.
3. Is the lead from Shamokin Creek? Our analyses indicate that lead levels in the creek are above the EPA Recommended Water Quality Criteria for aquatic life (Chronic Exposure) (2.5 ppb) at a hardness of 100mg/L , however no other surface water samples had lead above these criteria.
4. Is the lead from groundwater or surface water contaminated by lead dissolved from tailings or pockets of lead-rich unmined bedrock around the Doughty mine on the east bank? While XRF screening indicates two quarry soil samples have higher lead concentrations than other samples, levels are only in the 100 ppm range. Surface water samples along the east side of the river (Robert Kresch, this symposium) do not show elevated lead levels.
5. Is the lead from possible past use of lead and arsenic pesticides on farm fields on the northern half of Byer's Island? XRF field scans indicated lead and arsenic were present in the soil profile, but not at levels substantially higher than other area samples.
6. No smoking gun for elevated lead was found!
7. Elevated manganese levels in surface water, however, may be related to elevated concentrations of manganese in island soil samples. Groundwater concentrations of manganese are high at two of three groundwater locations, which is consistent with concentrations detected in glacial outwash northeast of the study area (Williams and Eckhardt, 1987).

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