Report as of FY2008 for 2008NJ164B: "Identifying the source of excess fine-grained sediments in New Jersey rivers using radionuclides"

Publications

- Conference Proceedings:
    - Galster, Josh, Kirk Barrett, Huan Feng, Nicole Bujalski, Jared Lopes, 2008, Characterizing the source of fine-grained sediments in New Jersey rivers using radionuclides, in Geological Society of America Abstracts with Programs, Denver, Colorado, v. 40, p. 194.
    - Galster, Josh, Kirk Barrett, Huan Feng, Jared Lopes, Nicole Bujalski, 2008, Identifying the source of excess fine-grained sediments in New Jersey rivers using radionuclides, in NEGSA Abstracts with Programs, Denver, Colorado, v. 40.

Report Follows

Problem and Research Objectives

This proposal directly addresses a NJWWRI stated research Priority IV, Methods of analysis of contaminants. We will be testing a proven analytical method to determine the source (watershed vs. streambank) and the residence time of sediments in stream channels.

Sediment is well known to be an important aquatic pollutant in New Jersey and elsewhere. Sediment carried into streams, lakes and estuaries adversely affects aquatic biota by, for example, smothering benthic habitats and carrying attached pollutants such as heavy metals, organic pollutants and nutrients through sediment runoff. Excess sediments decrease light penetration, water clarity and can interfere with respiration. Sedimentation also affects humans by filling in lakes and diminishing their recreational value and water storage capacity. Sedimentation was listed as the number one cause of river and stream impairment in the USEPA's most recent "National Water Quality Inventory" (USEPA, 2007). In New Jersey, the NJ Department of Environmental Protection (NJDEP) has identified nearly 50 "assessment units" (mostly equivalent to HUC14s) that are impaired by excessive suspended sediment concentrations, encompassing 370 square miles and over 700 stream miles (NJDEP, 2006). Over 100 additional assessment units were biologically impaired, with the cause of the impairment unknown; sedimentation is a likely cause in many of these cases.

Our objective is to assess how successful these established methods are at identifying the source of the fine-grained sediment within streams in New Jersey. Using radionuclides to "fingerprint" sediment coming from different sub-watersheds and from channel bank vs. surficial soil erosion within a drainage basin is an established technique, and has been used in a variety of geologic settings and in watersheds of various size (Bonniwell et al., 1999; Walling et al., 1999; Whiting et al., 2001; Polyakov and Nearing, 2004; Collins and Walling, 2004; Walling, 2005; Matisoff et al., 2005; Whiting et al., 2005). We propose to use the technique to distinguish between landscape and channel bank erosion in two New Jersey watersheds with different land uses, and to eventually influence land management practices (e.g., BMPs). Our hypothesis is that the fine-grained sediment in urban/suburban fluvial systems originates mostly from stream bank material produced from channel-widening erosion and will show relatively lower radionuclide activities, whereas, in areas with significant row-crop agriculture, substantial sediment originates from the landscape and will show relatively higher activities.

Methodology

Two watersheds with contrasting land uses were chosen for this project. The East Branch of the Rahway River, Essex County, New Jersey is predominantly (>80%) urban land use, while the Cold Brook watershed, Hunterdon County, New Jersey is predominantly agricultural land use. Within each watershed two sampling locations were selected, for a total of four field sites. Field samples were collected during the summer and fall of 2008.

At each of the four sample sites, samples were collected from the bank of the stream, the channel of the stream and from three soil pits, each approximately 5 m from the stream. Two bank samples were taken at each site. A tape measure was placed vertically down the bank face to measure depth, and a trowel was used take 5 cm grab samples. Five samples were taken from each bank at equally spaced intervals. The average bank height of the four sites is 95 cm. The samples were placed into a pre-labeled, plastic bag.

Each soil pit was dug with a shovel until rocks were hit, or it was deeper than 22 cm. The samples were taken in one centimeter intervals from the surface to 10 cm of depth. The deeper samples were taken at two centimeter intervals, from 10 cm depth to the bottom of the soil pit. A trowel was used to remove the sample and place it into a pre-labeled, plastic bag.

Samples from the stream channels were taken in triplicate, approximately 5 m apart. A corer was constructed for this project using two pieces of PVC piping, one inside the other. The corer was pounded into the stream sediment, and samples were taken at 1 cm intervals, until a depth of 10 cm when 2 cm intervals were used. The average depth of the cores was 9 cm. The extruder expelled the sample from the corer and the sediment was removed with a trowel and placed into a plastic bag.

Sediment samples were prepared at Montclair State University. ^{137}Cs and ^{210}Pb were measured by non-destructive gamma spectrometry (Canberra Model BE2020 Gamma detector housed at Montclair State) (Olsen et. al., 1986; Cochran et. al., 1993; Feng, 1997; Whiting et. al., 2005). In brief, samples were counted directly on an intrinsic germanium detector for ~24 hours to ensure sufficient accuracy and precision. ^{137}Cs and ^{210}Pb were determined from the gamma emission at 662 and 46.5 kev, respectively. ^{226}Ra activity was measured via the 352.0 kev ^{214}Pb gamma emission to obtain the supported ^{210}Pb value. The observed count rates of all measured nuclides were corrected for self-adsorption by measuring the attenuation of a known gamma source by the sample (Cutshall et. al., 1983; Cochran et. al., 1993; Feng, 1997). Sample analysis is on-going.

Principal Findings and Significance

Sediment has been analyzed and distinct radiometric signatures have been found in the sediment from each stream (Figure 1). Each watershed's stream banks and soil pits produced similar radiometric profiles. Soil pits had higher activity levels than stream banks, which reinforces our hypothesis of stream banks having older and less active sediment.

The difference between the two streams is in the sediment from each channel. The rural, agricultural watershed (Cold Brook) has channel sediment with much less activity than the channel sediment from the urban (East Branch of the Rahway) watershed. While preliminary, this suggests that more surficial material than previously thought is the source of the excess sediment within the urban stream.

To date this research has verified using this approach to distinguish between different sediment sources. Knowing the source will aid the NJDEP in their regulatory and restoration activities. For most sediment-impaired areas, the NJDEP must develop a “Total Maximum Daily Loads” (TMDL), along with a sediment load reduction plan. To develop this plan it is important to know what proportion of the sediments impacting a stream is coming from streambanks vs. the watershed. Depending on the primary source, the load reduction measures (e.g., streambank stabilization vs. riparian buffer restoration or conservation agriculture) would be quite different.

Sediment analysis at Montclair State is continuing, and will be completed by the end of calendar year 2009. We will analyze the results from the other sites within the agricultural and urban watersheds in order to assess the intrabasin variability in the radiometric signal.

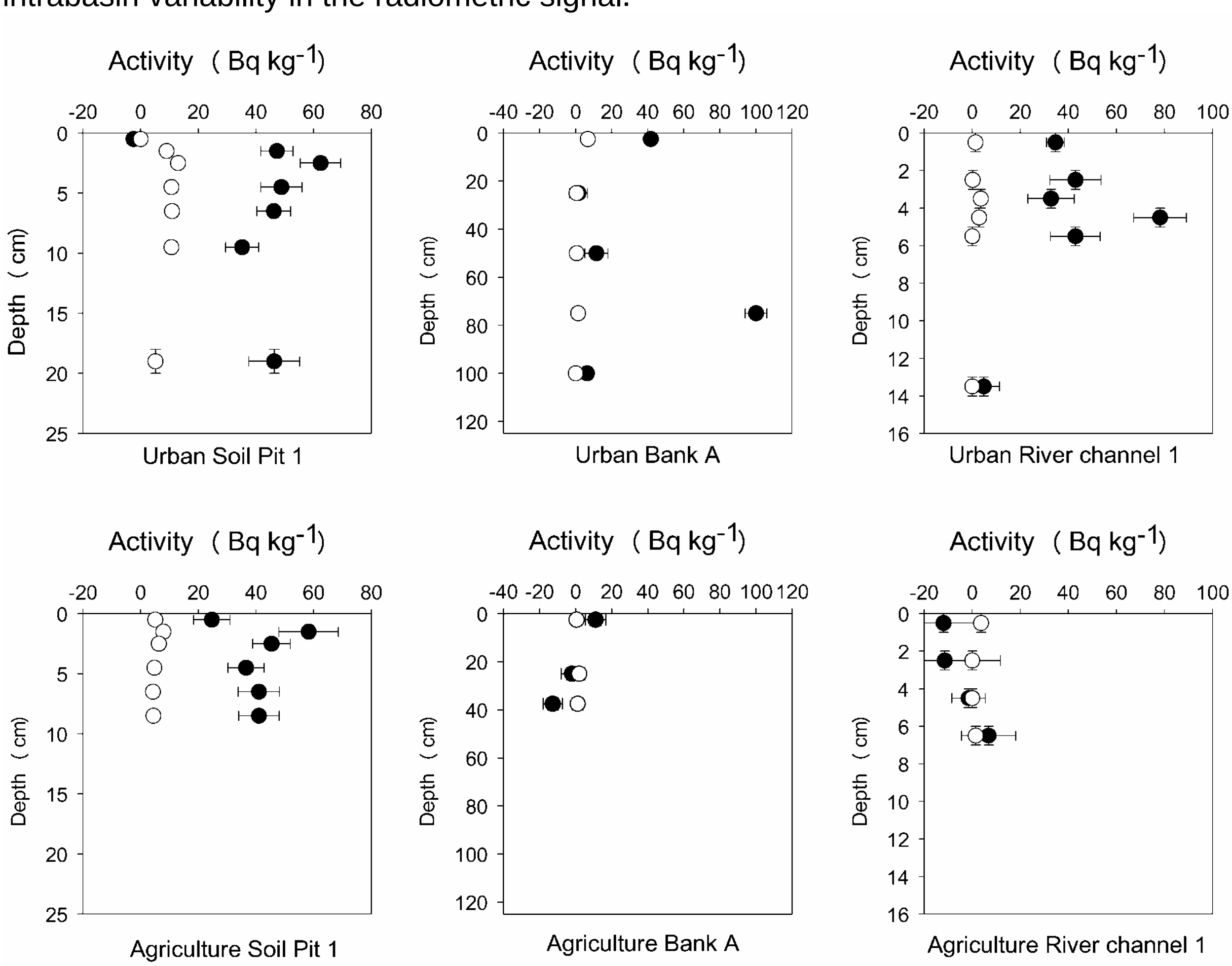

Figure 1. Sediment activity (^{210}Pb in black circles, ^{137}Cs in white) from the urban watershed on top, and the agricultural watershed below. The results are similar between the two except for the higher levels of ^{210}Pb in the urban river channel sediment.

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