Introduction

The works of Gellis et al. (2009) and Duerr et al. (2010) demonstrated the applicability of trace elements to fingerprinting the source of trace elements [gastropod shell]. Sediment sources could be attributed to various land use/land covers, important in assessing the impacts of agriculture, deforestation, urbanization, and erosion on erosion and sedimentation of rivers and wetlands. Northwest New Jersey has similar concerns for its water resources, given the land use changes of growing urbanization as well as the need to conserve natural resources and open space. We attempt a similar study here, as part of the larger NSF sponsored project at Montclair State University and NJ School of Conservation, "Multidisciplinary environmental science research on forest lakes in northwest New Jersey." The overall goal is to assess the trace elements in a cross-section of streams in the Highlands Region and Delaware Valley, by means of field-based fluvial geomorphic sampling, and sampling and laboratory analysis of stream sediments as well as contributing soils from upland areas in the watersheds. The results presented here illustrate an initial analysis of stream bed sediments only. What trace elements are best related to stream stability as a measure? Can trace elements indicate proximate sources of sediment, such as stream banks and reworked channel sediments?

Methods

1. Field locations involved a selection of forested, agricultural, and urban settings. REU team members used the Rapid Geomorphic Assessment (RGA, figure 2), obtaining stream channel, bank, and flophasiometrics data (Kohn et al. 2006). A channel stability stream assessment Samples were obtained from locations along the Flat Brook, Wallow, and Rockaway River watersheds (see Appendix A), using the RGA, a relationship based on the distance from reworked channel sediments to the bed.

2. Samples were oven dried, then pulverized to a fine powder using a metal rod miller and pestle and a Model 6500/115 Shatter Box and placed in storage containers.

3. Approximately 0.5 g of the powder is combined with 6.4 g of LiH and fused in a muffle furnace at 1050°C. The mull is broken into 2.5% HNO3 solution and with the acid mixture. Solutions with 5% HNO3 is diluted to 1000sL of diluted solutions for ICP-MS.

4. Sample trace element analysis was conducted by the use of inductively coupled plasma mass spectrometry (ICP-MS) on a Thermo X-series quadrupole inductively coupled plasma mass spectrometer housed in the Dept of Earth & Environmental Studies, Montclair State University. Along with the project samples, 15 USGS standard samples, (Rb, G, G, G, G, G, G, G, G, G, G, G, G, G, G) were measured to ensure the accuracy of the ICP-MS calibration. Sample results were compared to expected concentrations. Samples were run in 2 replicates.

5. Accuracy is determined by taking the mean of each element to the mean of all samples for each replicate and comparing the two. Average accuracy is given as ±1.5%.

Results

Streams in northern New Jersey span a broad range of environments and land covers, including urban, agriculture, wetlands, and forest. Stream sediments receive input from these environments, and indicate pulses or stages of land use change, or stability. In this project, we use trace elements, including rare earth elements, to fingerprint sediment sources and differentiate between land use as well as immediate source of sediment such as floodplains, uplands, or urban inputs. Samples of stream bed, stream bank, floodplain sediments, and urban and upland soils were obtained from eight locations in the Flat Brook, Rockaway River, and Wallkill River watersheds in Sussex and Morris counties in New Jersey. Samples were prepared for trace element analysis with inductively coupled plasma mass spectrometry (ICPMS). Element content was compared to land use, sediment sources, and a stream stability index (RGA Rapid Geomorphological Assessment). Several elements (Cr, Ni, Sr, Pb) were statistically significant at distinguishing between land use. Cr and W were able to distinguish sediment source (i.e. floodplain, bank, upland soils). With further work on calibration confidence. Related to stream and bank stability, the RGA showed significant positive correlation with Cr and Co content (increasing Cr and Co with increasing instability), indicating these elements as good proxy indicators for bank erosion. Ongoing studies of element ratios, combined with Co-186 and Pb-204 activity levels by gamma detector, will further refine the sediment characterization, with the goal of approximating a sediment budget across different land uses and identifying hot spots that deliver disproportionately high amounts of sediment.

Discussion and Conclusions

1. Trace elements respond differently to within-channel erosion potential. Several elements, notably Cobalt, Lead, and Strontium, indicated a good correlation to the RGA survey (Figure 3). In other words, an increase in these elements in indicative of increased within-channel and/or bank erosion. Other elements, such as Gallium, Rubidium, Yttrium, and Niobium, indicate a more complex relationship with stream stability (Figure 4). Both very stable (low RGA) and very unstable (high RGA) conditions seem to limit the abundance of these trace elements, while middle values of stability have higher trace element content. It is clear that a better understanding of the trace element and sediment budget is needed, a topic of ongoing research. There is already indication that the RGA is well correlated to land use, such as RGA - urbanized watersheds.

2. Sediment sources are important, and some trace elements reveal the origin of the sediment (within the channel, in the banks or floodplain, from upland forested or agricultural areas, or urban sources). No single element is able to differentiate all sediment sources, and a combination of elements would be necessary to discern all sediment sources.

3. Our preliminary chemical analysis indicates that some trace element are also related to land use, relating to the sediment source. Chromium, for instance, is statistically significant in determining a difference between forested, agricultural, and urban areas. These relationships will be explored further as additional samples are analyzed. Currently, the existing samples co-vary land use with local geology, a confounding factor.

4. We hope to gain a better understanding of the trace element flux and budget that it relates to erosion and sediment transport and storage. Samples are being processed for Pb-210 and Cs-136 activity levels that will serve to differentiate recent versus older sediments.