Sediment Fingerprinting in a Southern Piedmont Watershed - Preliminary Results

R. Mukundan[1], D. E. Radcliffe[1], L. M. Risse[2], W. P. Miller[1] and J. C. Ritchie[3]

[1]Dept. of Crop and Soil Sciences, University of Georgia, Athens, GA

[2]Dept. of Biological and Agricultural Engineering, University of Georgia, Athens, GA

[3]USDA ARS Hydrology and Remote Sensing Lab, Beltsville, MD

Contact: rajith@uga.edu

INTRODUCTION

Many of the stream segments in the Piedmont region of Georgia and other southeastern states are impaired because of high levels of sediment. This poster describes the sediment fingerprinting approach used to identify the sources of sediment based on the preliminary results of a study conducted on a 926 ha sub-basin of the North Fork Broad River Watershed in Georgia.

OBJECTIVE

To estimate the relative contribution of various sources to the total sediment load in streams using mixing models

METHODS

- A suite of chemical tracers were analyzed in the source and the stream sediment samples
- Source samples includes upland sources and bank material
- Relative source contribution was estimated using three different methods

Method-1 Simple mixing model (Nagle and Ritchie, 2004)

$$C_{Surface} = \frac{P_{Sediment} - P_{Bank}}{P_{Surface} - P_{Bank}} \times 100$$

Where,

$C_{Surface}$ is the contribution from surface sources (in percent) and

P is the value of a selected property from the different sources and sediment; (1- $C_{Surface}$) gave the contribution from stream bank.

Method-2 Multivariate mixing model (Walling, 2005)

$$Res = \sum_{i=1}^{n} \left(\frac{C_{ssi} - \left(\sum_{s=1}^{m} C_{si} P_s \right)}{C_{ssi}} \right)^2$$

Where,

Res - Residual sum of squares

Cssi - Concentration of tracer property i in the sediment

Csi - Mean concentration of the tracer property i in the source group s

Ps - Relative proportion from source group s

The more robust model uses all potential tracers (n=7) identified and the two sources (m=2) to estimate source contributions

METHODS(CONTINUED)

The mixing model equation was solved to minimize the residual sum of squares subject to the following constraints;

$$0 \le P_s \le 1 \qquad \sum_{s=1}^{m} P_s = 1$$

Method-3 Principal Component Analysis (PCA) and End Member Mixing Analysis (EMMA) (Christophersen and Hooper, 1992)

- PCA was performed on the tracer data to derive principal components that could explain the variability in source data
- The first two principal components that explained 91% of the variability was used to define the two end member subspace (line)
- Orthogonal projection of sediment samples towards the mixing line determined the relative source contribution

RESULTS

Tracer	Surface (n=11)	Bank (n=11)	Sediment
^{137}Cs (Bq/kg)	32.61	3.95	6.54(n=2)
Total C (%)	2.78	0.96	1.12(n=2)
As (ppb)	70.03	46.02	49.11(n=1)
Cd (ppb)	3.72	1.78	2.30(n=1)
Cu (ppb)	922.13	499.06	592.21(n=3)
Mo (ppb)	11.47	6.07	8.28(n=1)
U (ppb)	64.18	46.81	48.23(n=1)

Table 1. Concentration of potential tracers identified in the region

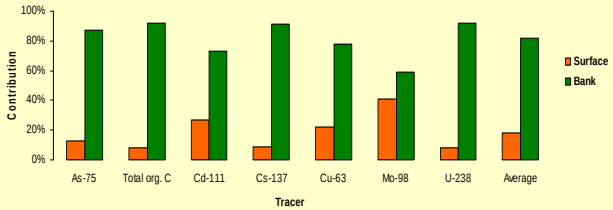

Figure 1. Relative source contribution estimated by simple mixing model

RESULTS (CONTINUED)

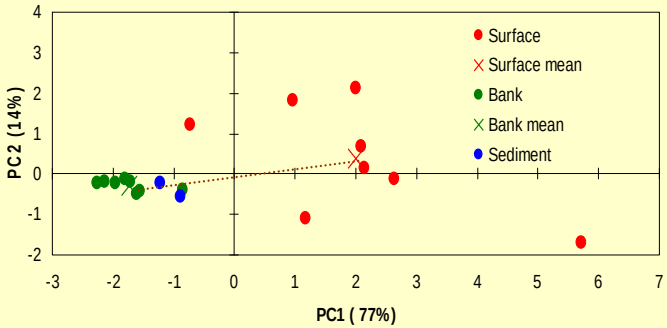

Figure 2. Two end-member mixing model for determining relative source proportions

Method	Surface	Bank
Multivariate mixing model	10	90
End-Member mixing model	13	87

Table 2. Relative source contribution in percentage

CONCLUSIONS

- Mixing models can be used to derive the relative contribution of various sources to the total sediment load in streams
- More sampling along with chemical and statistical analysis can lead to reliable conclusions

References

Christophersen, N., and R. P. Hooper. 1992. Multivariate analysis of stream water data: The use of principal component analysis for the end member mixing problem. Water Resour. Res. 28(1), 99-107

Nagle, G. N. and J. C. Ritchie. 2004. Wheat field erosion rates and channel bottom sediment sources in an intensively cropped northeastern Oregon drainage basin. Land Degrad. Develop. 15: 15-16

Walling, D.E. 2005. Tracing suspended sediment sources in catchments and river systems. Science of the Total Environment. 344:159-184