QUANTIFYING RELATIVE RATES OF UPLAND AND BANK EROSION USING RADIONUCLIDE TRACERS IN AN AGRICULTURAL WATERSHED (EP41C-0733)

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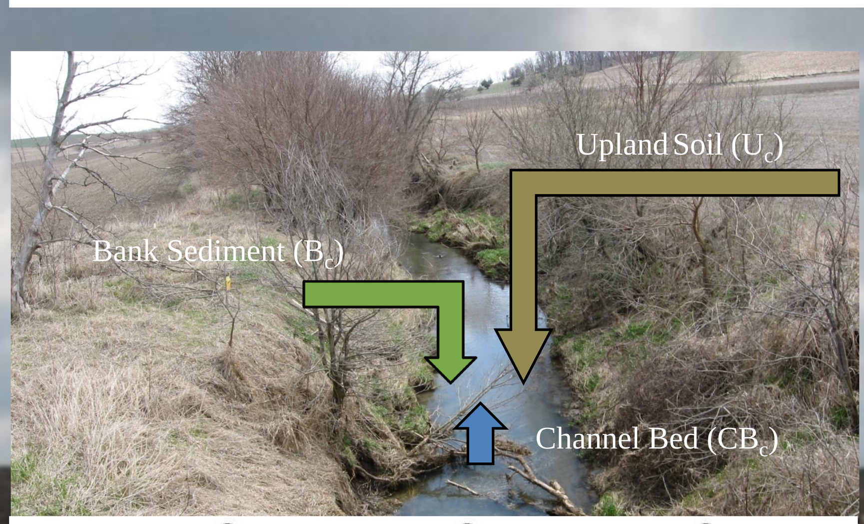
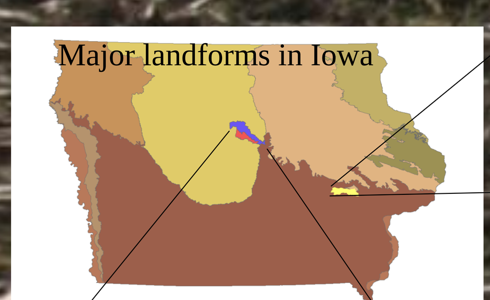
Summary: The goal of this study was to quantify the relative proportions of eroded upland surface soils and channel sediments in the fine suspended sediment load of agricultural watersheds in Iowa during single runoff events using activities of ^{7}Be and ^{210}Pb$_{xs}$. The two radionuclides provide unique biogeochemical signatures to the eroded upland soils and channel sediments due to their profiles in the soil column and the dominant erosion processes in the source areas. Eroded surface soils will have higher activities of ^{7}Be and ^{210}Pb$_{xs}$ than channel sediments. The fine suspended sediment, which is a mixture of these source material, will have an intermediate radionuclide signature that is quantified through a simple two-end member mixing model. Runoff events were sampled in different landform regions of Iowa, one with rolling hills and well drained soils and the other, which is flat and has poorly drained soils. Results suggest that eroded surface soils are more abundant in the suspended sediment early in the runoff event in both watersheds; however, the overall upland contributions from the poorly drained watershed were less than upland contributions from the well drained system. This is partly due to decreases surface runoff and sediment settling before it enters tile intakes.

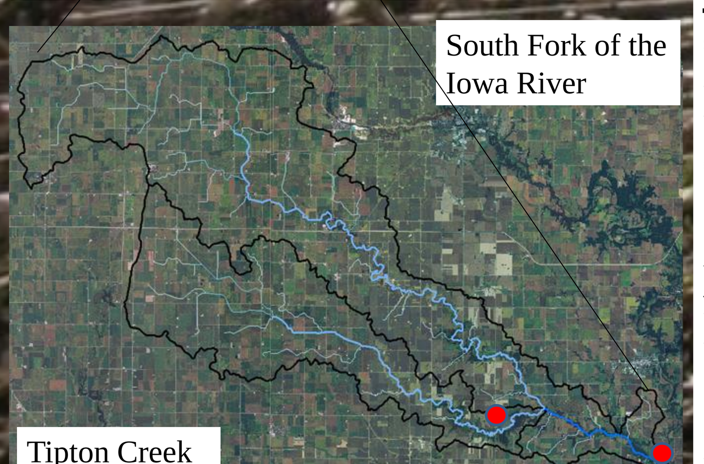


$$Q_s = \int U_C + \int B_C + \int CB_C$$

Objectives:

1. Identify unique radionuclide signatures for different sediment sources in Iowa agricultural watersheds and attribute signatures to fine suspended sediment loads (Q_s).
2. Quantify relative proportions of U_c and (B_c + CB_c) in the Q_s of single runoff events using activities of ^{7}Be and ^{210}Pb$_{xs}$ and a simple two-end member mixing model.





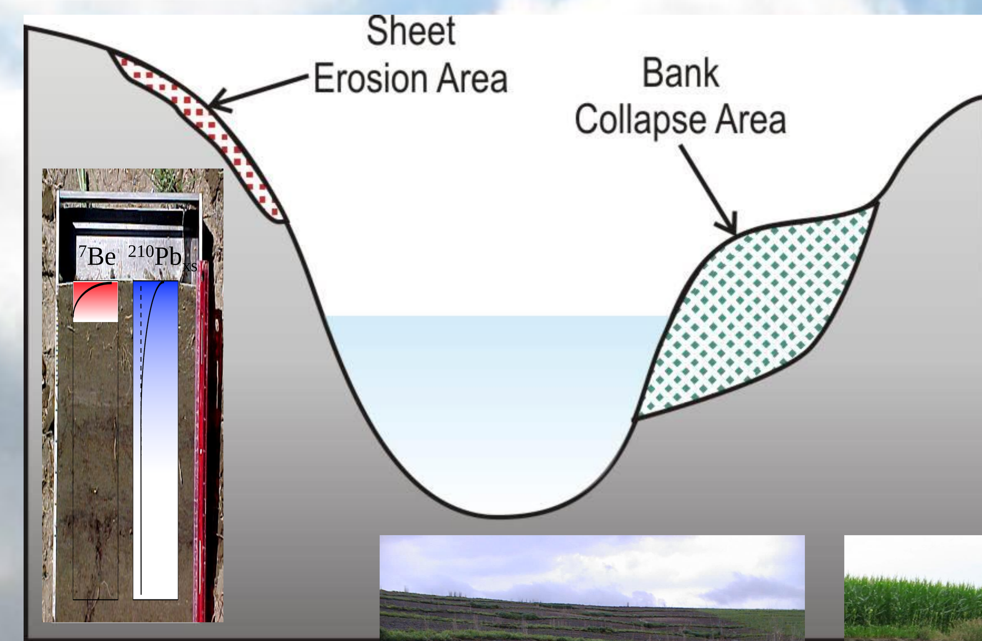
Study Sites:

Clear Creek (South Amana sub-watershed):
Drainage area = 26 km^2
80% of land is corn-soybean
Soil Series: Tama (well drained), Colo (somewhat poorly drained)
Located in the Southern Iowa Drift Plain (SIDP)

South Fork of Iowa River/ Tipton Creek:
Drainage area = 406 km^2/ 197 km^2
85% of land is corn-soybean
Soil Series: Clarion (well drained), Webster and Nicollet (poorly drained)
Located in the Des Moines Lobe (DML)

KEY DIFFERENCES: The DML is flat, poorly drained, and extensively tiled. The SIDP has rolling hills, better drainage, less tiles.

Theory:

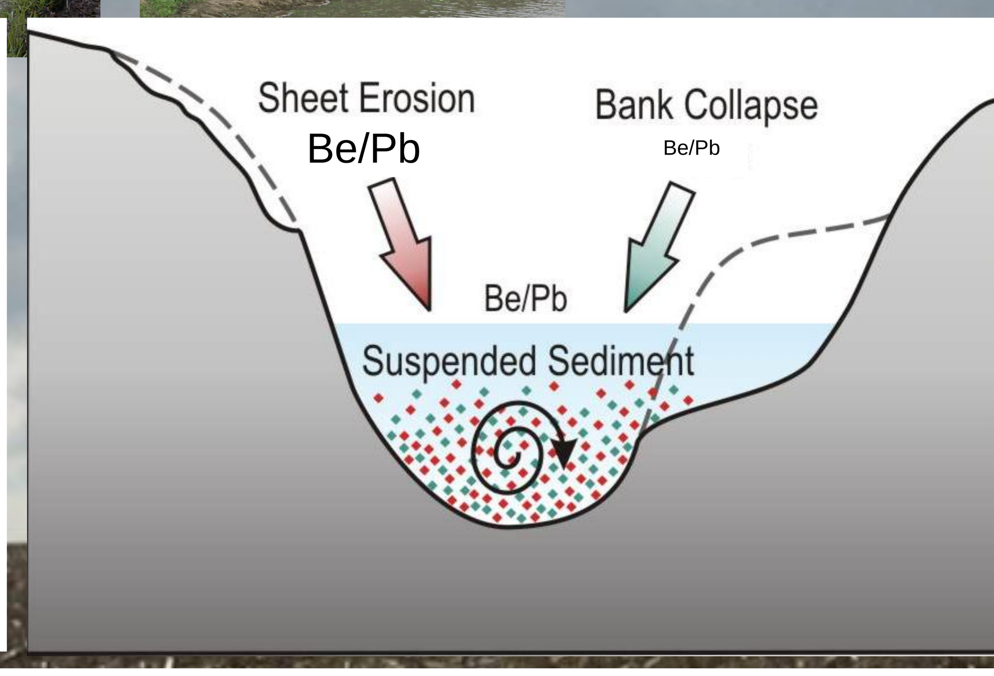


Radionuclides are delivered to upland soils during precipitation events. They sorb rapidly and strongly to surface particles within the top few centimeters.

Upland erosion processes (sheet and rill erosion) remove a thin layer of high activity soils.

Channel sources contain low activity sediment.

Near vertical banks receive little input from the rain and bank collapse removes large volumes of low activity sediment. Bed sediments sit on the bed for long periods with little replenishment from depositing sediment and undergo decay.

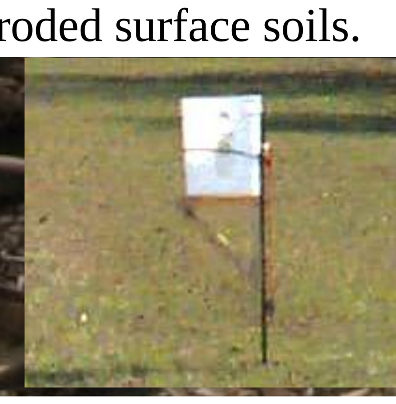


Suspended sediment contains a mixture of high activity upland sediment and low activity channel sediment, which produces an intermediate signature.

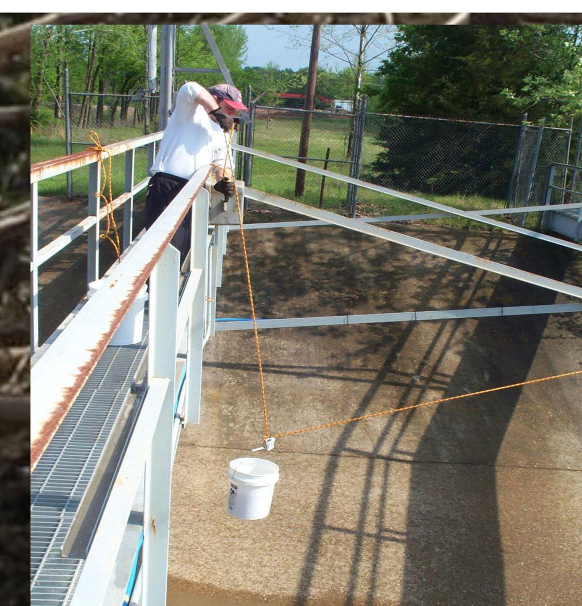
Methods:

Upland and channel source sampling requires high resolution cores to capture the radionuclide profile, which is done before the rain event.

Precipitation sampling during the event is to quantify the radionuclide delivery to the upland soils for the signature of the eroded surface soils.

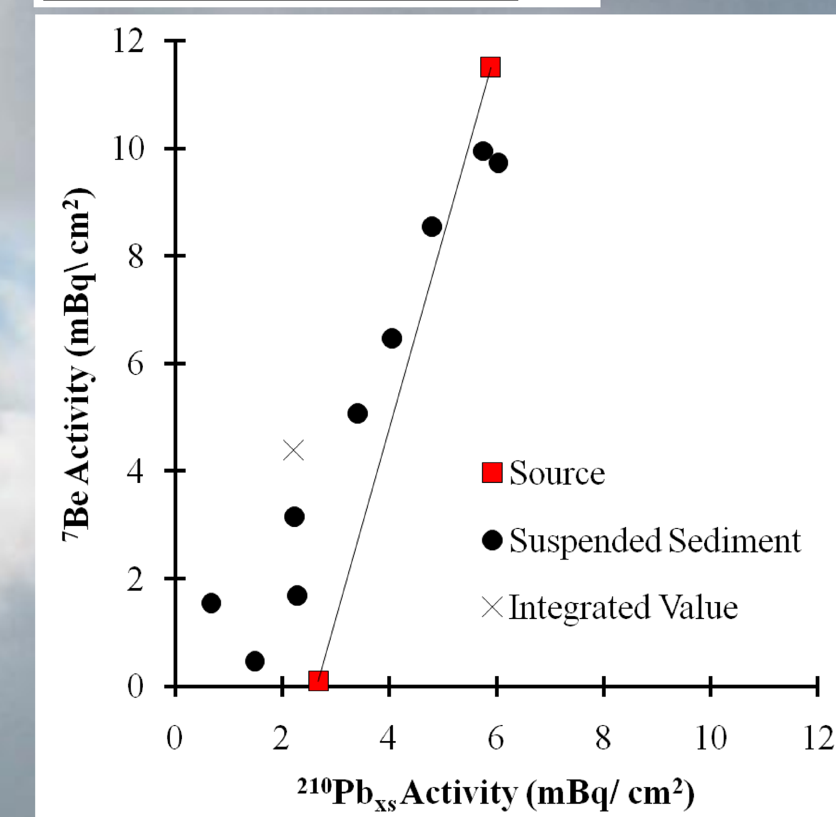


Suspended sediment samples are collected over the course of a runoff event hydrograph to see changes in source contributions over time.



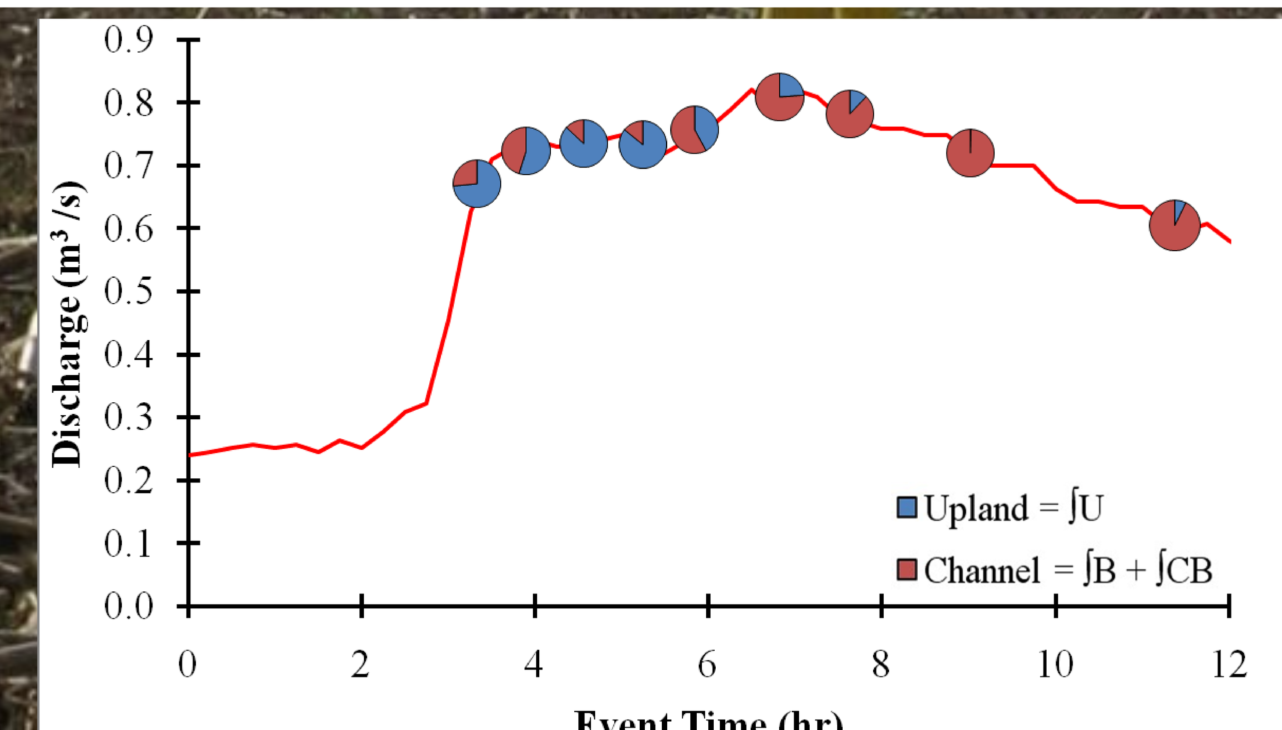
Sample analysis is conducted in the Iowa Radionuclide Analysis Lab (IRAL) at IIHR - Hydroscience & Engineering

Results and Discussion:



This plot shows an example of source and suspended sediments for one event in the Clear Creek watershed. The upland and channel sources (red squares) plot at different ends of a graph relating ^{7}Be activity to ^{210}Pb$_{xs}$ activity becoming two end members. The activities of the suspended sediment samples plot between the two sources along a mixing line. If these samples are projected towards the line at right angles, one can determine the relative proportions of the two sources to each sample.

The relative proportions of the two sources (upland and channel) in each suspended sediment sample is displayed in a pie chart below. The blue part of each pie represents the upland contribution and the red part represents the channel contribution. Each sample is placed along the event hydrograph at its collection time. At the beginning of the event, suspended sediment samples contain mostly eroded upland soils. As the event progresses, upland contributions decrease as runoff to the stream ceases. In addition, channel contributions become more significant. Fluvial erosion at the bank toe produces over steepened banks. The saturated upper parts of the bank become too heavy and collapse into the channel once they are no longer supported by the higher stream flows. A similar pattern was observed in all sampled events.



Watershed	Maximum Discharge (m^3/s)	Sediment Load (kg)	Percent Eroded Surface Soil	Percent Channel Sediment
Clear Creek – Event 1	0.82	20,000	34 ± 8	66 ± 15
Clear Creek – Event 2	3.52	200, 400	33 ± 11	67 ± 24
Tipton Creek	5.45	273,386	20 ± 2	80 ± 2
South Fork of Iowa River	28.0	2,294,274	19 ± 2	81 ± 2

The upland contributions for the two events in Clear Creek, which is in the SIDP, were higher than the upland contributions from the DML systems. It is believed that steeper slopes and a less extensive tile system in the SIDP produced more runoff and, thus, more sediment delivery from the uplands. In the DML, a higher proportion of upland contributions must pass through the tile network. Sediment may settle out around tile intakes before passing through to the stream limiting upland contributions. The sediment-starved water from the tiles may also entrain more channel sediment to compensate its loss as it travels downstream.

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