MODELING OF THE DISTRIBUTION OF TRACE ELEMENTS IN FLOODPLAIN SOILS OF THE UPPER BLACKFOOT RIVER, MONTANA[1]

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Extended Abstract: Metal mining and ore processing have impacted river systems in much of the world. Many of these activities have occurred in alpine settings with gravel and cobble bed river systems such as the upper Blackfoot River in western Montana. This paper models the distribution of trace elements in floodplain sediments in relation to distance from the source areas and from individual sample locations.

Soil and sediment samples were collected along 20 transects in the upper 105 river km of the Blackfoot River, Montana. The transects were placed perpendicular to the channel, and ran from the estimated bankfull stage to the upper edge of the current floodplain as defined by an abrupt change in slope. The soil and sediment samples were collected from a total of 55 test pits, at 0-5, 5-15, 15-25, 25-35 and 35-45 cm intervals. The samples were air dried, sieved to the ≤ 2 mm fraction, and digested in Aqua regia. The acid digests were analyzed for total recoverable As, Cd, Cu, Mn, Pb and Zn using inductively coupled plasma spectroscopy. Samples were also analyzed for pH, soil organic matter and particle size distribution.

The maximum trace element levels detected in the soil and sediment samples were: As) 479.8 mg/kg; Cd) 204.2 mg/kg; Cu) 4160.3 mg/kg; Mn) 1.86 %; Pb) 3.09 %; and Zn) 1.73 %. Median (background) trace element concentrations in the soil and sediment were: As) 12.5 mg/kg; Cd) 1.3 mg/kg; Cu) 33.8 mg/kg; Mn) 383.5 mg/kg; Pb) 17.5 mg/kg; and Zn) 87.9 mg/kg. Soil As decreased to median background concentrations 14 km from the Blackfoot headwaters, followed by Cd and Pb (20 km), Mn and Zn (36 km) and Cu (67 km).

Nonlinear (exponential and power form) regression models were developed using SPSS statistical software to predict the spatial distribution of trace elements downstream from the mine source areas. These models were based on trace element concentrations (dependent variable) of the 0-5 cm soil interval and river kilometer (independent variable). River kilometer (distance upstream from confluence of Blackfoot River with Nevada Creek) was found to be the best

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independent predictor of metal concentrations for use in these equations. Other variables explored included soil pH, percent organic matter, and particle size. Adjusted R squared values for the equation models ranged from 0.515 for As to 0.858 for Pb.

Geostatistical models of the spatial distribution of trace elements in the floodplain soils and sediments were developed using Variowin and ArcGIS 9.0. Spherical variogram models were developed for each of the elements (As, Cd, Cu, Mn, Pb and Zn) contained in the 0-5 cm soil depths, with a lag distance of 600 m. Ordinary kriging interpolations were then produced using the range, sill and nugget values from the variograms. Standardized root mean square errors for the kriging interpolations were: As) 2.047; Cd) 0.851; Cu) 1.072; Mn) 0.8671; Pb) 1.707; and Zn) 0.9807. These models were further validated by using them to interpolate trace element concentrations in the 5-15 cm soil layer.

The nonlinear regression and geostatistical models were compared based on overall root mean square errors between the predicted versus actual element concentrations in the soil. The nonlinear regression models produced the lowest root mean square errors for As, Cd and Pb versus the geostatistical models. The geostatistical models produced the lowest root mean square errors for Cu, Mn and Zn versus the nonlinear models for these elements.

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