Distance weighted approach to modeling sediment metal concentrations in Johnson Creek Watershed, Portland Oregon

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Distance-weighted approach to modeling sediment metal concentrations in Johnson Creek Watershed, Portland Oregon

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Heavy metals contaminate the environment and interfere with the metabolic process of living beings causing both environmental and public health issues. The heavy metals from the source are transported to the various components of the ecosystem through air, wind, and water. Understanding the way in which these metals end up in our soil and water is important to control their concentration in our environment. In this work, we model the different sediment metal concentration (Lead, Zinc, Copper, Chromium, and Cadmium) of Johnson Creek watershed, Oregon using the easily available landscape level datasets. The sediment samples were collected from the several sites along the Johnson Creek and were analyzed in the lab. We use land cover, elevation, slope, and soil as our predictor variables in a regression modeling. The land cover and soil data were used to derive the curve number for the entire watershed. We use four different representations of landscapes. They are an average of the basin, inverse distance weighted based on Euclidean distance, inverse distance weighted based on flow length, and inverse distance weighted based on proportional flow accumulation. We report that for most of the heavy metal types, inverse distance weighted based on flow length and flow accumulation provided with the best model attributes. We conclude that for sediment metal concentration of Johnson Creek, flow length or flow accumulation based model works best but landcover, soil, and topographic variables are not enough to explain the spatial pattern of those metal concentrations.

Keywords: *flow accumulation, landscape characteristics, Curve Number*

Outline

Substance of Interest

Sediment Metals

(Pb, Zn, Cu, Cr, Cd)

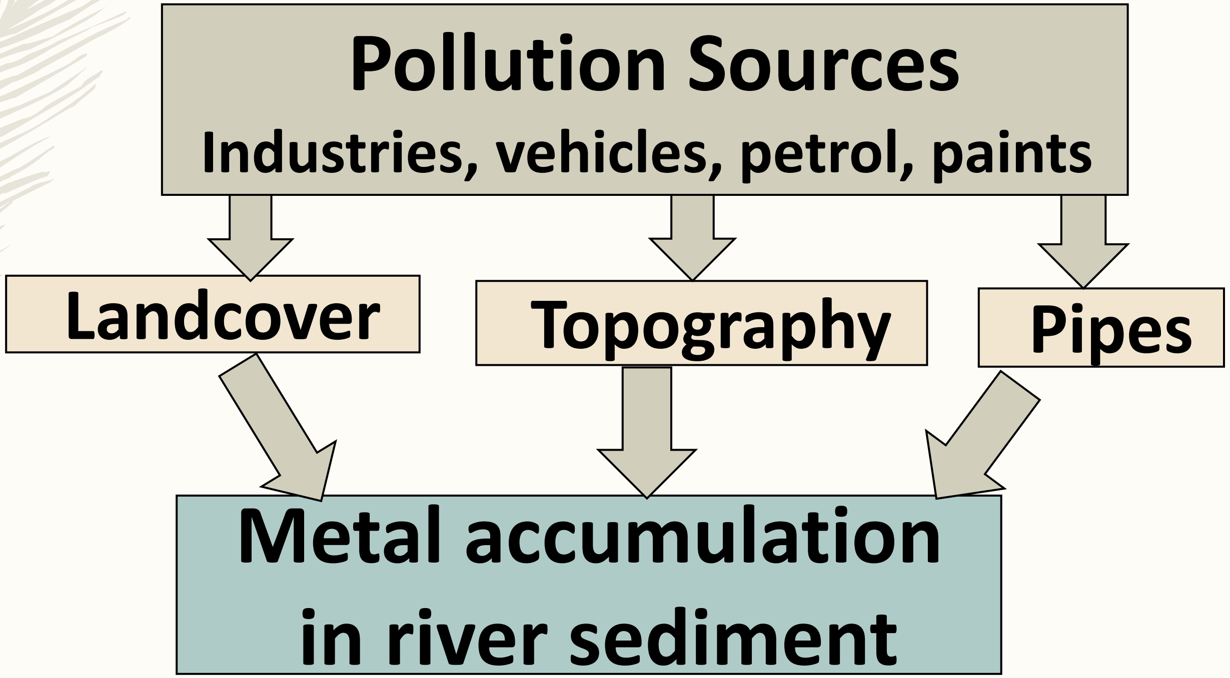
Predictors

Land cover, soil, and topography

Methods

Does inclusion of distance weighted approach and flow accumulation increase the model performance?

Conceptual Framework



Visualizing Landscape Representations

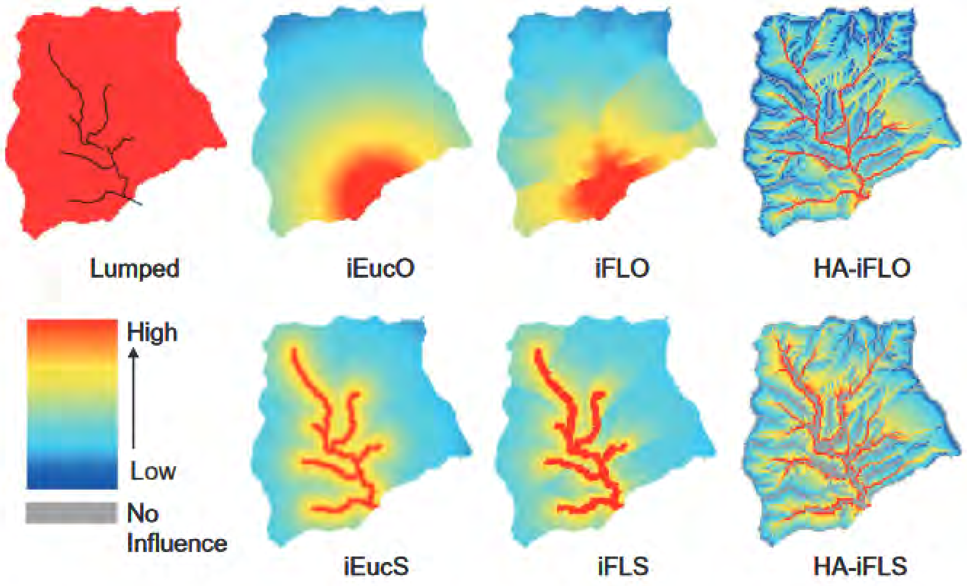
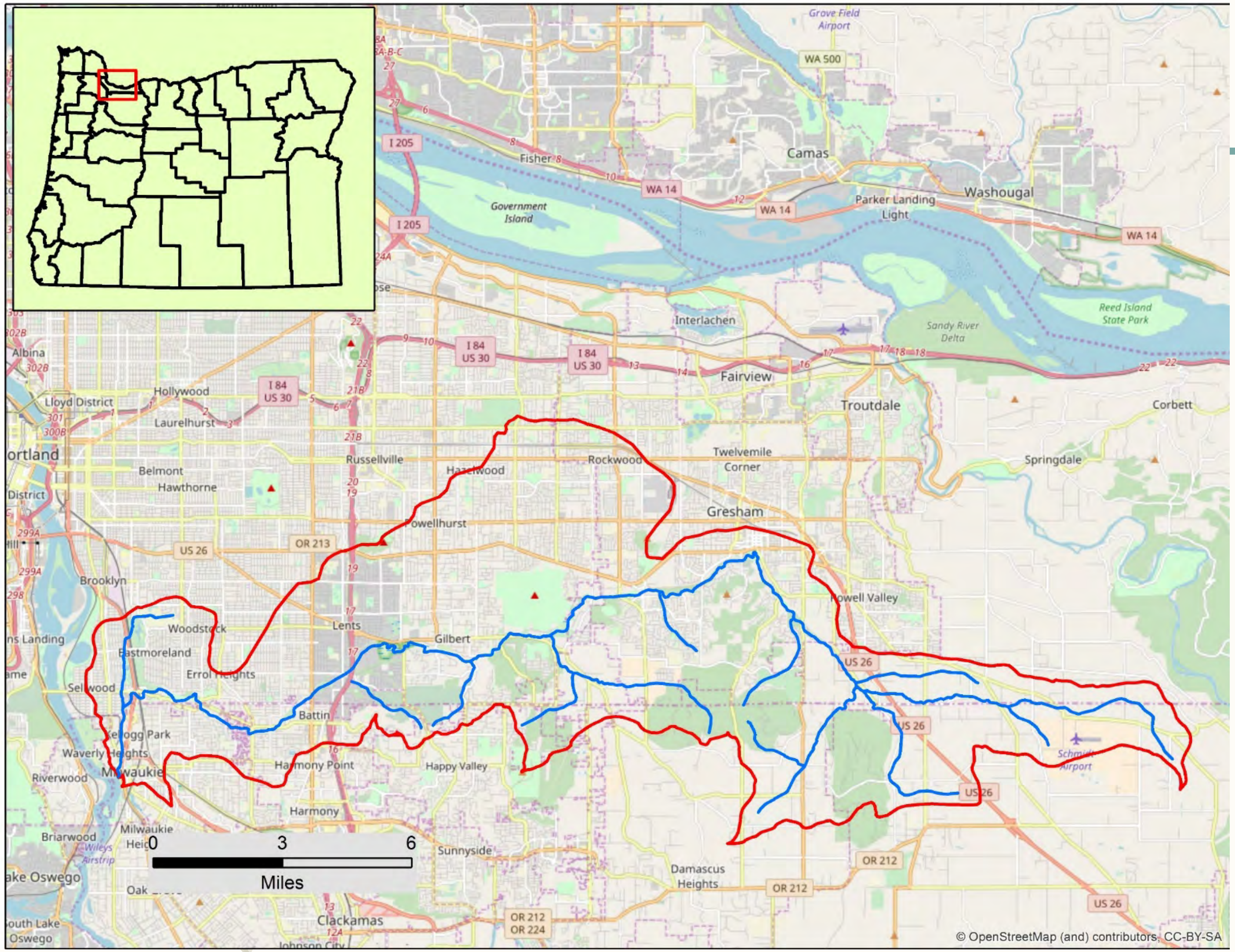


Fig. 1 Landscape representation metrics. Lumped metrics are non-spatial and all cells are considered to have equal influence. In an inverse-distance-weighted (IDW) metric, distance (*d*) may be based on Euclidean distance (iEucO, iEucS) or the flow length (iFLO, iFLS) either to the stream outlet (iEucO, iFLO) or the stream (iEucS, iFLS). Hydrologically active inverse-distance metrics (HA-IDW) are based on the product of the flow accumulation at each cell and the inverse flow length to the stream outlet (HA-iFLO) or the stream (HA-iFLS). All inverse distances were based on $(d + 1)^{-1}$. For plotting purposes, the HA-IDW metrics were standardised to range from 0 to 1 and weights are shown on the $\log_{10}$ scale with the same minima and maxima. Also, the black lines in the lumped metric represent the stream network.

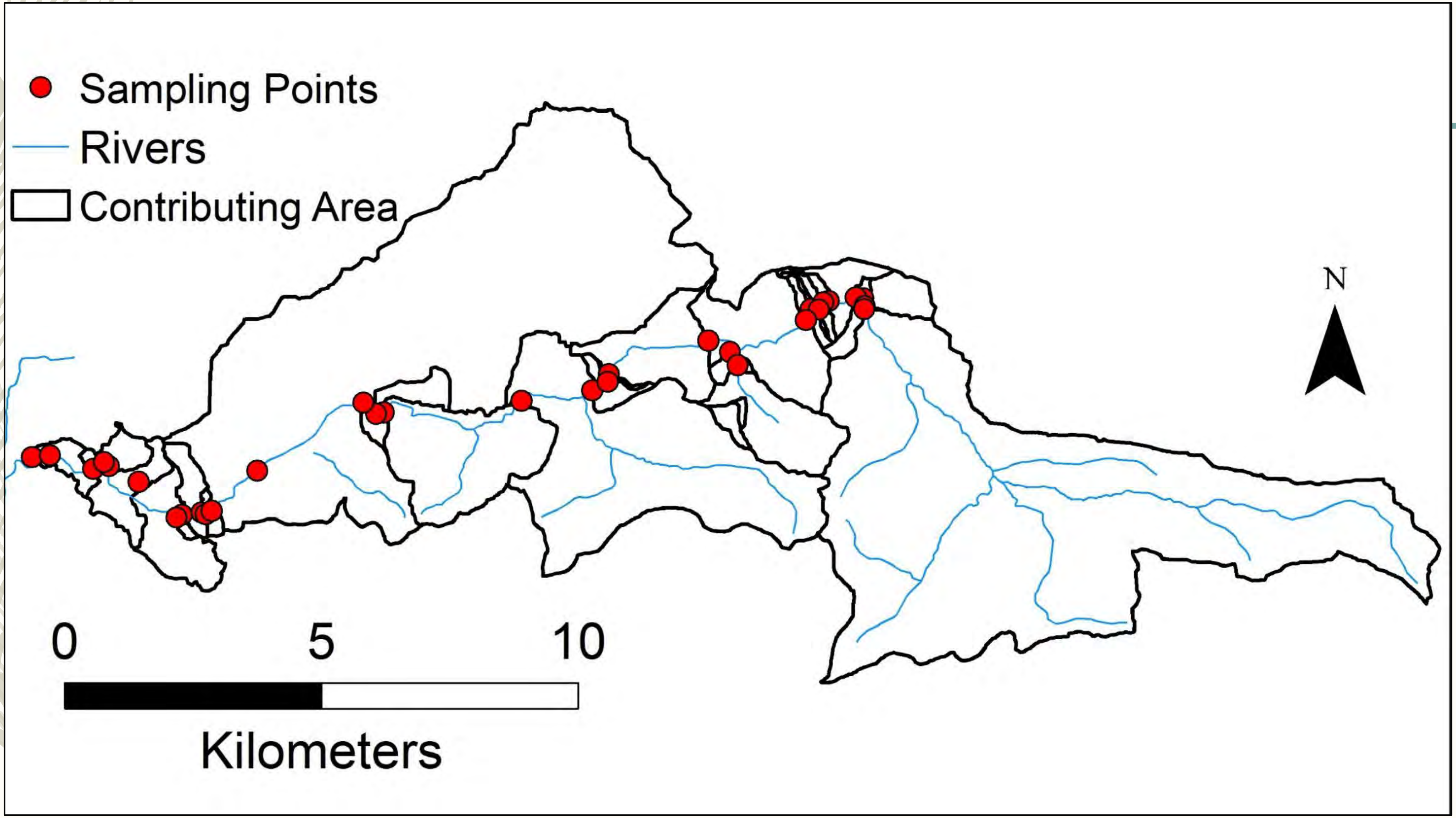
Peterson et al. 2011

Back to Johnson Creek

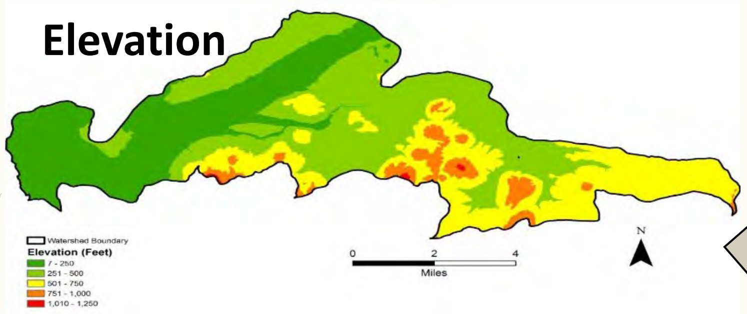


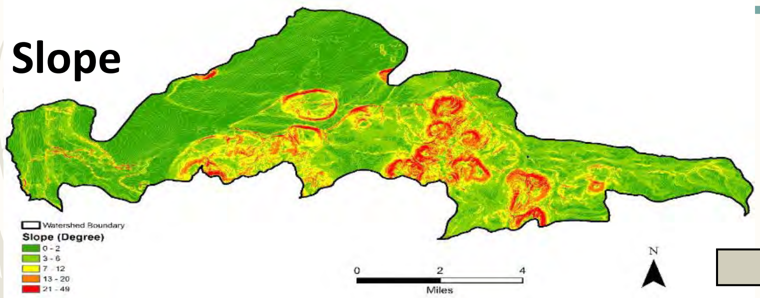
- About 40 km long
- Area- 138 sq km
- City of Gresham, Milaukie, and Portland
- Mixed Landuse, development dominated

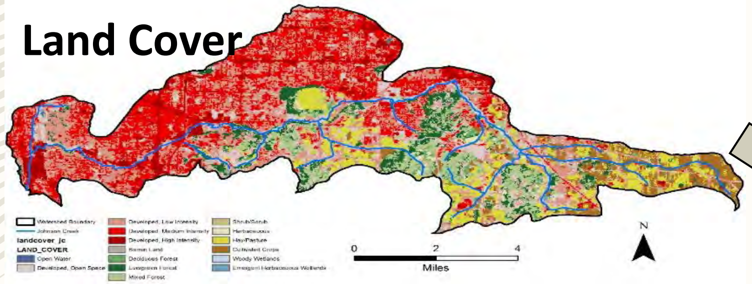
One more map

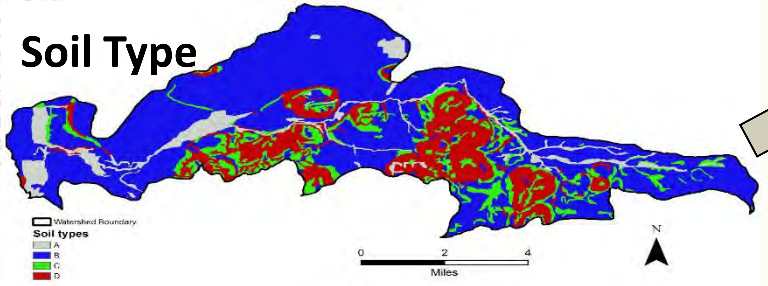

Sampling Points
Rivers
Contributing Area
N
0
5
10
Kilometers

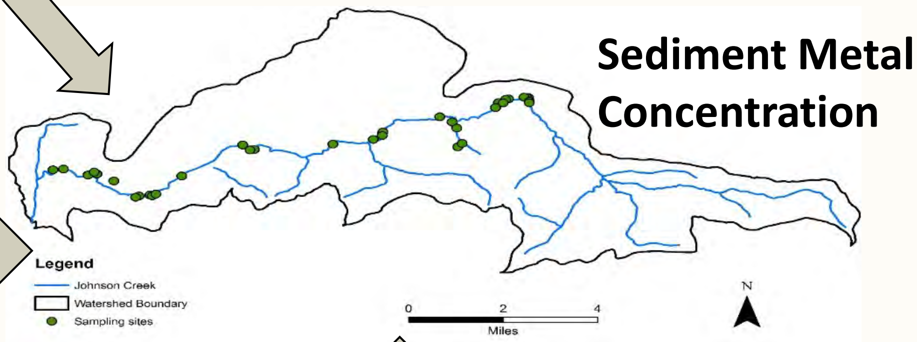
Methods

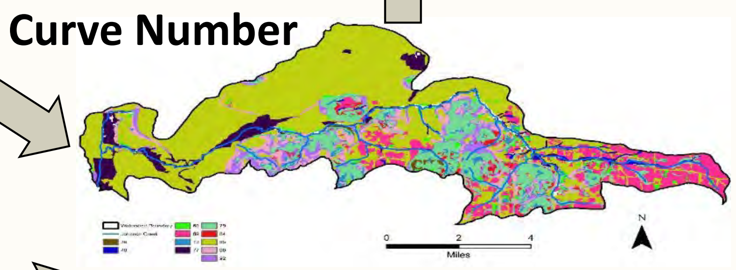

Elevation
Watershed Boundary
Elevation (Feet)
7 - 250
251 - 500
501 - 750
751 - 1,000
1,010 - 1,250
0 2 4
Miles
N


Slope
Watershed Boundary
Slope (Degree)
0 - 2
3 - 6
7 - 12
13 - 20
21 - 49
0 2 4
Miles
N


Land Cover
0 2 4
Miles
N


Soil Type
Watershed Boundary
Soil types
A
B
C
D
0 2 4
Miles
N


Sediment Metal Concentration
Legend
Johnson Creek
Watershed Boundary
Sampling sites
0 2 4
Miles
N


Curve Number
0 2 4
Miles
N

Methods

1. Calculation of curve number
2. Elevation and Slope Data
3. Python scripts to derive the all watershed level information for four different models
4. Four different models
   - Non distance weighted metrics (Average slope, curve number, elevation, basin size, cn*slope)
   - Distance weighted
   - Distance weighted overland flow
   - proportional flow accumulation

5. Regression analysis with different model (R software)

Results

Let it **Lead (Pb)**

Model	R^2	Equation
Lumped	0.08	NA
IDW	-0.05	NA
IDW overland flow	0.37*	-17.31+0.41*IDW2_CN_OL+5.63*IDW2_Slope_OL +0.035*Slope_OL-0.097*Slope_OL
IDW flow accumulation	0.37*	1.6-0.00003*size+0.0002*IDW_CN_FA + 0.003*IDW_Slope_FA-0.00005*IDW_CN_Slope_FA

Zinc (Zn)

Model	R^2	Equation
Lumped	0.029	0.08-0.035*avgSlope+4.277*CN_Slope
IDW	-0.156	NA
IDW overland flow	0.17*	26.49+1.22*IDW2_CN_OL+ 14.8*IDW2_Slope_Ol-0.21*IDW2_CN_Slope_OL
IDW flow accumulation	0.045	0.01 + 0.001*IDW_slope_FA- 0.0001*IDW_CN_Slope_FA

Copper (Cu)

Model	R^2	Equation
Lumped	-0.14	NA
IDW	0.2	NA
IDW overland flow	0.9*	-26.9+0.6*IDW2_CN_OL-4.71*IDW_Slope_OL+ 42*IDW2_Slope_OL+0.6*IDW_CN_Slope_OL-0.55*IDW2_CN_Slope_OL
IDW flow accumulation	0.9*	0.21-0.000007*size+0.0003*IDW_CN_FA+0.002*IDW_Slope_FA-0.0003*IDW_CN_Slope_FA-0.00004*IDW_Elev_FA

Chromium (Cr)

Model	R^2	Equation
Lumped	-0.08	NA
IDW	-0.2	NA
IDW overland flow	0.15	-0.55+0.24*IDW2_CN_OL+0.99*IDW_Slope_OL+2.42*IDW2_slope_OL-0.05*IDW_CN_Slope_OL
IDW flow accumulation	0.08	1.17-0.0000002*size+0.00001*IDW_CN_FA+0.0001*IDW_Slope_FA-0.00002*IDW_CN_Slope_FA

Cadmium (Cd)

Model	R^2	Equation
Lumped	-0.18	NA
IDW	-0.16	NA
IDW overland flow	0.1	0.062+0.001*IDW2_CN_OL+0.02*IDW2_slope_OL-0.001*IDW2_Cn_slope_OL
IDW flow accumulation	0.11	0.12-0.00002*IDW_Cn_Slope_FA

Some Takeaways

- Distance weighted overland flow based model and distance weighted proportional flow accumulation model mostly outperformed lumped attribute based model
- Different metal concentrations responded differently towards different models and not all metal concentrations were significantly modelled using this approach
- Addition of more variables like road density, vehicle movement, and some other datasets showing pollution sources might help explain the metal concentration better

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