

RELATIONSHIPS BETWEEN METAL CONTAMINATION IN WADABLE STREAMS IN SOUTH CAROLINA AND LAND USE CHARACTERISTICS

Alan J. Jones¹, Elizabeth R. Carraway^{1,2}, Stephen J. Klaine^{1,3}, Mark C. Scott⁴

¹Clemson Institute of Environmental Toxicology, Clemson University.
²Department of Environmental Engineering atEarth and Sciences, Clemson University.
³Department of Biological Sciences, Clemson University.
⁴South Carolina Department of Natural Resources, Pendleton, SC.

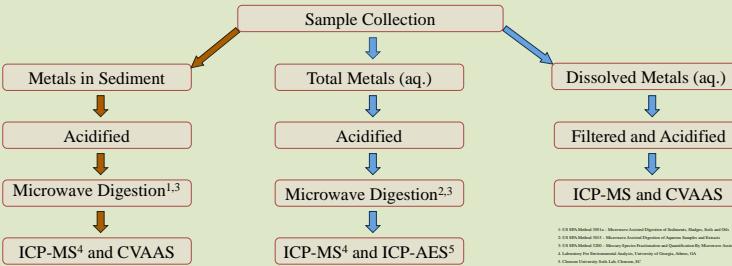
ABSTRACT

At present, little data is available concerning the overall quality of small aquatic ecosystems in South Carolina. A study of wadable streams in South Carolina is currently being conducted in cooperation with the South Carolina Department of Natural Resources (SCDNR). The overall goal of this work is to assess overall ecosystem quality in order to provide information needed for improved management strategies. The project assesses fish population and health and in addition performs measurements of stream characteristics, chemical contaminants present, and fish exposure to chemical contaminants. This presentation focuses on metal contaminants found in water and sediments in 2006 and 2007 and relationship between metals and land use in the drainage areas or watersheds of the sites sampled. Sites were randomly selected using known streams and GIS-determined watersheds of appropriate size (less than 150 km²). GIS and the National Land Cover Data Set (NLCD) were used to determine the land use distribution for each sampled watershed. Water and sediment samples were collected and analyzed using ICP-MS, ICP-AES and Cold Vapor-AAS. Among the metals of interest are aluminum, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, zinc, and others. Results indicate that a small number of sites exceed the published US EPA constant contaminant concentration and contaminant maximum concentration for a few waterborne or dissolved metals (e.g., cadmium, copper and nickel). In addition, a small number of sites exceed published risk threshold values for metal-contaminated sediments. Linear regression was used to correlate individual dissolved metal measurements with land use activities in individual and combined watersheds. Results indicate that changes in land use can change pollutant loads and impact the quality of the stream. The strongest relationships were observed for agricultural and forest land use with several metals (e.g., chromium, nickel, selenium, and potassium). Developed land area has not shown significant effects in these small and largely rural watersheds. Correlations are also considered for the whole study and are separated by watershed and ecoregion. Principle components analysis (PCA) is applied to watershed land uses to simplify interpretation and to reveal parameters responsible for metal contamination variability.

OBJECTIVE

To support South Carolina Department of Natural Resources to develop, implement an effective strategy to protect, conserve, and restore the aquatic resources of the State of South Carolina

METALS ANALYSIS



AQUEOUS RESULTS

Metal	% Samples Above	% Sites Above	4P ¹	2P ²	1P ³	1P ⁴	Maximum		
Ag	98	96	0.341	0.404	0.549	0.78	0.996	1.34	
Al	97	0	10.2	22	44	129	207	986	
As	98	0	0.394	0.452	0.854	1.71	2.45	4.09	
B	97	35	36	6.1	13.3	39	26	32	367
Ca	97	0	0	424	1237	5484	14512	28288	57423
Cd	98	30	31	0.152	0.184	0.321	0.489	0.736	13.4
Cr	98	17	17	0.279	0.307	0.698	3.55	15.1	151
Cu	98	0	0	1.13	1.54	2.93	4.57	10.7	49.4
Fe	97	0	0	454	1089	3689	1485	33497	14897
K	97	0	0	127	533	1594	2796	4314.4	6777
Mg	97	0	0	187	427	1799	2626	3385	32634
Mn	97	0	0	9.8	22	42	84	204	1358
Na	97	0	0	520	2288	4254	5672	7303	136643
Ni	98	0	0	0.529	0.772	1.35	2.07	4.16	484
P	97	14	14	8	18.5	37	66.5	167	1466
Pb	98	5	5	0.197	0.299	0.523	0.879	1.227	15.7
S	97	0	0	176	495	1153	2594	2997	44432
Se	98	11	11	0.147	0.206	0.314	0.445	0.767	3.66
Tl	98	42	43	0.129	0.16	0.224	0.348	0.488	8.976
Zn	98	0	0	3.92	7.37	12.6	21.4	37.7	98.3

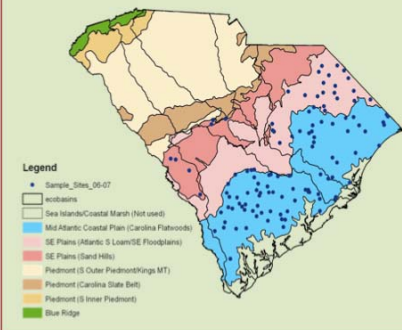
Above: Aqueous metals results summary table (mg/L).

Metal	CCC Equation	CMC Equation	Sites > CCC	Sites > CMC
Ag	NA	y=0.0021 ^{0.753}	NA	1
Cd	y=0.0714x ^{0.903}	y=0.0215x ^{1.07}	1	1
Cr	y=1.4625x ^{0.657}	y=12.346x ^{0.20}	2	0
Cu	y=0.1844x ^{0.957}	y=0.1688x ^{1.0}	39	28
Ni	y=1.0609x ^{0.585}	y=0.4126x ^{0.82}	8	1
Pb	y=0.0169x ^{0.993}	y=0.4130x ^{0.99}	29	0
Zn	y=2.4404x ^{0.997}	y=2.4342x ^{0.99}	2	2

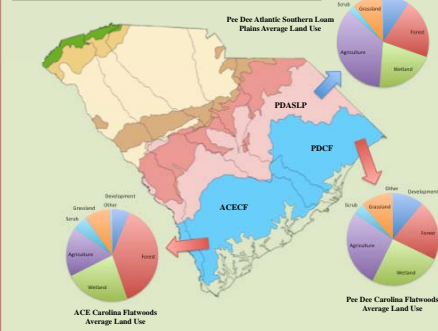
Left: Equations used to adjust observed metal concentrations for water hardness (form y=Ax^b where x=hardness) and number of sites exceeding the threshold.

SITE SELECTION

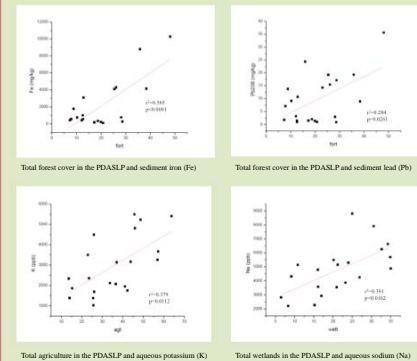
•South Carolina was divided into ecoregions based on the major river watersheds then further subdivided into smaller wadable watersheds.
•Sites were randomly selected in each ecoregion using a Geographical Information System (GIS)-based selection program.



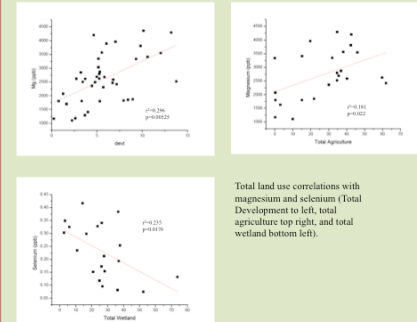
LAND USE CORRELATION



Pee Dee Atlantic Southern Loam Plains (PDASLP)



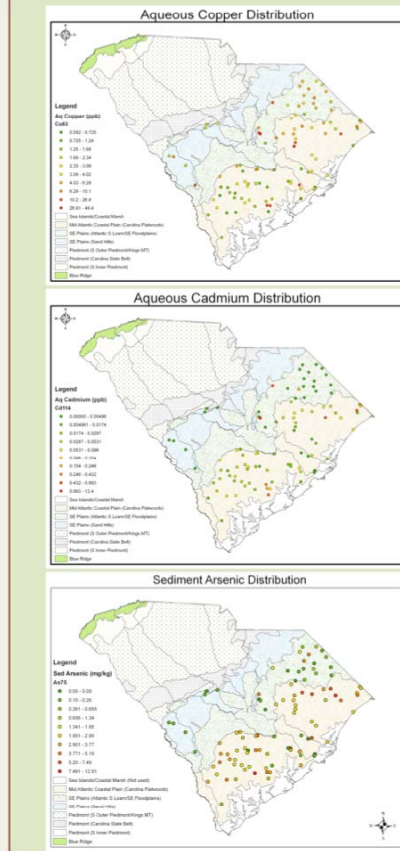
Pee Dee Carolina Flatwoods (PDCFC)



ACE Carolina Flatwoods (ACECF)

•No correlations were observed in the ACECF with any metals and land use.

GEOGRAPHIC DISTRIBUTIONS



DISCUSSION

•Results strongly indicate the presence of metals in the water column and in sediments, with several sites at concentrations above the EPA Constant Contaminant Concentration (CCC), Contaminant Maximum Concentration (CMC), and sediment risk thresholds.
•Significant trends between metal concentrations and land use within the watersheds are evident.
•Geographic hot spots of metal contamination are evident. This indicates that metals are geographically distributed.

ACKNOWLEDGEMENTS

Kevin Kubach, SCDNR; Troy Cribb, SCDNR; William Poly, SCDNR; Cathy Marion, SCDNR; Drew Gelder, SCDNR; Brandon Seda, CIET; Molly Keaton, CIET; S.C. Water Resources Center