GEOCHEMICAL MAPPING OF Cd, Pb AND Zn IN THE TRI-STATE MINING DISTRICT OF MISSOURI

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ABSTRACT

Four locations in southwest Missouri purportedly contaminated with mining wastes, Joplin, Aurora, Springfield and the James River, were investigated for lead and zinc content using spatial distribution and statistical analyses. The content of Pb and Zn concentrations in sediment samples was compared spatially against a regional background concentration map to determine both the contamination level and dispersion of these metals.

National Geochemical Dataset was extracted, and the1,019 data points were plotted within the study area were meaningful for statistical purposes

Concentrations of Pb and Zn in Joplin and Aurora were significantly higher, while the concentrations of Pb and Zn at the two sites near Springfield were closer to regional background concentrations. The metal content maps and association among metals both indicate that mining wastes are the main source of contamination.

Conclusions Even though mining ceased over 40 years ago and remediation has been applied to the area, some sediments in the area contain potentially toxic concentrations of Pb and Zn, especially around the cities of Joplin and Aurora. The background geochemical maps of the area were instrumental for identifying the sources and extent of these metals in sediments in this area.

SEDIMENTS AS ENVIRONMENTAL INDICATORS

Geochemical analyses of sediment have been used by numerous investigators in studying contaminant impact on streams. Sediments integrate contaminant concentration over time, rendering a long-term picture of the effects of e.g., mining, agriculture and urbanization than that obtained with water samples.

Our sediment geochemical data contained total metal content data, since they were collected to primarily fill a spatial gap. The conventional analytical procedure is a digestion of the air-dried sieved solid with *aqua regia*, (HCl-HNO_3) followed by element analysis using an inductively coupled plasma mass spectrometer (ICP-MS).

THE TRI-STATE MINING DISTRICT

The Tri-State Mining District includes parts of Kansas, Missouri, and Oklahoma and encompasses an area of a little more than 3,000 km^2 (Brockie et al. 1968), with lesser satellite deposits that extend to the east. The TSMD was first mined for lead in the mid-1800s but soon became a major producer of zinc. Pb and Zn were first mined in the 1800s from the surface to a depth of about 50 m, with mining activities in the Missouri part of TSMD ending around 1950 (Brockie et al. 1968; Beyer et al. 2004).

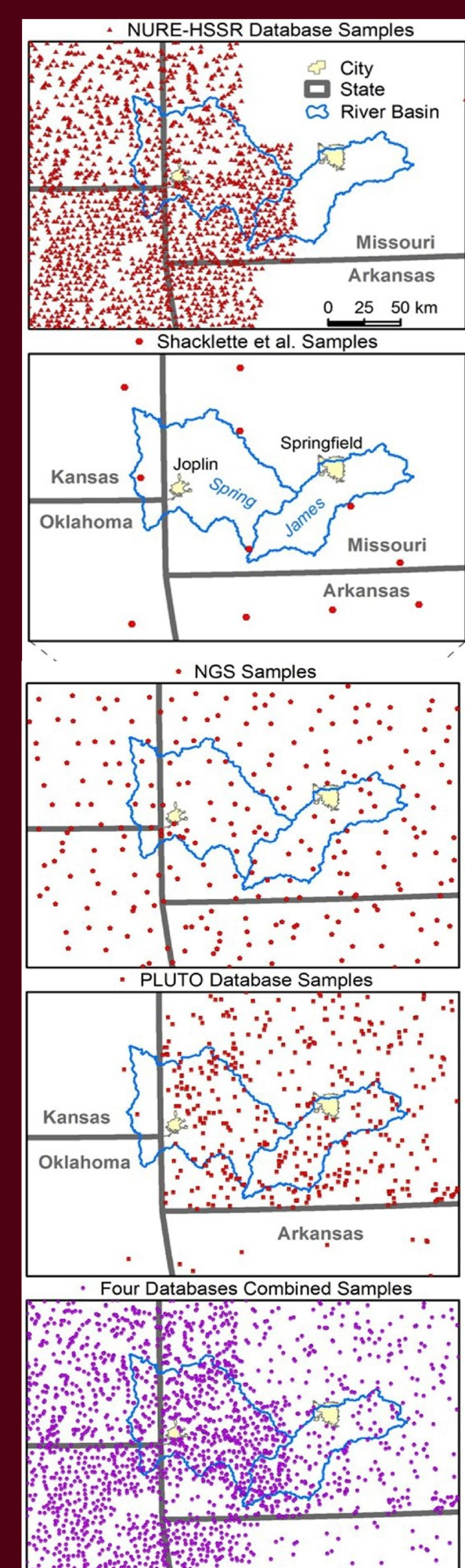
All of these metals are known to be toxic to birds and to aquatic life

Although less abundant than Zn in the TSMD ore, Pb is very important for environmental reasons because of its higher toxicity and for having polluted sediments and aquifers in the TSMD (USEPA 2012). Cd is a metal of concern too because of its toxicity (Satarug et al. 2003) and its close association with zinc in the TSMD (Brockie et al. 1968).

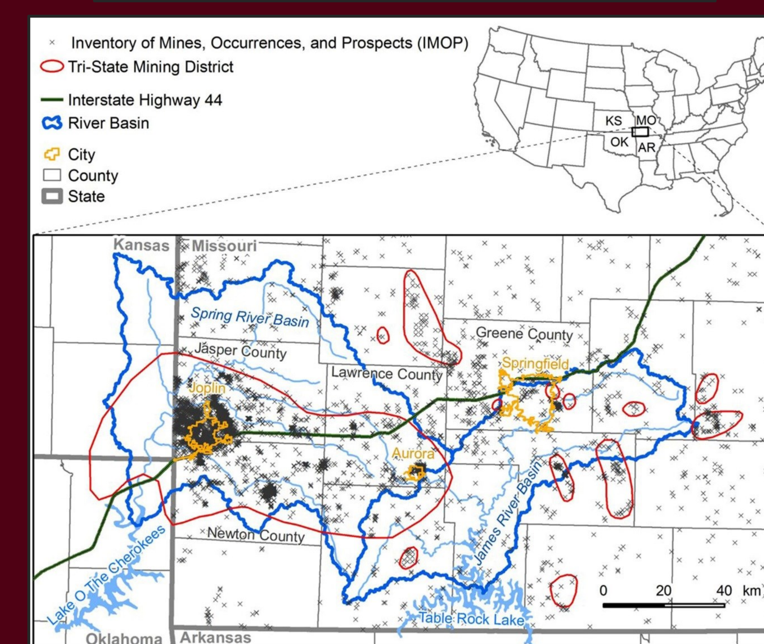
MSU theses have investigated the metal content in key areas (mining towns). Theses include Trimble (2001), Fredrick (2001), Rodgers (2005), Kothenbeutel (2008), and Peebles (2013),

METHODS

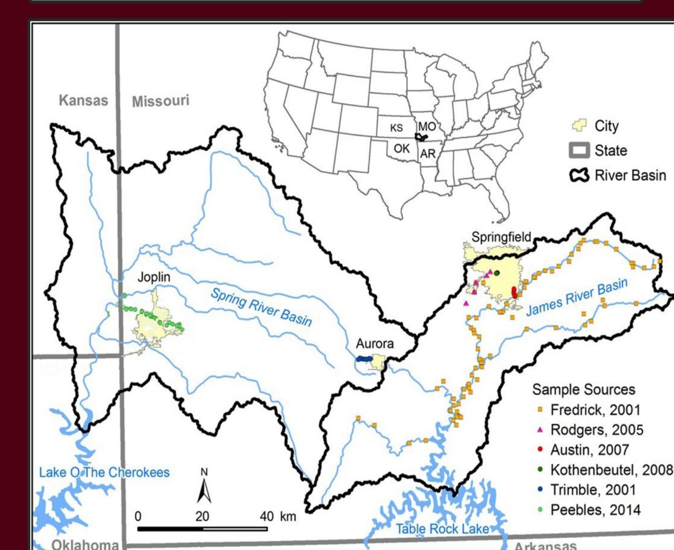
Stream sediment data were retrieved from USGS Geochemical Databases (N = 1,019) with which sediment geochemical maps were constructed. Publically available metal content data for each of four historic mining sites were also retrieved from separate studies. The Pb and Zn concentrations at each of the historic mining sites were compared against background concentrations using geochemical mapping interpolation (IDW method), box plot diagrams, Pearson correlation and ratioing.



MINERALIZATION



WATERSHEDS



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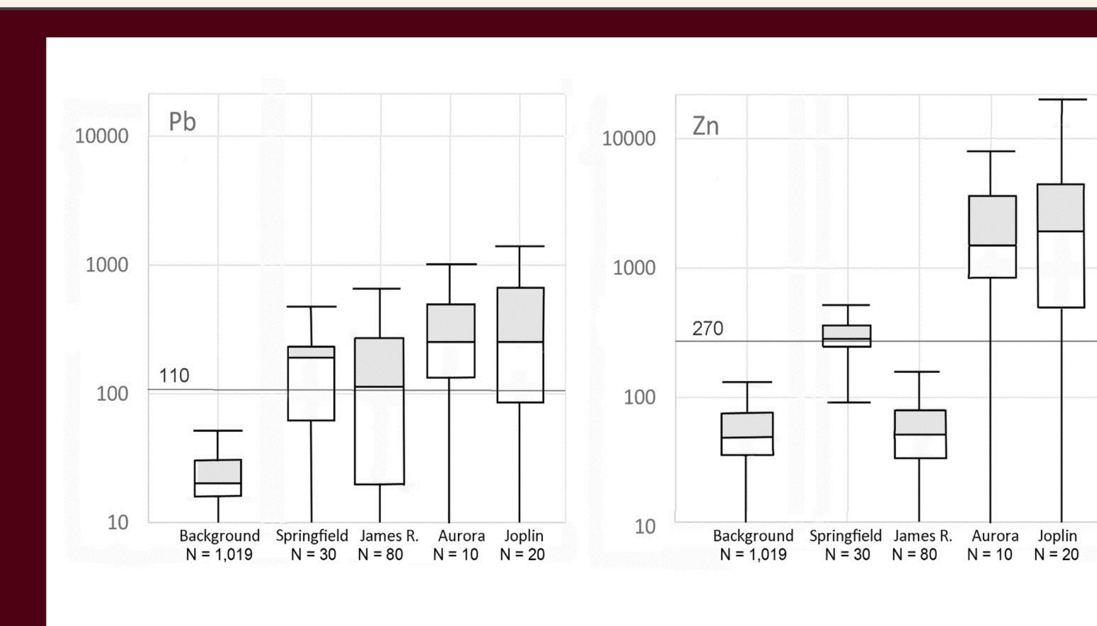
RESULTS

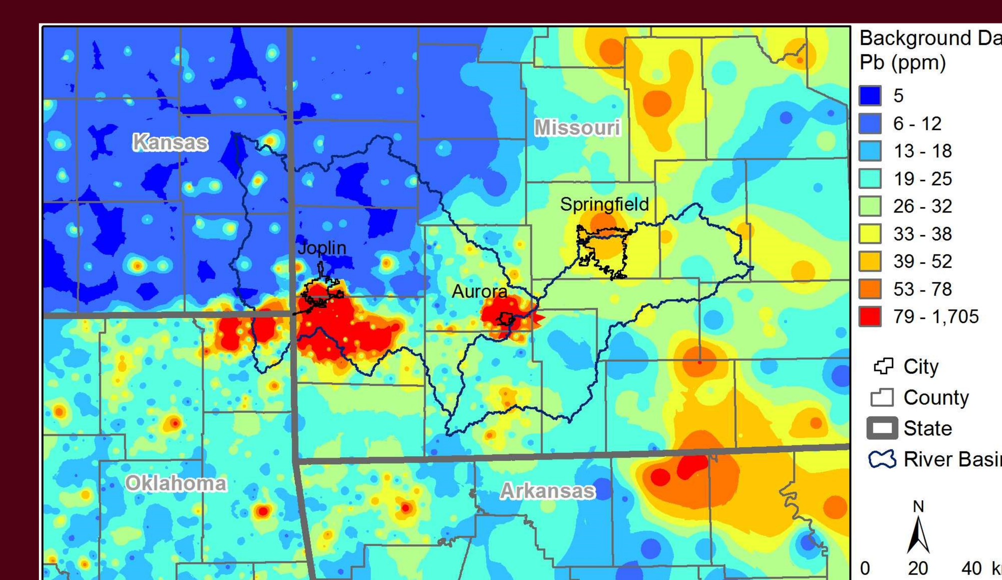
Table 1 Selected parameters used to differentiate Pb, Zn content and their associations at each of the four historic mining sites. In this context, % anom is the percent outliers (samples above the upper hinge value in the box plot analysis of background data 49.5 mg kg^{-1} Pb and 136.5 mg kg^{-1} Zn)

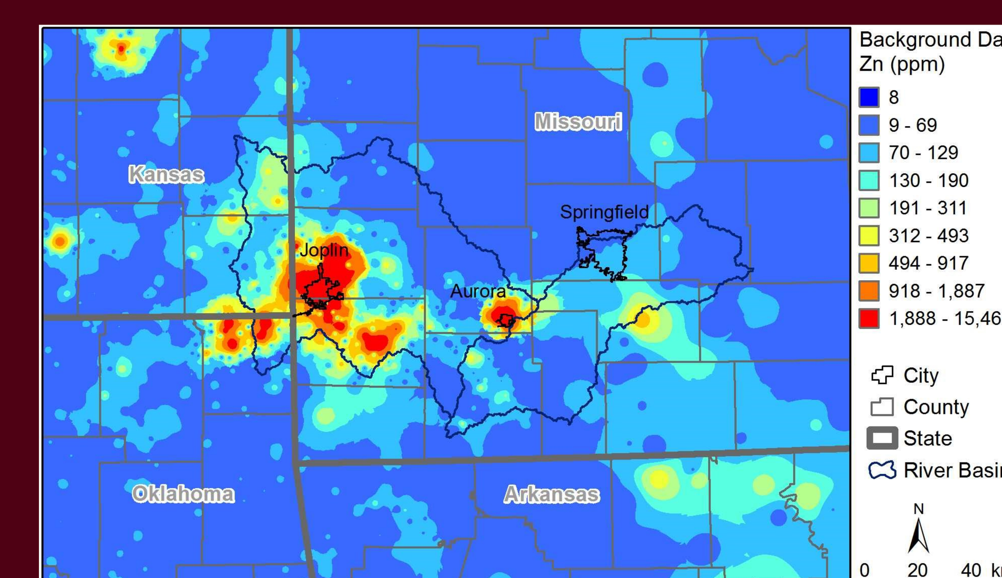
Location	Top 3 ave. mg kg^{-1}		% anom	% anom	weight	Correlation (p <0.001, 1-tailed)		
(N)	Pb	Zn	Pb	Zn	Zn/Pb	Zn:Pb	Zn:Fe	Pb:Fe
Joplin (20)	2,327	8,597	95	100	8.9 ± 5.6	0.61*	No	0.72
Aurora (10)	622	4,123	100	90	6.4 ± 1.9	0.99	No	No
Springfield (30)	327	519	83	100	3.3 ± 4.5	No	No	No
James River (80)	105	533	6	11	2.2 ± 5.1	0.71	No	0.46



Pb and Zn were present in a large range of values in the regional background data (values up to 3,460 mg kg^{-1} Pb and 14,027 mg kg^{-1} Zn) with a median of 22.0 and 53.0 mg kg^{-1} respectively. Concentrations of Pb and Zn in Joplin and Aurora were significantly higher, while the concentrations of Pb and Zn at the two sites near Springfield were closer to regional background concentrations. The metal content maps and association among metals both indicate that mining wastes are the main source of contamination.

Maps of Anomalies





The contamination is more severe in sediments of and near urban areas of Joplin and Aurora and these deposits have not yet been dispersed but remain relatively well contained.

Certain thresholds have been established for residential soils and restoration action, but not yet for sediments. Some formal and informal guidelines are listed in Table 2 below.

	Sediment Upper fence (box plot)	Sediment ER-M (aquatic organisms)	EPA soil remediation TSMD (level 2)	SL-EPA Superfund residential soils	Jasper County Health Dept. Soil ordinance
Pb, mg kg^{-1}	49.5	110	800	400	800
Zn, mg kg^{-1}	136.5	270	N/A	2,300	N/A
Cd, mg kg^{-1}	N/A	9	N/A	7	120
Reference	This study	Long and Morgan (1990)	USEPA (2012)	USEPA (2013)	health.jaspercounty.org
% samples exceeding the guideline					
Joplin					
Pb	95.0	85.0	20.0	45.0	20.0
Zn	100.0	95.0	N/A	55.0	N/A
Aurora					
Pb	100.0	92.0	0.0	25.0	0.0
Zn	90.0	92.0	N/A	33.3	N/A
Springfield					
Pb	83.3	60.0	0.0	0.0	0.0
Zn	100.0	66.0	N/A	0.0	N/A
James River					
Pb	6.0	2.5	0.0	0.0	0.0
Zn	11.3	1.0	N/A	0.0	N/A

CONCLUSIONS

Even though mining ceased over 40 years ago and remediation has been applied to the area, some sediments in the area contain potentially toxic concentrations of Pb and Zn, especially around the cities of Joplin and Aurora. The background geochemical maps of the area were instrumental for identifying the sources and extent of these metals in sediments in this area.