Variability of Metal Content in Sediments In and Around Aurora, Missouri, a Historical Mining Town

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ABSTRACT

The state of contamination of the historic mining town of Aurora, Missouri, was investigated. Sediments were collected in and around Aurora during 2014-2015 and analyzed for metal content (Cd, Pb, Zn) using the conventional method of ICP-MS after digestion with *aqua regia*. Once merged with other reported data, there were 109 data points scattered over a 15 x 10 km area, yielding a coverage of 1 data point per 1.37 km^2.

Data were analyzed to determine:

(a) the correlation among metals,

(b) the variability in metal content between urban and non-urban areas,

(c) the variability in metal content within Chat Creek, and

(d) the metal content variability between Chat Creek and other streams.

For these determinations, Pearson correlation, t-test, and spatial IDW (inverse distance method) were utilized. Of the total number of samples, 45% contained toxic levels of Pb and 70% of Zn, based on sediment quality guidelines PEC (probable effect concentration) reported for the area. To better appraise the metal contamination of the area, maps showing the varying metal content for each Pb and Zn were created.

SEDIMENTS AS ENVIRONMENTAL INDICATORS

Geochemical analyses of sediment have been used by numerous investigators to study contaminant impact on streams. Toxicity of sediments is determined by how contaminant concentrations affect a particular type of aquatic life, while mobility is determined by how much of the contaminant is by one (or more) solution (e.g., weak acid representing rain) and by sequential extraction.

Sediments integrate contaminant concentration over time, rendering a long-term picture of the effects of e.g., mining, agriculture and urbanization, better than that obtained with water samples.

THE TRI-STATE MINING DISTRICT

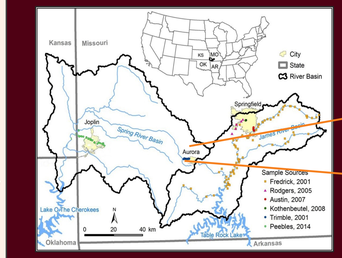
The Tri-State Mining District includes parts of Kansas, Missouri, and Oklahoma and encompasses an area of a little more than 3,000 km^2 (Brockie et al. 1968), with lesser satellite deposits that extend to the east. The TSMD was first mined for lead in the mid-1800s but soon became a major producer of zinc. Mining activities in the TSMD ended around 1950 (Brockie et al. 1968; Beyer et al. 2004). Mining wastes laid exposed for decades

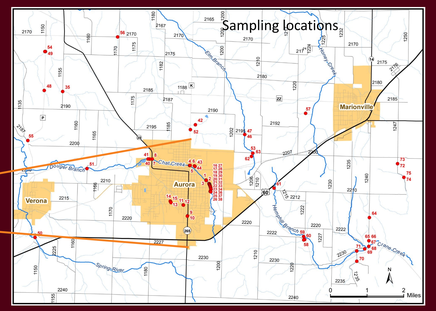
Aurora belongs to the TSMD. Mining concentrated in the northern part of town. Chat piles were remediated in steps, 1980, then 1990s, and so on.

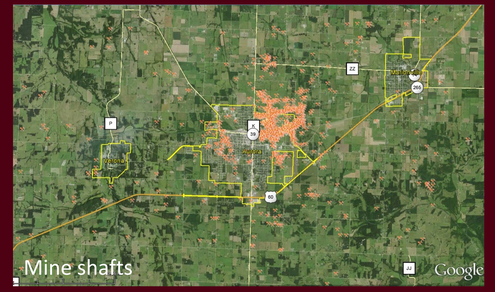
Although less abundant than Zn in the TSMD ore, Pb is very important for environmental reasons because of its higher toxicity and for having polluted sediments and aquifers within the TSMD (USEPA 2012), whereas Cd occurs in association with Zn (Brockie et al. 1968) and is highly toxic to aquatic life even at small concentrations.

Before and after remediation of chat piles

WATERSHEDS







METHODS

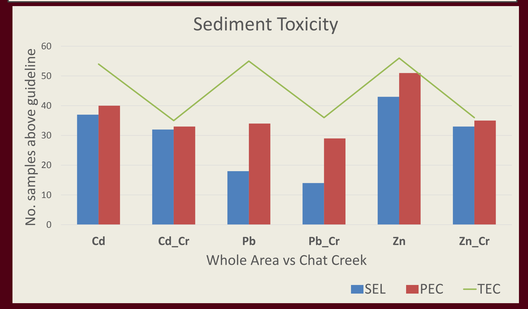
Samples are air dried in the laboratory and sieved to 1 mm particles. Dried, sieved samples were sent to a commercial lab where the metal content was determined by digestion with *aqua regia*, (HCl-HNO_3) and element analysis using an inductively coupled plasma mass spectrometer (ICP-MS) to a subsample of dried sediments pH and the % fines (fragments less than 0.14 mm)

The figure at right shows sediments drying in the laboratory. Notice the large variety of colors due to varying amounts of iron oxides and organic matter. The source rock is cherty limestone which results in abundant chert fragments in the sediment. Cd, Pb and Zn minerals in chat piles are attached in chert originally and will transfer to clays and iron and manganese oxides with further weathering.

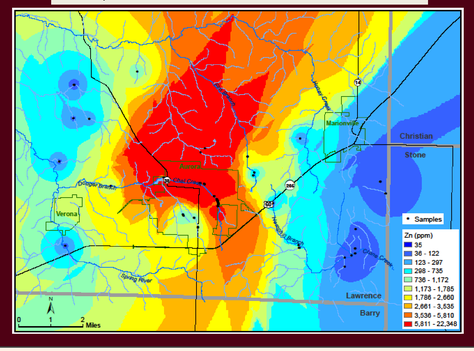
Lack of correlation between grain size (% fines) and metal content suggests that the 50 or so years exposure have not been long enough to weather the metals into these more mobile forms and much remains attached to chert fragments.

RESULTS

Table 1 % values surpassing sediment quality guidelines from a total of 75 samples. SEL = severe effect level, PEC =probable effect concentration, TEC = threshold effect concentration



Spatial Distribution of Zn concentrations



Pb and Zn were present in a large range of values (values up to 8,200 mg kg^{-1} Pb and 51,600 mg kg^{-1} Zn) with a median of 102 and 2,010 mg kg^{-1} respectively.

The concentrations were higher in Chat Creek, a stream crossing the City of Aurora.

In the regional (background) data the medians were 22 mg kg^{-1} Pb and 71 mg kg^{-1} Zn. The metal content maps and strong association among metals both indicate that mining wastes are the main source of contamination.

Table 2. Median concentrations of Cd, Pb and Zn in streams in and surrounding Aurora & in Chat Creek

[1] Persaud et al. 1993; [2] MacDonald et al. 2000

	Cd ppm	Pb ppm	Zn ppm
SEL			
Severe Effect Level[1]	**10**	**250**	**820**
(Harmful effects expected)			
PEC			
Probable Effect Conc.[2]	**5**	**128**	**459**
(Harmful effects likely above this concentration)			
TEC			
Threshold Effect Conc.[2]	**1**	**36**	**121**
(Harmful effects unlikely below this concentration)			
Area around Aurora	**8.3**	**102**	**2,010**
Chat Creek	**33**	**196**	**5,720**

CONCLUSIONS

- Even though mining ceased over 50 years ago and remediation has been applied to the area, some sediments remain potentially toxic with respect to Zn, Cd and Pb , in that order.
- The most contaminated areas correspond to the areas where mining occurred. Concentration pattern shows that metals have not dispersed much since mining times and concentrates around the northern part of Aurora and surroundings. Levels show the need of further remediation and/or monitoring of metal content.
- Geochemical maps were an excellent tool for identifying the sources and extent of these metals in sediments.

ACKNOWLEDGEMENTS

A Faculty Research Grant from MSU funded this study. Seven undergraduate students have worked/are working on distinct aspects of this project. Additional samples will help delineating the contaminated areas better. Two students are looking at the mobility and availability of metals using Na-acetate acid solution as extractant, one student is looking at possible groundwater contamination from surface water leaks, and one is looking at historic aerial photos and GIS to test the hypothesis of contamination being associated to the former location of chat piles.

REFERENCES

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