# Importance of Coarse Sediment for Assessing Metal Contamination from Historical Mining in Big River, SE Missouri.

Hannah Eades. Faculty Advisor: Dr. Robert Pavlowsky
Department of Geography, Geology, and Planning, Missouri State University Springfield, MO

## Abstract

From 1864-1972 numerous lead and zinc mines were in operation in the Old Lead Belt District, Southeast Missouri. As a result, metal-rich tailings were released into nearby streams and are still stored in channel deposits today. Typically, the <2 mm size fractions are evaluated for contamination in sediment assessments. However, mine tailings often can contain particle sizes from 2-16 mm. The purpose of this study is to analyze heavy metal concentrations and mass distribution among varying size fractions of channel bar deposits in the Big River in the Old Lead Belt in St. Francois County, Missouri. A total of 14 sediment samples were collected from two sites. Each sample was separated into six different size fractions and each fraction was analyzed by X-Ray Fluorescence (XRF) spectroscopy for metals. The coarser fractions (>2 mm) were crushed prior to metal analysis. Fine gravel sediments were composed of >50% tailings and contained >2,000 ppm Pb. Fine sediment is typically transported away from the source of contamination relatively quickly, while larger size fractions are heavily contaminated and remain in the channel for longer. These coarse sediments may increase long-term environmental risk as they release metals into the channel by weathering, and dissolution.

## Background and Location

- The Big River, a tributary of the Meramec River flows Northward through the Heart of the Old Lead Belt in St. Francois County.
- Galena and sphalerite are the major ore minerals in the area with Galena being the most abundant.
- Ore was mainly mined from the Cambrian Bonne Terre Dolomite. (Pavlowsky et al., 2017)
- Mining sediment contains chat, or tailings which is the material left over after processing ore.
- These tailings can be found for distances of several hundred km downstream and can be stored in channel deposits. (Pavlowsky et al., 2017)
- Tailings have been found to contribute to 30-70% of lead concentrations found in channel deposits
- Erosion is continuing to release metals stored in channel and floodplain deposits

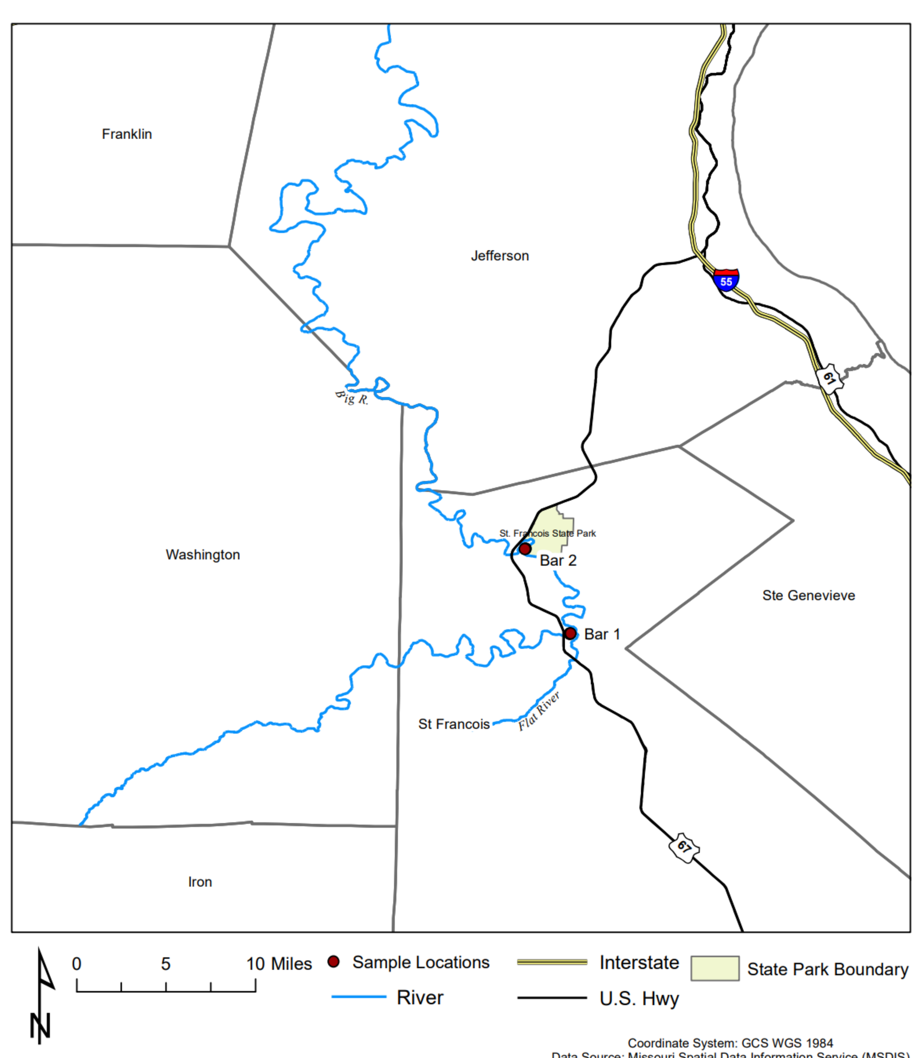


Figure 1: Location of the study area, with sampling sites labeled as Bar (1) at the upstream location and Bar (2) at the downstream location.

## Methods and Sampling

### Sampling and Size Analysis

- 14 samples were taken at two locations on the Big River in St. Francois County (1) below Flat River Creek and (2) at St. Francois State Park
- Site (1) surface and subsurface samples were taken at the head, middle high, middle low, and tail of the gravel bar with 8 samples total
- At site (2) surface and subsurface samples were taken at the head, middle, and tail of the gravel bar with 6 samples total
- All 14 samples were dried and passed through a sieve to separate into 6 different size fractions (>16mm, 16-8, 8,4, 4-2, 2-250, <250)
- Sediment >16mm was not included in sediment analysis as it is not useful in determining metal concentrations
- Each size fraction was weighed to determine percent distribution of mass

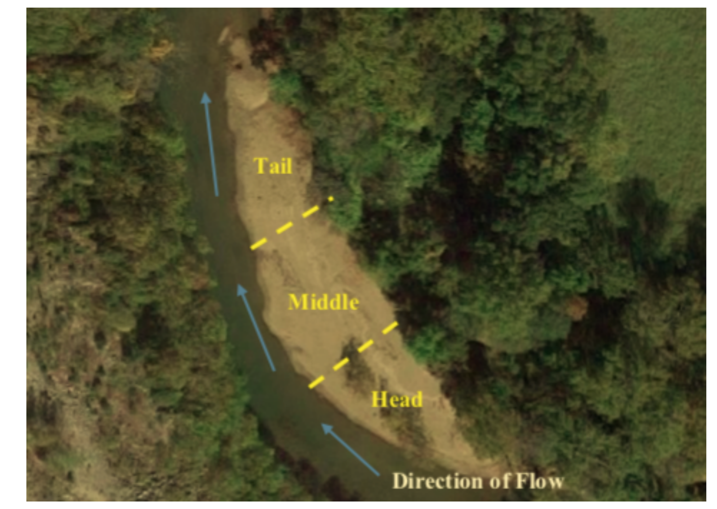


Figure 2: Shows bar head, middle, tail positions of a typical point bar (Olson, 2017)

Figure 3: Bar (1) Head

Figure 4: Bar (1) Middle-High

Figure 5: Bar (1) Middle-Low

Figure 6: Bar (1) Tail

Figure 7: (Above) Shows a sub-sample from a 4-8 mm size fraction that has been separated based on dolomite fragments (left) and all other sediment grains (right)

### Grain Counts:

- Sub-samples were taken from the 2-4, 4-8, and 8-16mm fractions
- Each sub-sample contained approximately 100-200 grains
- Dark gray dolomite fragments are tailings produced by mining activities in the area
- In each sub-sample tailings and the other grains were separated and counted to determine the percent tailings in each size fraction

### Geochemical analysis:

- X-ray fluorescence (XRF) was used to determine the concentrations of Pb and Ca in the <2mm samples.
- Standards and duplicates were run every 10 samples measured

Figure 8. A 2-0.25mm and <0.25mm

Figure 9. X-Ray Fluorescence (XRF)

## Results and Discussion

### Grain Counts:

- >45% of the total grains counted were mine tailings and >55% of tailings were of the 4-2mm size fraction.
- The Tables 1. and 2. indicate that in the 2-4mm and 4-8mm size fractions the average percent of tailings is greater in the downstream sample site (Bar 2) than in the upstream site (Bar1)
- The tailing distribution among channel form is similar between 2-4mm and 4-8mm size fractions

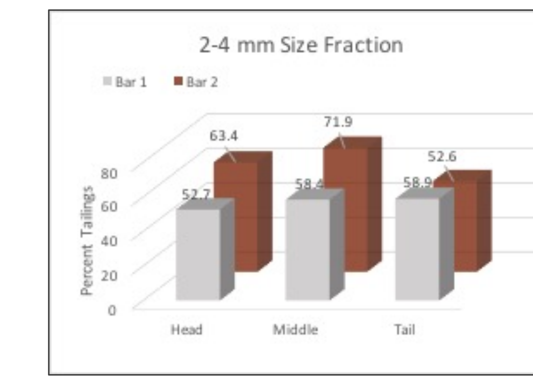


Table 1.

- Table 3. The percent tailings is greater in Bar 1 unlike the smaller size fractions
- Table 3. Also shows that as grain size increases the overall percent average tailings decreases.

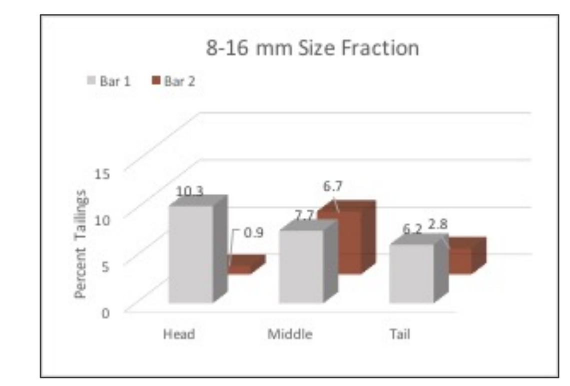


Table 3.

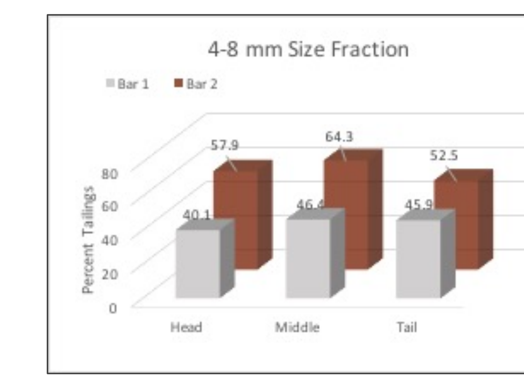


Table 2.

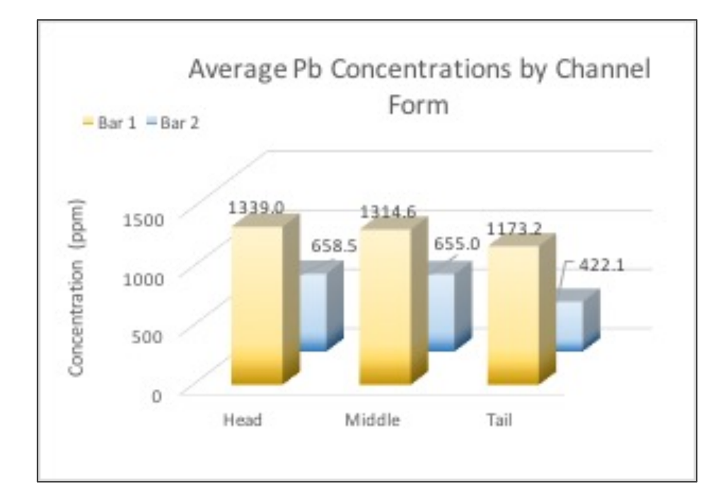


Table 4.

### XRF Analysis of <2mm fractions:

- Table 4. This graph uses average concentrations of Pb in <2mm size fractions to show the distribution of lead contamination between sample locations and channel form
- Bar 1 (the upstream location) contains higher concentrations of Pb
- Pb concentrations typically decreases downstream

| Size Fraction (mm) | Pb | Ca |
|---|---|---|
| 8-16 | 712 | 18,930 |
| 4-8 | 2,936 | 84,934 |
| 2-4 | 4,434 | 134,091 |

Table 5. Results from a report on Big River near the confluence of Flat River Creek (Pavlowsky, 2019)

- Table 5. Concentrations from >2mm size fractions.
- 4-8mm and 2-4mm Pb concentrations exceed the average concentration of the <2mm size fraction by at least 3 times
- Ca concentrations associated with the dolomite tailings can indicate percent of tailings in a size fraction
- Concentrations of Ca increase as size fractions decrease

Discussion: All 14 samples exceeded the PEC of 128ppm for Pb by at least 3 times in the <2mm size fractions. Pb concentrations of <2mm size fraction averaged 951 ppm. Based on past studies tailings of >2mm size fractions are found to contribute to a significant portion of Pb contamination in sediment. 2-16mm size fractions account for >40% of the total sediment mass with >40% of grains being contaminated mine tailings.

## Acknowledgements and References

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- Pavlowsky, R.T., Lecce, S.A., Owen, M.R., and Martin, D.J., 2017, Legacy sediment, lead, and zinc storage in channel and floodplain deposits of the Big River, Old Lead Belt Mining District, Missouri, USA: Geomorphology, v. 299, p. 54–75, doi: 10.1016/j.geomorph.2017.08.042.
- Olson, Lindsay Marie, "Channel Bar Morphology, Distribution, And Mining-Related Geochemistry In The Big River, St. Francois County, Missouri: Implications For Geomorphic Recovery" (2017). MSU Graduate Theses. 3198.

## Conclusion

Overall the combined results from XRF analysis of the <2mm size fractions, tailing counts, and previous reports indicate that the Big River will continue to be contaminated for an extended period of time. The <2mm size fractions are typically used to determine levels of contamination but as this study and previous studies have shown, 2-16mm size fractions contain higher levels of Pb and nearly half of the total tailings. More studies need to be conducted to determine just how much these size fractions will affect Pb concentrations in the Big River temporally and spatially.