Determining the Extent of Contamination and Potential Health Effects from Water Quality of the Oklahoma Section of the Historic Tri-State Mining District

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Introduction

The Tri-State mining district is an area of abandoned lead and zinc mining covering portions of Kansas, Missouri and Oklahoma (Pope, 2005). The area was mined for approximately 100 years from the 1870's until the 1970's. The most productive portion of the Tri-State mining district was the 40-square mile "Picher mining district" in Oklahoma (Andrews et. al., 2009). The mining produced large amounts of waste rock known as 'chat' which has been left in surface waste piles around the mines (Andrews et. al., 2009). These waste piles, located mostly in Oklahoma near the town of Picher, contain lead (Pb), Zinc (Zn) and other elements potentially harmful to human and ecological health. Surface water can leach these hazardous elements from the rocks and then contaminate local stream systems. Underground abandoned mines can also flood in heavy rain events and seep into streams and groundwater. Beyer et. al. (2004) found increased concentrations of Pb in waterfowl, robins, and cardinals related to red blood cell activities. They also determined that concentrations of cadmium in the livers and kidneys of swallows, cardinals, and robins were significantly higher in birds from the district than in birds from non-contaminated sites (Beyer et. al., 2004). A study in 1996 revealed that 34% of the children in this community had lead poisoning. Due to the environmental and health impacts of the mine, officials evacuated the residents of Picher in the mid 2000's. The EPA eventually established Picher as a Superfund Site.

The purpose of this presentation is to analyze the impact of the Picher mine tailings on local streams, evaluate the extent of contamination relative to the distance from mined areas, and examine potential health effects related to water contamination.

Methodology

Field sampling was conducted on May 14-15th, 2014, beginning along the Spring River and Tar Creek in the Kansas portion of the Tri-State Mining District which was used as a baseline for surface water entering the Picher mining area. Sampling continued at sites along these two river systems, as well as Lytle Creek and the Neosho River in the Picher mining area; and concluded on the southern side of the dam that forms the Grand Lake O' the Cherokees. Samples were filtered with 0.45 µm filters into new acid washed containers. Nitric acid was added as a preservative to the container designated for trace metal analysis. At all sampling locations water parameters were collected along with water samples for anions, cations, and trace metals.

Laboratory analysis included cation and anion analysis on a Dionex ICS-2100 Ion Chromatography System and processed with Chromeleon 7 software. Trace elements were measured on an ICPMS. The aquatic geochemical modeling software, PHREEQC, was used to determine speciation of contaminants in the surface water.

Results

The water samples collected upstream and/or greater than 15 km downstream from the center of mining activity had lower concentrations of cations, anions, and metals. Higher concentrations were recorded at the four sites located within 15 km downstream from the center of mining activity. These results are depicted in Table 1 and reported in mg/L concentrations based on distance from the center of mining activity.

Ion Concentration according to distance from center of mining activity

	Up Stream Sampling Sites	Sites <15km Downstream	Sites >15km Downstream
Chloride	12.7	27.0	0.1
Sulfate	34.3	767.3	0.1
Fluoride	21.0	48.2	0.1
Sodium	8.9	23.5	12.8
Calcium	36.8	241.6	52.2

Table 1: Selected ion concentrations in mg/L at sampling locations upstream, within 15km downstream and greater than 15km downstream from the center of mining activity in Picher, Oklahoma.

This pattern persisted for metal concentrations, as well. Zinc was measured at concentrations of <0.25 mg/L at all sites excluding the four sites within 15km downstream of the center of mining activity. Those sites produced concentrations ranging from 1.2 mg/L to 2.87 mg/l with an average of 1.9 mg/L. Other contaminants, such as Mn, Fe, Co, Ni, As, Sr, Mo, and Cd revealed higher concentrations within 15 km of the mining region, relative to the upstream and > 15 km from the mining. Geochemical modeling (PHREEQC) was utilized to determine the speciation of the contaminants in the surface water.

Discussion

Average concentrations for chloride, fluoride, sulfate, calcium, magnesium and sodium at sites within 15km downstream of the mining region are higher than the averages for the upstream sites or sites greater than 15 km from the mining region. The four highest values for manganese, nickel and zinc were recorded at sites within 15km downstream. “The Criterion Continuous Concentration (CCC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect” (EPA, 2009). The EPA’s Chronic Criterion Concentration for zinc in freshwater is 0.120 mg/L, which was exceeded by sites T2 (2.87 mg/L), T3 (2.28 mg/L), T4 (1.2 mg/L) and L1 (1.28 mg/L), all of which are within 15Km downstream from the center of mining activity. Fluoride concentrations upstream (21.0 mg/L) and within 15km downstream (48.2 mg/L) from the center mining activity were well above the maximum contaminate level established by the EPA of 4.0 mg/L. These results indicate contributions of ions and metals from the mining activity into local waterways that rival and in many cases exceed EPA water quality standards.

These contaminates are likely to be sourced from two main areas, “seepage of metals in ground water (from flooded abandoned underground mine workings and locally perched water tables) discharging to streams; and leaching of metals from streambed sediments, and tailings” (Andrews et. al., 2009). When examining measured concentrations of metals Andrews et. al. (2009) identifies other factors that must be considered like precipitation of metals to sediments. The lithology underlying each stream must also be considered as Andrews et. al. (2009) measured aluminum concentrations to be about an order of magnitude lower at sites along the Spring River than the Neosho River; possibly due to limestone beneath the Spring River and aluminum rich shale under the Neosho. Speciation of the contaminants plays a big role

in whether there will be health effects from the mining contaminants in population downstream, and determining the availability of the contaminants to human and aquatic health.

Conclusions

Sites within 15km downstream from the center of mining activity exhibit higher concentrations of ions and metals than sites further downstream. This is likely due to two main factors, the larger Neosho River intersecting the smaller Tar Creek (the main stream within the mining activity) at approximately 15km downstream. The second factor is the propensity of metals to precipitate or be absorbed to other minerals indicated by Andrews et. al. (2009). Sediment samples from Tar Creek could provide a good barometer for the concentration of metals lost due to precipitation and absorption. The flowrate and volume of water that is introduced by the Neosho River at approximately 15 km downstream, along with metal concentrations of the Neosho, could further account for the drastic drop in concentrations at this point.

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