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Tri-State Mining District, Ecological System, and Human Health: Systematic Literature Review Analysis

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ABSTRACT

Objective: Although extensive research exists on corrosive environments in the Tri-State Mining District (TSMD), there has been a lack of research on how such harmful effects in the TSMD could affect residents living in those areas. However, quite recently, such research regarding relationships between the health conditions of low-income residents and toxic elements in TSDM began to grow. Therefore, the increase of empirical studies means greater complexity of the findings that require a more intricate understanding.

Methods: To meet the necessity of the study, this research was conducted by an extensive systematic review of the literature on the harmful effects of TSMD on the physical health of residents living in TSMD areas along with significant findings of the formation and toxicity of TSMD areas, and the contamination impact on the ecological system (aquatic systems, wild birds) to better comprehend the mechanism of TSMD effects on human beings.

Results: This research addressed that toxic metals not only negatively impact natural habits in the TSMD environments (ALA reduction, kidney and liver problems, decrease of fish species) but also seriously and continuously affect the health of residents living in that area (ingestion, inhalation, dermal absorption) and increase the possibility of a person developing overweight or obese.

Conclusion: This study would make a vital contribution building upon the existing outcomes of the correlations between toxic elements coming from the TSMD areas and low-income residents. Furthermore, this study outcome will be updated information for policymakers and health-related professionals who aim to promote economic and social justice by providing adequate and innovative remediations to improve the natural environment and health of residents in the TSMD.

Keywords: TSMD, lead, zinc, cadmium, arsenic, habitats, health conditions, remediation.

INTRODUCTION

The Tri-State Mining District (hereafter TSMD) of Kansas, Missouri, and Oklahoma mined lead (Pb) and zinc (Zn) actively from 1850 to 1970 and has been shut down since 1970 . Even though the mining companies moved out, the TSMD ground water, soil, and sediments have been contaminated due to the concentration of toxic metal components, such as Pb, Zn, and Cadmium (Cd) in spite of remediation efforts. In addition, studies about finding relationships between human being's health and the toxic components have been growing since a decade ago (kidney, lung cancer) and to other ecological systems (e.g., aquatic systems, wild birds).

The U.S. Environmental Protection Agency (USEPA) and other stakeholders have remediated to reduce the problems of TSMD. However, as aforementioned, living creatures including human beings in the TSMD are still susceptible to toxic components even though the condition of Pb, Cd, and Zn in water, soil, and sediments have been improved.

Accordingly, there have been numerous studies about characteristics and habitats in the TSMD, as well as various health conditions relevant to residents in the TSMD. However, unfortunately, not so many studies have focused on the TSMD residents' obesity and overweight even if many scholars have found significant relationships between drinking water and physical conditions. Therefore, this study has an aim to bring up how the toxic components would lead to the physical condition (including obesity, overweight) of the TSMD residents by utilizing systematic review analysis.

METHODS

For this purpose, first, I describe the history and the characteristics of the TSMD, the conditions of habitats in the TSMD, and how toxic components would affect the TSMD ecological system and human bodies in the literature review. Secondly, for the analysis, I attempt to utilize a database tool, Systematic Review and Meta Analyses. Finally, I discussed how my study findings would make a vital contribution building upon the existing outcomes of the correlations between toxic elements coming from the TSMD areas and health conditions of low-income residents. Additionally, this study outcome will be updated information for policymakers and health-related professionals who aim to promote economic and social justice by providing adequate and innovative policies and practices in TSMD rural areas.

Table 1. Location of TSMD Superfund Sites

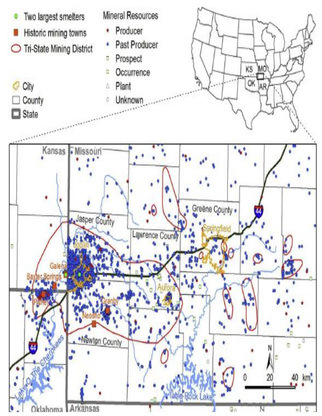


Figure 1. A chat pile stands as backdrop to a Picher home

Figure 2. Chat piles surround Picher's old baseball field

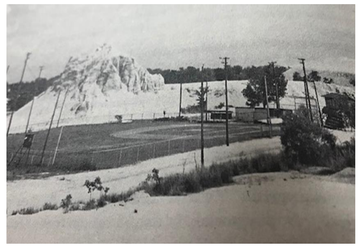
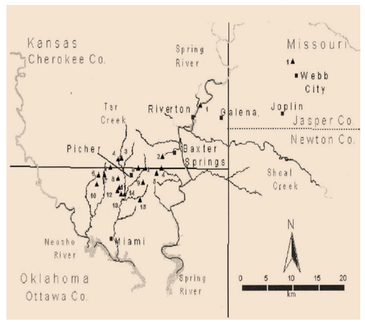


Table 2. The TSMD Lead and Zinc Mining District



RESULTS

History of the TSMD: The TSMD of Kansas, Missouri, and Oklahoma had produced ore since 1850. However, by the 1970s, ore was depleted, and most mines and smelters shout down. Overall, the TSMD made 23 million tons of Zn concentrates and four million tons of Pb concentrates. Non-ore waste rock and mill wastes have been piled up near production centers, which is called "chat" piles. Emissions from smelters were also accumulated to the metal content of topsoil through fugitive dust and fallout. **(Table 1)**

There is a large portion of toxic metal areas, which are called "Superfund" sites. In spite of remedial actions, there have still been tons of waste materials (in particular, Pb, Cd, Zn), mining shafts and tunnels left in those areas, which in turn contaminated groundwater and soil. Most of all, the components of Pb and Zn are associated with the geographical location of former mining and smelting centers.

Characteristics of TSMD Superfund Sites and Their Contamination: In the 1980s, USEPA designated some areas in the TSMD as Superfund sites—Tar Creek, the area of Picher in *Ottawa County* in Oklahoma, *Cherokee County* in Kansas, and the Oronogo-Duenweg Mining Belt near *Jesper County* in Missouri. **(Table 2)**

***Picher, Cherokee County (Kansas) Superfund Site (298 km²)*:** After the mining operation and dewatering pumps were stopped, mines started flooding into a local aquifer. Water combined with sulfide minerals became acidic, which dissolved metals. This acidic water in metals overflowed into Tar Creek. The remaining chat is widespread in residential areas of Picher. Remediation of this site was undertaken in 1986 which aimed to prevent downward migration of acid waters by hindering recharge to the aquifer and plugging abandoned wells and mine shafts.

***Jasper County (Missouri) Superfund Site (498 km²)*:** Jasper county includes Joplin, Webb City, and Carterville. Residential soils in Joplin were primarily impacted by dust and fallout from a smelter that was open until 1970 and mining wastes. Contaminated metallic soil was removed from 2600 properties by 2002, water supply systems improvements were completed in 2007, and 6.06 km² of milling waste were remediated by 2012. However, the 2011 tornado (F-5) brought up the issue of displacement of contaminated soils throughout the area, and new funding was collected for additional remediation. Consequently, various assessments to detect the dispersion of metals of the city of Joplin have been initiated.

Tar Creek, Ottawa County (Oklahoma) Superfund Site: The Tar Creek Superfund site covers Picher, Miami, Commerce, Cardin, and Peoria. The mining wastes Cd, Pb, and Zn were found in 60-meter-high piles and in sediments of former flotation ponds. Along with the designation of the Superfund site, the USEPA implemented remediation from 1984 to 1986, including plugging wells and constructing dikes to divert water around abandoned mines and collapsed mine shafts.

Impact of Toxic Metal Components to Ecological Systems and the Human Body: For many **wild birds** within the TSMD, the metal contaminants have caused serious health effects. These birds may have been exposed to the contaminants through inhalation or ingestion of Pb from chat or plants. The brown thrasher, cardinal, and robin most likely consumed Pb-contaminated soil or food because Pb usually appears on the surface of soil where birds can accidentally take in. Birds can also be exposed to Zn by the freshwater vascular plants that absorb Zn-contaminated water; aquatic plants can also build up iron and Zn plaque on their roots. Therefore, birds who consume these plants are also ingesting metal contaminants.

***Impacts on microbial communities*:** Metal contaminants' effect on microbial communities influence the health of other organisms and the environment. Metal contaminants often decrease bacterial diversity, bacterial biomass, and the richness of an environment. This can cause serious disruptions in the ecosystem by harming the health of other organisms and biochemical elements in soil. Particularly for other organisms, the reduced bacterial diversity and biomass result in less bacterial by-products, which are important for nutrient absorption for animals by assisting the intestinal epithelial cells. Therefore, many rats that live within remediated sites have reduced microbiota diversity, meaning that metal contamination is a factor in their declining health.

***Impacts on Human Health*:**
Zota et al. (2011) found that children living near a mining-impacted Superfund site could be exposed to the metal contaminants. The dust within the residents' homes had a higher level of Zn, Pb, Cd, and As than the dust concentrations discovered in the nearby **soil.** Because many children crawled and easily put their hands in their mouths, they were more susceptible to ingesting metal particles.
Pierzynsk and Vaillant (2006) discovered that residents within TSMD who got their drinking **water** from private wells were likely to get metal ores because these were the wells' water source. Hence, these people were exposed to metal contaminants from past mining activity and experience adverse health effects (Pb poisoning).
Delvaux et al. (2014) found that since children in TSMD were exposed to toxic elements, they were likely to be overweight/obese.

CONCLUSION

The TSMD was one of the leading producers of metals. This smelting process in the TSMD left byproducts called *chat* and *slag*. Chat can easily harm the local soil. The soil was not only affected by this waste but also the soil experienced sinkholes that resulted from the mining process. Even though USEPA recognized and tried remediation, their efforts were not wholly successful as the mines continue to harm the environment and human beings to this day.

3 Recommended Cost-Effective Remediations

I. Recovering the contaminated areas to reuse and recycle the mining wastes.
- Repurposing mine wastes produce economic benefits while addressing environmental concerns.
- Waste rocks can be used as filling for mine shafts and cavities.
- Benign tailings can be mixed with cement to cover less benign tailings.

II. Phytoremediation utilization can possibly assist bioaccumulated plant revival through roots, stems, or shoots

III. Application of the methodology used in Oklahoma to other Superfund sites
- Evidence-based methodology can be safely and economically utilized in other TSMD areas.
- This methodology initially consists of hydrology, the reactivity of contaminants, and bedrock geology, which showed the effectiveness already.

In sum, the recommended remediations would not only be helpful for habitants in the TSMD environment but also for the effective boost in physical well-being of residents in those areas.

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