International Journal of Ecology and Environmental Sciences
www.ecologyjournal.in
Online ISSN: 2664-7133, Print ISSN: 2664-7125
Received: 05-07-2022, Accepted: 21-07-2022, Published: 06-08-2022
Volume 4, Issue 3, 2022, Page No. 81-85

Historical slag piles and contaminated sites: A case of restoration in East Helena, USA

Anshu Singh[1], Vir Singh[2]
[1] Chief of Environmental Services, Riverside Global, 629 State Ave, Hampton, United States
[2] Professor, Department of Environmental Science, GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Abstract
A large smelter was built in East Helena in USA around 1888. Historically, slag was considered innocuous and in absence of strict regulations, often dumped directly into lakes, streams, and low-lying areas in forests. The scale of heavy metal pollution in environment is as massive as the economic impact of Industrial Revolution. In general, the prominent heavy metals in slag-contaminated sites are lead (Pb), chromium (Cr), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), and nickel (Ni). The restoration project is creating an eight mile trail and park system connecting East Helena to Montana City's community trails. East Helena is a success story of one of the world's prominent slag piles receiving significant attention from the authorities. A restoration revolution is required to address the issue of environmental degradation caused due to the Industrial Revolution. The United Nations has declared 2021- 2030 as the UN Decade on Ecosystem Restoration, with one common goal of preventing, halting and reversing the destruction of natural spaces. Together, we need to build a global movement to accelerate remediation and restoration efforts to bring the world back on the track for a sustainable future.

Keywords: East Helena, ecosystem restoration, environmental degradation, heavy metals, slag piles

Introduction

The recent news of slag removal from a former smelter site at East Helena, a city in Lewis and Clark County, Montana, United States (Figure 1), is building some kind of optimism not only for the residents but also for the global community. A large smelter was built in East Helena around 1888; later it became one of the world's largest lead processing plant, the American Smelting and Refining Company (ASARCO), and was in operations until 2001. For over a century, the company processed 70,000 tons of lead per year and left behind an estimated 16 million tons of slag. As per the Montana Environmental Trust Group (METG), slag at this site is the largest source of selenium in the East Helena area and mostly responsible for around three-quarters of groundwater contamination (METG, 2018). In December 2020, METG stated that an international metal trader named Metallica will remove and transport 2 million ton of slag to a zinc smelting company located in South Korea (KTVH, 2020). The slag removal is expected to begin in April 2021 and will continue for five years. Though the plan is to remove only 2 million tons of slag, it is an important initiative and will have a greater impact on the landscape of East Helena. As per METG estimation, it will reduce the slag pile's height by half.

This news gives hope to many communities, particularly located in developed countries, where smelting has occurred on a large scale since the Industrial Revolution. While large metal refining operations have brought significant economic prosperity, they have also left a legacy of pollution that includes piles of waste slag. Historically, slag was considered innocuous and in absence of strict regulations, often dumped directly into lakes, streams, and low-lying areas in forests (Piatak et al., 2004). Some of these historical slag piles are very large, for example the Coniston slag pile in Sudbury, Ontario, Canada (400,000 sq. mt.), one in Silesia, Poland (150,000 sq.mt.), and the biggest dumping ground near the Ely Copper mine in Vershire, Vermont, USA (7,300,000 sq.mt.) (Kierczak et al., 2013). Besides these, there are a large number of small and mid-size slag piles spread across the globe, adversely affecting the quality of soil and surface waters of the surrounding areas. In the United States, more than 70% of the total 100,000 sites of soil pollution are reported to have heavy metals and/or metalloids contamination (US EPA, 2014).

The scale of heavy metal pollution in environment is as massive as the economic impact of Industrial Revolution. Although these smelting sites have not been functional for decades, the presence of historical slag piles is still considered to be a serious environmental concern. The long term exposure of slag to the atmospheric conditions causes weathering and leads to dissolution of heavy metals. In general, the prominent heavy metals in slag-contaminated sites are lead (Pb), chromium (Cr), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), and nickel (Ni) (Evanko and Dzombak, 1997). Depending on the composition and surroundings, each slag pile can have different environmental impacts on adjoining land, aquatic ecosystems, and biodiversity (Lottermoser,

2002: Navarro et al., 2008). A review of environmental aspects of slag by Piatak et al. (2015) listed various studies on historical slag piles and their environmental impact on surrounding ecosystem. For instance, the soils in the vicinity of the Hopewell National Historic site in Berk and Chester counties in Pennsylvania contain higher concentrations of Cr, Cu, Fe, Pb, and Zn than unimpacted background soils. Baron et. al. (2006) also reported that 95% of Pb content in local soils came from the medieval metallurgical workshops located at the Mont-Lozere Massif (Sothern France). Similarly, Kierczak et al. (2013) found significantly high concentrations of Pb, As, Cu and Zn in soils near historic smelters located in Rudawy Janowickie Mountains (South-western Poland). Ultimately, the physical weathering of soils near slag piles leads to metal contamination in surface water bodies like lakes and rivers, as these are the final destination of polluted runoff from its watershed. Heavy metals present in slag pile soils also have the potential of leaching into the groundwater systems and further contaminating the ecosystem by following various pathways (Figure 2).

Fig 1: An aerial view of East Helena (Photo: Anshu Singh)

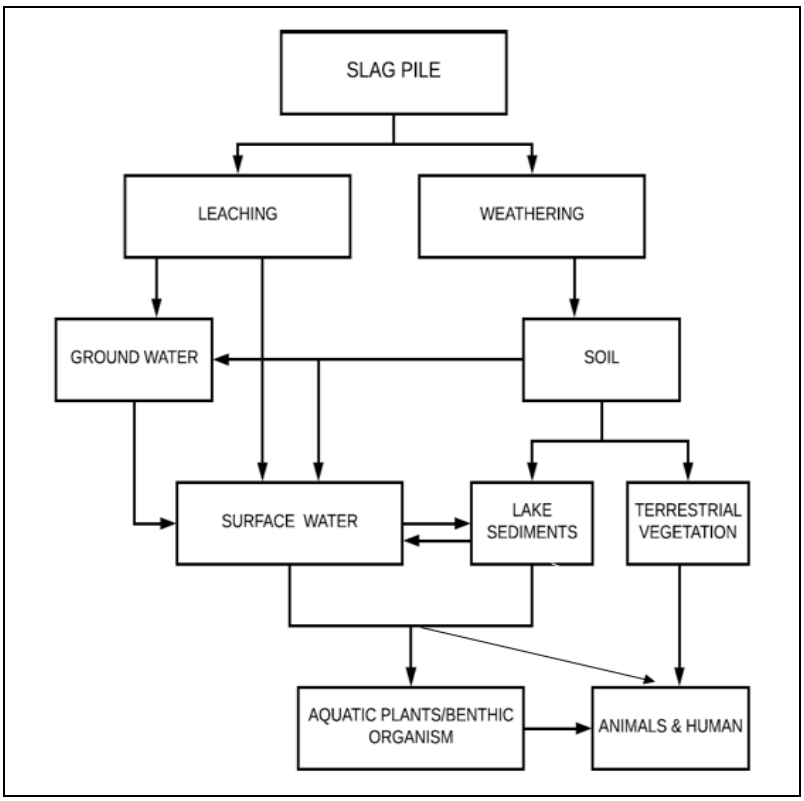

Fig 2: Potential pathways of metal transfer from slag pile to the food web

Among all pollutants, heavy metals are recognized as priority pollutants most hazardous to ecosystems. Most important, heavy metals are non-biodegradable, persistent in natural conditions, and cannot be completely removed once introduced into the environment (Adriano, 2003). Heavy metals present in environments tend to accumulate in plants, leading to the introduction of metals in the food chain. Other than disrupting the ecosystem, presence of these toxic heavy metals in the food chain is a potential threat to human health. High levels of lead can result in damaging the nervous systems of infants, lead to cardiovascular diseases and infertility (ATSDR, 2007).

Ni is known as human carcinogen and can cause severe kidney and lung complications (Borba et. al., 2006). Cd is another carcinogen, responsible for weakening of bones, renal function, and the gastrointestinal system (Zang and Bolger, 2014). The deleterious effects of heavy metals on human health are reasonably obvious from Table 1

Table 1: Impact of toxic trace metals on human health (ATSDR, 2019)

Metals	Impact on Human beings
Cd	Carcinogenic, chronic anemia, kidney dysfunction, bone disease, renal failure, gastrointestinal weakening
Pb	Cardiovascular disease, infertility, renal failure, children's nervous system damage, In adults- loss of memory, insomnia, anorexia, nausea, joint weakness
Ni	Cancer of the lungs, nose, throat and stomach, kidney and liver complication, pulmonary fibrosis
Cu	Brain and kidney damage, liver cirrhosis and chronic anemia, stomach and intestinal irritation
Zn	Dizziness and fatigue

Given the serious detrimental effects of historical slag piles, there is a growing need of restoration and reclamation of such sites to preserve the environmental integrity of natural resources. In the United States, there are many federal laws like National Environmental Policy Act (NEPA), Surface Mining Control and Reclamation Act (SMCRA), the Clean Water Act (CWA), the Clean Air Act (CAA) etc. to regulate the industry and to protect environment and human health. In most of the developed countries, the environmental regulatory agencies are quite active in clean up, remediation and restoration of metal contaminated sites, and also have schemes of ecological revitalization for turning contaminated properties into community assets. However, the efforts of the governments and environmental agencies are not sufficient enough to manage the clean–up of historical slag piles along with the ever growing slag inventories.

For more than 100 years, ASARCO operations along the bank of Prickly Peer Creekin East Helena deposited lead, arsenic, copper, zinc, cadmium and other heavy metals into the soil, surface water and groundwater of the Helena Valley until it was placed on the Superfund program's National Priorities List (NPL) in 1984. Now after years of multi-partner collaboration, all structures of the former smelter have been demolished, contaminated soils have been removed and portions of slag pile have been covered to prevent runoff from seeping through and contaminating groundwater (USEPA, 2016; USEPA, 2018). In August 2019, the remediation and redevelopment efforts of the METG East Helena Team were recognized with a Region 8 Excellence in Site Reuse Award. However, it took more than three decades to get funding for the planning of the Prickly Pear Creek Greenway Trail project. The restoration project is creating an eight mile trail and park system connecting East Helena to Montana City's community trails. Finally, with all funding and land in place, the Prickly Pear Creek Greenway Trail officially began in December 2020. (See the satellite imageries of East Helena in Figures 3 for 2005, 2013, 2017 1nd 2020).

(a) (b)

(c) (d)

Fig 3: Satellite imageries of East Helena: (a) 2005, (b) 2013, (c) 2017, and (d) 2020 (all photos: Anshu Singh)

As indicated above, the pace of restoration planning and implementation is much slower than the rate at which environmental degradation is taking place. The restoration of degrading ecosystems itself is a long process and can take decades or even centuries for full recovery. The acceleration of the restoration process needs human assistance on a large scale. East Helena is a success story of one of the world's prominent slag piles receiving significant attention from the authorities. However, there are many small to medium size slag piles that remain unnoticed or not prioritized by the concerned agencies due to limited resources. There is an urgent need to call for more resources and efforts into slag pile restoration projects from governments, local communities and environmental groups like METG. A restoration revolution is required to address the issue of environmental degradation caused due to the Industrial Revolution.

Restoration is an important tool for the recovery of ecosystems, particularly now when the earth's environment is under tremendous stress and signs of climate changes are more pronounced than ever before. The United Nations has declared 2021- 2030 as the UN Decade on Ecosystem Restoration, with one common goal of preventing, halting and reversing the destruction of natural spaces (UNEP, 2021). This is our last chance to restore earth and avoid devastating climate change. Together, we need to build a global movement to accelerate remediation and restoration efforts to bring the world back on the track for a sustainable future.

References

1. Adriano DC. *Trace Elements in Terrestrial Environments: Biogeochemistry, Bioavailability and Risks of Metals*, 2nd edition. New York, USA: Springer, 2003.
2. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Lead (Update). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, 2007. Available at: https://www.atsdr.cdc.gov/ToxProfiles/tp13-c2.pdf
3. ATSDR. Toxicological Profile. Available at: https://www.atsdr.cdc.gov/az/c.html
4. Baron S, Carignan J, Ploquin A. Dispersion of heavy metals (metalloids) in soils from 800-year-old pollution (Mont-Loz_ere, France). *Environ. Sci. Technol*,2006:40:5319e5326. Available at: http://dx.doi.org/10.1021/es0606430.
5. Borba CE, Guirardello R, Silva EA, Veit MT, Tavares CRG. Removal of nickel (II) ions from aqueous solution by biosorption in a fixed bed column: experimental and theoretical breakthrough curves. *Biochem. Eng. J*.,2006:30:184-219.
6. Evanko CR, Dzombak DA. Remediation of metals-contaminated soils and groundwater. Tech. Evaluation Report. TE-97-01, Ground-Water Remediation Technologies Analysis Center (GWRTAC)-E Series, Pittsburgh, Pa, USA, 1997.
7. Kierczak J, Potysz A, Pietranik A, Tyszka R, Modelska M, Néel C, et al. Environmental impact of the historical Cu smelting in the RudawyJanowickie Mountains (south-western Poland). *J. Geochem. Explor*.,2013:124:183-194.
8. KTVH. News, 2020. Available at: https://www.ktvh.com/news/2m-tons-of-material-to-be-removed-from-east-helena-slag-pile
9. Lottermoser BG. Mobilization of heavy metals from historical smelting slag dumps, North Queensland, Australia. *Mineralogical Magazine*,2002:66:475-490.
10. METG. Former ASARCO East Helena Facility Corrective Measures Study Report. Prepared by CH2MHill., 2018. Available at: http://www.mtenvironmentaltrust.org/east-helena/cercla-activities/
11. Navarro A, Cardellach E, Mendoza JL, Corbella M, Doménech LM. Metal mobilization from base-metal smelting slag dumps in Sierra Almagrera (Almería, Spain). *Appl. Geochem*.,2008:23:895-913.
12. Piatak NM, Seal II RR, Hammarstrom JM. Mineralogical and geochemical controls on the release of trace elements from slag produced by base- and precious-metal smelting at abandoned mine sites. *Appl. Geochem*.,2004:19:1039-1064.

13. Piatak NM, Parsons MB, Seal RR. Characteristics and environmental aspects of slag: a review. *Appl. Geochem*.,2015:57:236-266. doi:10.1016/j.apgeochem. 2014.04.009.
14. United States Environmental Protection Agency (US EPA). Cleaning up the Nation's Hazardous Wastes Sites. Available at: http://www.epa.gov/superfund/
15. US EPA. Five Year Review Report, Fourth Five Year Review Report for East Helena Superfund Site, EPA ID MTD006230346, East Helena, Lewis and Clark County, Montana, 2016. Available at: https://semspub.epa.gov/work/08/1768518.pdf
16. US EPA, 2018. Available at: https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0800377
17. United Nations Environment Program (UNEP) Decade on Ecosystem Restoration, 2021-2030. Available at: https://www.decadeonrestoration.org/about-un-decade
18. Zang Y, Bolger PM. Toxic Metals: Cadmium. *Encycl. Food Saf*.,2014:2:346. doi:10.1016/B978-0-12-378612- 8.00202-X.