

Effects of Heavy-Metals on Soil Microbial Activity in Palmerton, Pennsylvania

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Introduction

The presence of Zn, Cd, Pb, and Mn is being studied through a chronosequence of soil samples to look at short-term reclamation of soils in Palmerton, Pennsylvania. By studying soil respiration in relation to the heavy-metal content of the soil, a general estimation of the overall quality of the soil can be determined.

Background

Palmerton, Pennsylvania, is located in Carbon County near the Lehigh River Gap, between Blue Mountain and Stony Ridge. Two New Jersey Zinc Company zinc smelters were in operation between 1898 and 1980. The ores used in the smelting process contained 55% Zn, 31% S, 0.15% Cd, 0.30% Pb, and 0.40% Cu. The highest rates of daily emissions were 6000-9000 kg of Zn and 70-90 kg Cd¹. The result of the heavy-metal deposition was soils that not only contained high levels of contamination but were also incapable of recovering without replanting assistance.

Sampling

Three sample sites were used to create a short-term chronosequence to assess the reclamation potential for the soil. The first site was the Baseline site which was never replanted. The second site was the 2003 site, which was replanted in 2003. The third site was the 2006 site, which was replanted in 2006. Each sample was taken as a core to 10 cm depth after the top layer of organic matter was removed. Six samples were taken from each sample site to account for variation.

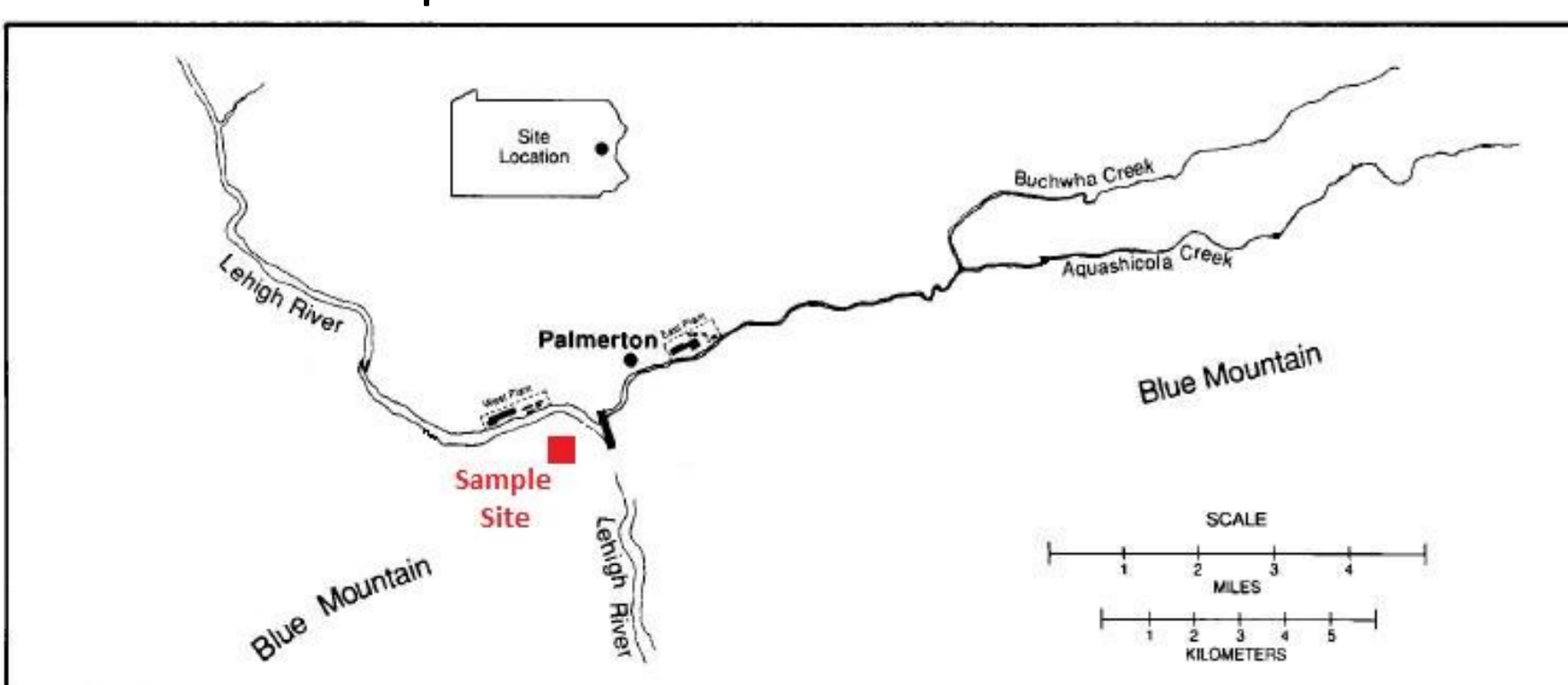


Figure 1. Diagram of sample site location

¹Buchauer, Marilyn J. "Contamination of Soil and Vegetation Near a Zinc Smelter by Zinc, Cadmium, Copper, and Lead." *Environmental Science & Technology*. 1973.

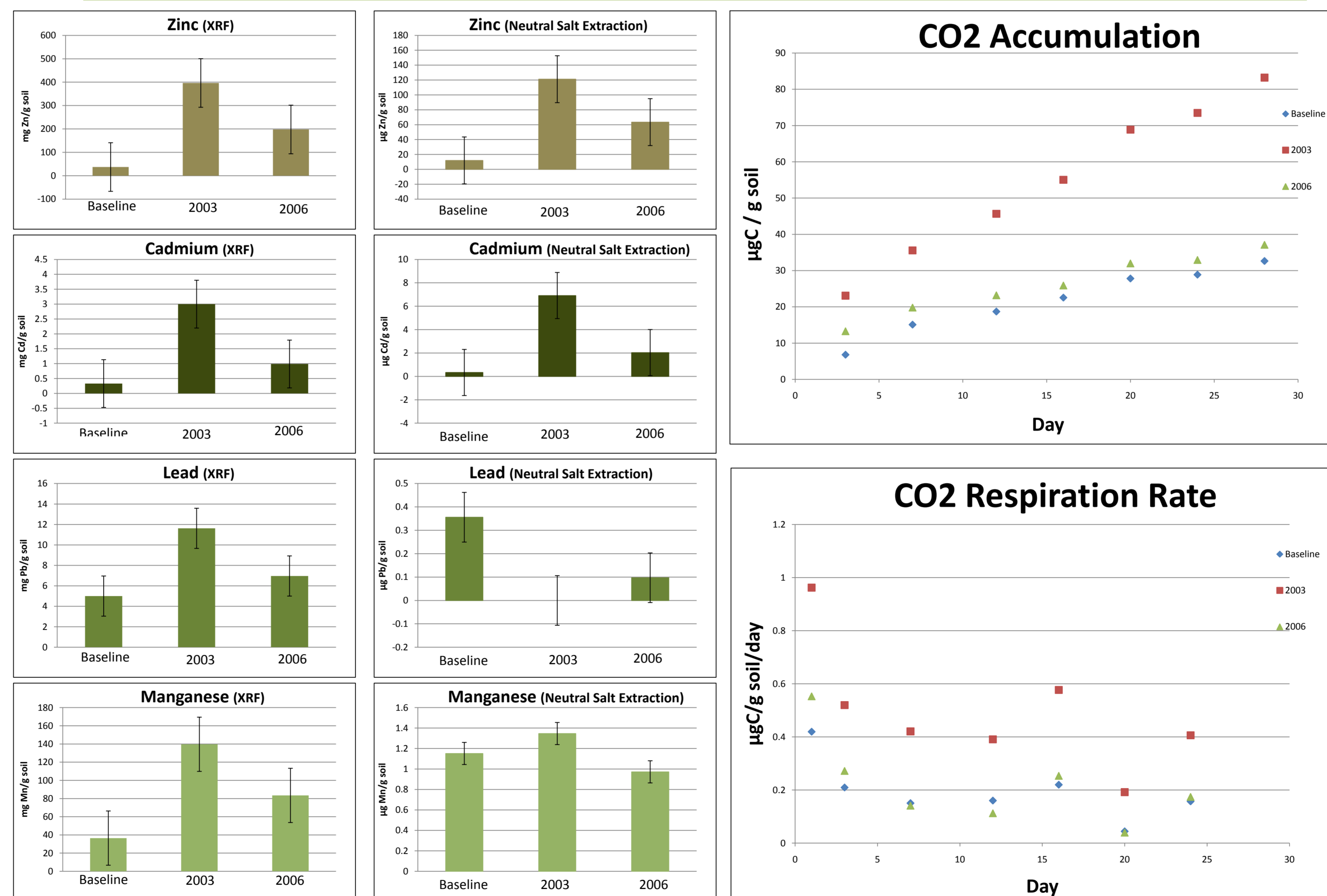
²Storm, G. L., G. J. Fosmire, and E. D. Bellis. "Persistence of Metals in Soil and Selected Vertebrates in the Vicinity of the Palmerton Zinc Smelter." *Journal of Environmental Quality*. 1994.

Methods

Methods:

- Two methods were used to determine heavy-metal levels:
 - XRF: total heavy-metal
 - Neutral Salt Extraction: easily extractable heavy-metal available to plants.
- An elemental analysis of C and N was used to determine percentages of both in each sample because higher levels of C and N will allow for increased microbial activity. Therefore, the CO₂ accumulation and respiration rate would reflect the variation in C and N between the three sample sites.
- An incubation to determine the soil respiration and CO₂ release was used because the respiration will indicate the level of microbial activity. The presence of an active microbial community is an indicator of good soil quality.

Results



Sample	% of Elements				Sample Composition	
	Zinc	Cadmium	Lead	Manganese	Nitrogen	Carbon
Baseline	32.30 ± 1.220	0.101 ± 0.007	0.007 ± 0.007	0.003 ± 8.36E-05	0.155 ± 0.061	5.218 ± 2.750
2003	30.50 ± 0.641	0.231 ± 0.002	nd	0.001 ± 7.68E-05	0.426 ± 0.315	17.80 ± 6.120
2006	32.10 ± 1.120	0.206 ± 0.009	0.001 ± 0.009	0.001 ± 7.00E-05	0.130 ± 0.080	5.302 ± 6.320

*nd: not detectable

In 2003, the Lehigh Gap Nature Center (LGNC) began to replant test plots downwind of the smelters² with different grass species to determine which plants would be the most useful in the reclamation efforts. After three successful years of plant survival, the LGNC implemented a wide scale replanting effort around their initial test plots.



Sample Site: Baseline #1



Sample Site: 2003 #1



Sample Site : 2006 #1

Observations

- The metal with the highest concentration across the three sample sites in terms of both total and easily extractable quantities was zinc.
- The site that contained the highest percentage of C and N was the 2003 sample site.
- The site that had both the highest total CO₂ accumulation and CO₂ respiration rates was the 2003 sample site.
- The largest quantities of mobile Zn, Pb, and Mn were in the Baseline samples, while the largest quantity of mobile Cd was in the 2003 sample.

Conclusions

Based on the short-term chronosequence, there does not seem to be a quick solution to achieving a better soil quality in Palmerton, PA. However, the survival of the grasses over the seven year period for the 2003 plot and the four year period of the 2006 plot suggests that a longer and larger scale reclamation effort is possible and may yield more success. Large-scale replanting may at least contribute enough organic matter to the system to allow the microbial activity to increase, thus helping the soils achieve a better quality and improve beyond their current state of contamination.