EFFECTS OF METAL CONTAMINATION AND SOIL REMEDIATION STRATEGIES ON INDIGENOUS SOIL MICROBIAL COMMUNITIES AT THE ANACONDA SMELTER SITE IN ANACONDA, MONTANA[1]

Jennifer A. Humphries, Catherine M. Bens, Stephen B. Cox, Dennis R. Neuman, John C. Zak, and Michael J. Hooper[2]

Extended Abstract. Soil surrounding the Anaconda Smelter site, in southern Deer Lodge County, Montana, is severely contaminated with metals, including copper, cadmium, lead, zinc, and the metalloid arsenic. Increasing concern over the negative effects of metal contamination on humans, wildlife and the environment has prompted increased focus towards the restoration and remediation of metal contaminated sites. Traditional engineering-based methods of land reclamation (i.e. excavation and relocation of contaminated soils) are costly, and as a result, may be inapplicable to many sites. Phytoremediation, the use of green plants to stabilize the soil profile, has proven a cost-effective, environmentally low-impact remediation strategy; however, there remain gaps in the knowledge for optimizing and maintaining a healthy soil ecosystem in metal contaminated soils. Metals have been shown to negatively affect the diversity, biomass, and activity of soil microbial communities, which can cause a cascade of ecosystem level disruptions in nutrient cycles, soil formation, and plant-root interactions. Soil metals are also known to inhibit plant growth, which often necessitates significant amendment of the soils with nutrients, lime and organic materials to decrease toxicity and improve soil health. Aggressive soil amendment and remediation strategies may further modify microbial communities in the soil. The goal of this study was to characterize the combined effects of long-term metal contamination and soil reclamation strategies on soil microbial communities at the Anaconda Smelter Site. From these studies, a better understanding of the responses of soil microbial communities associated to revegetation processes will be achieved, which may aid in the optimization of plant – based remediation.

Additional Key Words: Biolog, functional diversity, phytoremediation

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[2] Jennifer A. Humphries is a PhD candidate in the Department of Environmental Toxicology at Texas Tech University, Lubbock TX, 79407; Catherine M. Bens is the quality assurance officer at the National Wildlife Research Center–USDA in Fort Collins CO, 80521; Stephen B. Cox is an assistant professor in the Department of Environmental Toxicology at Texas Tech University; Dennis R. Neuman is the acting director of the Reclamation Research Unit at Montana State University, Bozeman MT, 59717; John C. Zak is a professor and chair of the Department of Biological Sciences at Texas Tech University; and Michael J. Hooper is an associate professor in the Department of Environmental Toxicology at Texas Tech University.

The Anaconda Revegetation Treatability Study (ARTS), a joint project established by Montana State University's Reclamation Research Unit, the US EPA, the Montana Department of Environmental Quality and the Atlantic Richfield Company, was initiated at the Anaconda Smelter site in the early 1990's. The Dragstrip demonstration area, a 1.5 acre reclamation site contaminated with fluvially and aerially deposited metal residues, was established as part of ARTS to test the effectiveness of different soil amendment strategies in terms of their ability to stabilize the soil profile and prevent off-site movement of contaminated residues. Six 120 foot x 90 foot experimental treatment plots were amended as follows: treatments 1-4 received different combinations of organic matter (compost, manure or log yard waste), liming materials ($Ca(OH)_2$, and $CaCO_3$), fertilizer, and were plowed to a depth of 12"; treatment 5 received liming materials, fertilizer, and was plowed to a depth of 12"; treatment 6 was plowed to a depth of 24" and received no additional soil amendment. An unamended plot adjacent to the treatment plots served as the experimental control. Experimental treatment plots were uniformly seeded with grasses and legumes and were revegetated with shrubs and tree tubelings in Spring 1994. Experimental treatments were monitored over time and were shown to support a diverse range of plant species, increased plant production and plant cover, and were effective in decreasing off-site dissemination of contaminated residues thought wind and run-off, relative to the unremediated control plot.

Soils were collected from this site during the summers of 2000 and 2005, to characterize the impacts of reclamation activities on the soil microbial communities over time. Biolog microtiter plates were used to evaluate the functional diversity of the soil microbial community through carbon substrate utilization. Substrate utilization patterns (SUPs) and physical soil parameters (metal concentration, pH, % moisture content, % organic matter, soil nutrients) were compared between remediated and unremediated soils from both univariate and multivariate perspectives.

Results from this study show that there are significant differences in soil nutrient, metal and physiochemical profiles within the experimental plots and the unremediated control. Metal concentrations were elevated in the remediated treatments compared to the unremediated control, possibly due to heterogeneity of the soils across the Dragstrip demonstration area. Additionally, treatments that received organic matter and fertilizer amendments had elevated concentrations of P, K, and % organic matter, indicating the potential for soil amendments to cause continued selective pressure on microbial communities over time. The bacterial SUPs in the remediated soils were significantly shifted relative to the SUPs in the unremediated soil. Microbial activity, a measure of the amount of substrates utilized, was not significantly different between the treatment groups, however was significantly decreased in 2005, relative to 2000. The identities of the substrates utilized by the bacterial communities were also significantly different between the treatment groups and over time. In 2000, P and Mg significantly related to the identities of the substrates utilized; whereas, in 2005, Ca, K, Cd, and Zn were significantly related to the identities of substrates utilized. Estimates of genetic components of biodiversity (e.g., community DNA extraction, PCR amplification of eubacterial 16S rDNA, denaturant gradient gel electrophoresis (DGGE) and DNA sequencing of unique species) will be used next to monitor the shifts in microbial community structure following phytoremediation amendments. Concurrent analysis of soil microbial community structure and function may increase the resolution of observed treatment related effects and aid in future optimization and implementation of phytoremediation at metal contaminated sites.