PLANT-ASSISTED STABILIZATION OF ARSENIC CONTAMINATED IRON KING MINE TAILINGS IN DEWEY-HUMBOLDT, AZ DOES NOT ENHANCE ARSENIC LABILITY

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Introduction

A low cost solution to reduce mine tailings erosion and dispersion is to apply a phytostabilization technique whereby plant growth is encouraged on the surface of mine tailings with irrigation, nutrients, and locally native seed. Establishment of a vegetation cap on top of the mine tailings contains the contaminant at the point-source to prevent further distribution in the environment. This method aims to achieve a self-sustaining ecosystem that requires no additional financial input or monitoring. Although this method of remediation is used in the mining industry, long term field-scale studies investigating the transport fate of metal contaminants are limited (Mendez and Maier 2008). This field-scale research investigation includes annual sampling for four years.

Methodology

The field site (described by Hayes et al. 2014) is located on the surface of the Iron King Mine tailings pile at the Iron King Mine and Humboldt Smelter Superfund site in Dewey-Humboldt, Arizona and contains approximately 4,000 mg kg^{-1} arsenic determined by ICP-MS, exceeding the State of Arizona Soil Remediation Level of 10 mg kg^{-1}. Desert plants native to the southwestern United States (*Festuca arizonica, Buchloe dactyloides, Acacia greggii, Prosopis juliflora, Cercocarpus montanus, and Atriplex lentiformas*) were selected based on their ability to exclude metal contaminants from above ground biomass when grown in Iron King Mine tailings (Solis-Dominguez et al. 2012). The study was initiated in 2010. Varied parameters include compost amendment (0, 10, 15, and 20% added on a mass basis to the top 20 cm of the tailings) and addition of native seed (seeded and not seeded). All treatments receive equal irrigation. Field cores 90 cm in length were collected annually from 2010-2014. Sample analyses include synchrotron-based X-ray spectroscopy, sequential extraction, pH, electrical conductivity, total organic carbon, total nitrogen, and powder X-ray diffraction.

Results

Arsenic and iron K-edge X-ray absorption near-edge structure (XANES) of untreated samples show oxidation of pyritic minerals [e.g. FeS_2, FeAsS] to ferric (oxy)hydroxide [e.g. ferrihydtite] and (oxy)hyroxide sulfates [e.g. jarosite-type minerals; $XFe^{(III)}_3(OH)_6(SO_4)_2$, where X = K^+, H_3O^+, ½ Pb^{2+}] in near-surface tailings, indicating an oxidation front penetrating the profile. Arsenic XANES indicate that both irrigation and compost are associated with enhancement of sulfide oxidative weathering. Importantly, an increase in arsenic lability related to compost addition was not observed. Sequential chemical extraction and iron XAS results indicate that sulfide weathering may be associated with formation of an ammonium oxalate-resistant iron mineral phase, affecting the mobility of iron-sorbed arsenic in the tailings.

Conclusions

These results suggest that this method of using vegetation to stabilize contaminants at the mine tailings point source in a semi-arid environment may not enhance the potential for arsenic to mobilize in the subsurface despite the increase of organic matter in the surface tailings.

References

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