One Health Research Project Abstracts

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Title: Climate variability controls toxic metal(loid) speciation and bioaccessibility in particulate matter from mine tailing sites: Impacts on human and animal health risk

Research Abstract:

The massive annual production of fresh parent material for mineral ore extraction is similar in magnitude to the naturally occurring weathering of top soil (*ca*. 21 Gt/yr; Hayes et al., 2014). This produces considerable quantities of mine tailings comprising elevated levels of toxic metal(loid)s, such as arsenic (As), lead (Pb), and zinc (Zn), sequestered in heaps exposed to atmospheric weathering (O'Connor et al., 2021). Consequently, mine tailings sites are point sources of fugitive dust pollution as particulate matter (PM), which can also be released as contaminants to aquatic systems (Thomas et al., 2018). The toxicity and bioavailability of metal(loid)s in PM is a function of concentration and chemical form (i.e., speciation). Because the total metal(loid) concentrations may not represent the bioactive concentration at a target organ after ingestion (Brandon et al., 2006; Sánchez et al., 2021), solubility (a.k.a., "bioaccessibility") is investigated by monitoring the release of toxic metal(loid)s from PM to biofluids with *in vitro* bioassay (IVBA, Root and Chorover, 2022). At sulfide ore tailing sites, initially deposited minerals are oxidatively weathered to produce ferric hydroxide minerals and sulfuric acid, which enhances the release of toxic elements. Studies have established the impact of oxidative weathering on speciation of metal(loid) contaminants in tailings, and that solubility is a function of speciation (Meunier et al., 2010; Pascaud et al., 2014; Ollson et al., 2016; Thomas et al., 2018; Monneron–Gyurits et al., 2020; Sánchez et al., 2021; Root and Chorover, 2022). However, the impact of climate, which drives weathering, on bioaccessibility has not been studied. Therefore, we will compare speciation and IVBA release from PM across a climate gradient spanning mean annual temperature and precipitation to develop a predictive risk model and enhance our understanding of bioaccessibility. We hypothesize that as the weathering driven redox gradient develops (and migrates downward) in the near surface of exposed tailings, climate and ore lithology will control metal(loid) lability and bioaccessibility.

Mine tailings samples have been collected from across the oxidative weathering reaction front (0-200 cm) from 13 sites in the western U.S. from AZ to WY, spanning a wide range in climate (i.e., hot-dry to cold-humid). These samples were field-sealed and protected from post-sampling exposure to oxygen prior to preparation for initial characterization, e.g., pH, electrical conductivity, and microwave assisted acid digestion prior to ICP-MS analysis for total elemental concentrations. Analysis showed that As from arid sites was enriched at intermediate depths (10-50 cm) and depleted at the surface (0-10 cm) and deepest samples (<200 cm). In contrast, in humid climates, As was generally depleted in the surface to intermediate depths (< 50 cm) and enriched at depth (> 50 cm). Assuming a generally homogeneous parent tailings material, and similar edaphic impacts, weathering affected the mobility of As differently depending on climate. My research is now focused on investigating the molecular speciation of As and dominant host mineral elements Fe and S using X-ray absorption spectroscopy to provide insight into the link between climate-induced speciation and bioaccessibility. These speciation data will be compared to IVBA experiments, to elucidate climatic-controlled trends in toxic metal(loid)s speciation and bioaccessibility. Moreover, these relationships will be useful for developing a prediction tool for

managing PM generated from mine tailings sites that could extend long into the future and consider the impact of changing climate on tailing sites.

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