Simulated weathering effects on the bioaccessibility and speciation of arsenic in mine tailings

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The extensive gold mining legacy in the Western United States has left many former mining areas contaminated with potentially toxic metal(loid)s. In a number of abandoned gold mine sites, elevated levels of arsenic present potential health consequences to the residents and visitors to these historic sites. Furthermore, the long-term fate of the mine tailings and its health implications due to extensive weathering over time are under-studied.

Physical weathering of mine tailings can be simulated through mechanical grinding. Selected pre-sieved size fractions of bulk mine wastes from Empire Mine site in Grass Valley, CA (particle diameters 1700-2830 µm, 125-250 µm, and 45-75µm) were chosen as representatives to simulate the effect of weathering on the potential long-term bioaccessibility of arsenic. Each size fraction was pulverized in a mechanical Shatterbox fitted with an alumina ceramic ring and puck for two minutes. Simulated gastric fluid (SGF) extractions were then performed on both ground and unground tailings, followed by arsenic K-edge EXAFS spectroscopy of the unground and ground tailings both before and after SGF extraction. The EXAFS spectra were analyzed with linear combination fitting (LCF) to determine the species and proportions of arsenic present in the samples. In addition, micro-XRF mapping was performed on 30-µm polished thin sections of the unground, pre-SGF extraction samples to provide a visual/spatial representation of arsenic distribution in the mine tailing samples.

Results demonstrate that the grinding of mine tailings significantly increases the arsenic bioaccessibility due to the release of encapsulated arsenic, and the increase in surface area. Comparison of SGF extraction between unground and ground tailings show an average 5.5% increase in arsenic release in SGF. LCF analysis shows that arsenic pentoxide and amorphous ferric arsenate as the primary species at one site, and sodium arsenate at another site. In addition, micro-XRF mapping shows a presence of encapsulated arsenic species present in the tailings, supporting the potential for additional release of bioaccessible arsenic species due to weathering processes.

Physical weathering plays an important role in the increase in bioaccessibility of arsenic in mine tailings over time. Extensive weathering studies can inform the assessment of potential health hazards and policy implication that could impact the municipal communities surrounding these abandoned gold mines.