Identifying Predictors for Bioavailability of Arsenic in Soil at Mining Sites

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ABSTRACT

Assessing risk due to arsenic (As) in soil involves toxicity criteria based on exposures to As in drinking water, where bioavailability of soluble salts of arsenic is nearly 100%. Bioavailability of As in soil is usually much lower leading to immunoreactivity of risk. Site-specific relative bioavailability (RBA) in situ in soil requires field testing using one of the following methods: 1) Approximation of the As concentration that will rise in vivo to the maximum effective concentration of As in drinking water (i.e., 10 mg/L); 2) approximating the As concentration that will rise in vivo to a concentration of As in drinking water (i.e., 10 mg/L); 3) approximating the As concentration that will rise in vivo to a concentration of As in drinking water (i.e., 10 mg/L). In this study, we applied the third approach, which involves approximating the As concentration that will rise in vivo to a concentration of As in drinking water (i.e., 10 mg/L).

METHODS

Soil samples were collected at the Empire Mine State Historic Park in Nevada County, California. Sample locations were chosen in the field based on association with various mine features and As concentration as measured by field X-ray Fluorescence (XRF). Field activities were performed by DTSC in conjunction with Historic Park in Nevada County, California. Sample locations were chosen in the field based on association with various mine features and As concentration as measured by field X-ray Fluorescence (XRF). Field activities were performed by DTSC in conjunction with Historic Park in Nevada County, California.

INTRODUCTION

Arsenic (As) pollution is a global environmental and human health problem. As is a naturally occurring element and is found in many natural and industrial processes. Arsenic is a known human carcinogen and is classified as a Group 1 carcinogen by the International Agency for Research on Cancer (IARC). Arsenic is a known human carcinogen and is classified as a Group 1 carcinogen by the International Agency for Research on Cancer (IARC).

SUMMARY

Summary of Data for Sample E16

<table>
<thead>
<tr>
<th>Mineralogical Feature</th>
<th>Weight % As</th>
<th>Total Arsenic (mg/kg)</th>
<th>As Oxide As (mg/kg)</th>
<th>As Arsenide As (mg/kg)</th>
</tr>
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<tbody>
<tr>
<td>Arsenic State</td>
<td>90%</td>
<td>9,600</td>
<td>75,800</td>
<td>9,700</td>
</tr>
<tr>
<td>Total As</td>
<td>9,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Challenges in the Future:

- Mineralogical regimes with low Fe content
- Comparison of animal models: mouse, swine, mouse
- Inhalation RBA in vivo and in vitro

REFERENCES:

1. Basta, N.T., J. N. Foster, E.A. Dayton, R. R. Rodriguez, and S.W. Casteel. 2007. The effect of dosing compounds. The black lines are the spectra of the sample and the red line the spectra of the best fit model compound. A) All but one sample had spectrum best fit with As 5+ oxidation state. B) The single outlier (E12) is composed of 60% arsenopyrite (FeAsS).

Figure 2: Geographical distribution of As concentrations and bioaccessibility of As in the Empire Mine State Historic Park in Nevada County, California.

Figure 4: As X-ray Absorption Near Edge Structure (XANES) Spectra: Arsenic (As) XANES spectra of the As oxide (As+5) and As arsenide (As+3) oxidation states. The As oxide (As+5) spectrum is dominated by the d-d transition and the As arsenide (As+3) spectrum is dominated by the f-d transition.

Figure 5: Plots of Principal Component Analysis (PCA) Axes 1 and 2. The first two principal components (PC1 and PC2) explain the greatest amount of variance in the data. The PCA results show that the sample points are clustered according to their As mineralogical association.

Figure 6: Chemical speciation results for As in soil samples. A) The As oxide (As+5) spectrum is characterized by a single peak at approximately 13.5 keV. B) The As arsenide (As+3) spectrum is characterized by a single peak at approximately 7.5 keV.

Figure 7: Scanning electron microscopy (SEM) images of soil samples. A) Sample E16, which is composed of FeAsS (arsenopyrite). B) Sample E12, which is composed of Fe₂As₂ (ferroarsenopyrite).

Figure 8: Transmission electron microscopy (TEM) images of soil samples. A) Sample E16, which is composed of FeAsS (arsenopyrite). B) Sample E12, which is composed of Fe₂As₂ (ferroarsenopyrite).

Figure 9: X-ray diffraction (XRD) patterns of soil samples. A) Sample E16, which is composed of FeAsS (arsenopyrite). B) Sample E12, which is composed of Fe₂As₂ (ferroarsenopyrite).

Figure 10: Raman spectroscopy (RS) spectra of soil samples. A) Sample E16, which is composed of FeAsS (arsenopyrite). B) Sample E12, which is composed of Fe₂As₂ (ferroarsenopyrite).

Figure 11: Fourier transform infrared spectroscopy (FT-IR) spectra of soil samples. A) Sample E16, which is composed of FeAsS (arsenopyrite). B) Sample E12, which is composed of Fe₂As₂ (ferroarsenopyrite).

Figure 12: High energy synchrotron-based X-ray Analysis: The wide range of values for bioaccessibility and metal content is adequate to identify gradients and correlations. The data are plotted as a scatter plot with the bioaccessibility on the y-axis and the total As content on the x-axis.