INTRODUCTION

Mineral exploitation in SW England can be traced back to pre-Roman times with the main period of mining in the mid-nineteenth century. The Devon Great Consols Mine lies on the east bank of the River Tamar in the Tavistock district of Devon. In the early years of operation the mine raised copper ores from lodes consisting of chalcopyrite, pyrite, arsenopyrite and minor cassiterite. In the mid 1800s at about the same time as copper ore production declined the use of arsenic as a pesticide developed and the mine had a new lease of life as an arsenic producer; arsenic production continued until about 1925. Mining activities have left a legacy of contaminated land, with large areas of As-rich mine spoil and the ruins of treatment works and calciners. The bioaccessibility of arsenic in the soils in the vicinity of Devon Great Consols Mine and background agricultural soils has been assessed in the present study.

METHODOLOGY

PBTE TEST- Physiologically Based Extraction Test

An in vitro test, the physiologically based extraction test (PBET), developed by Ruby et al. (1996), has been used to simulate the leaching of a solid matrix by a simulated gastric and gastrointestinal tract. The term bioaccessibility is here used to describe the fraction of the total arsenic concentration that is soluble in the stomach and gut and as a result is available for systemic uptake.

RESULTS AND INTERPRETATION

Arsenic Bioaccessibility

Arsenic concentrations in soils in the mine site have a median value of 14 mg/kg. Agricultural soils over mine spoil are affected by mining activities and have much lower concentration of arsenic with a median value of 10 mg/kg.

The median values of bioaccessible arsenic are 400 mg/kg for the soils in the mine and 14 mg/kg for the agricultural soils.

The bioaccessible arsenic in the soils at the mine site have a median value of 400 mg/kg. Agricultural soils over mine spoil are affected by mining activities and have much lower concentration of arsenic with a median value of 10 mg/kg.

Relation between bioaccessibility and soil chemical properties in the mine soils

Total arsenic concentrations in the mine soils span two orders of magnitude, with a number of outliers suggesting that the arsenic data is derived from more than one population of samples. Based on similarity clustering of the soil's physico-chemical variables the soils have been grouped into 3 clusters. Cluster 1 and 2 group similarly the soils characterized by the arsenic concentration. Cluster 3 has however higher relative bioaccessibility of arsenic. Cluster 4, which groups the soils around the As works area, contains soils with very high concentrations of Fe and S, and identifies clearly the area of major pollution. Cluster 3 has intermediate arsenic values.

DEFRA and the Environment Agency have published a set of Soil Guideline Values (SGV) for assessing the risk to health from arsenic contamination (DEFRA and EA, 2002). A key assumption in the derivation of the SGV is that all of the ingested arsenic is available for absorption via the gastrointestinal tract. Based on this assumption the concentration of arsenic in the soil is an important determinant of the bioaccessibility of arsenic. The equation of the model is: Y = 0.349743018650286*X1 - 0.0001*219.63

Where Y is the concentration of bioaccessible arsenic and X1 is the total arsenic concentration.

The confidence interval for Y is -0.142015826141954*X1 and the 95% confidence interval for Y is -0.142015826141954*X1 + 0.142015826141954*X1.

Implication for contaminated land policy

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Sequence extraction data have been used to help elucidate the nature of the arsenic-hosts in the different soil types and to understand the relative influence of various factors on bioaccessibility.

A chemical sequential extraction has been used to investigate arsenic partitioning in the soil.

CISMeD-Test-Chemometric Identification of Substrates and Metal Distributions

A chemical sequential extraction has been used to investigate arsenic partitioning in the soil.

- Separate aliquots of nitric acid of increasing concentration.
- Performed through the sample under centrifugal force.
- Determined by ICP-AES.
- Chemometric data processing.
- Identification of physico-chemical hosts and the metal distributions within the sample under test.

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Multiple Linear Regression (MLR) is used to analyse the relationship between the bioaccessible arsenic content of the soil and other soil parameters for Cluster 1 and Cluster 2. The total element content; pH and organic matter were used as predictor variables and the two models’ coefficients. For Cluster 1, 6.8% of the variance in the bioaccessible arsenic is modelled using the total arsenic and the total iron content. Total arsenic has a positive coefficient and iron has a negative coefficient. This suggests that there is a portion of arsenic bound to an iron oxhydroxide that hosts arsenic in a non-bioaccessible form. For Cluster 2, 59.8% of the variance is modelled entirely by the total arsenic content. These results were comparatively significant at "0.05". An assessment of this risk to human health arising from exposure to soil As contamination has been carried out using the CLEA model developed by DEFRA and Environment Agency (2002) and the bioaccessible content. The parameters that have been used to calculate the average daily human exposure (ADE) are the default values assumed in the CLEA conceptual model for “contaminated land” use, selected on the basis that sensitive receptors live within the mine influence and consume home-grown vegetables grown on contaminated soils. The exposure pathways that are considered applicable to this standard land use are: ingestion of soil; ingestion of household dust; ingestion of contaminated vegetables; ingestion of soil attached to vegetables. The critical receptor is assumed to be a young female child with the exposures occurring in the first six years of life. Based on this assumption the ADE for cluster 1 is 4.1 times the index dose (ID) of 0.0003 mg/kg body weight/day has been calculated for the mine soils, while the ratio ADE/ID for the agricultural soils is 0.7. Using the bioaccessible concentration of arsenic in soils gives a more realistic indication of areas that are likely to pose an unacceptable risk to human health.

References

DEFRA and Environment Agency (2002) Bioavailability of Arsenic in Soils and Assessing the Risk to Health from Contamination. Published for the Environment Agency by Defra, DERA and BGS, Keyworth, Nottingham, NG125GG, UK. E-mail: bpal@bgs.ac.uk

A COMPARISON OF ARSENIC BIOACCESSIBILITY FROM SOILS IN THE VICINITY OF AN ABANDONED ARSENIC MINE AND BACKGROUND SOILS IN SW ENGLAND

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