BGS's 250,000 shovels of mud: why each one counts and what it means to you

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Geochemistry is the study of the distribution and movement of chemical elements within the Earth and at its surface. A geochemical baseline establishes the natural chemical status of the Earth's surface, and allows us to monitor changes resulting from natural and man-made influences on the environment (Johnson and Breward, 2004). We explain how a geochemical baseline is established and what it means for the everyday man and the contaminated land community.

The British Geological Survey's (BGS) G-BASE (Geochemical Baseline Survey of the Environment) project is part of the Environmental Modelling Group, who can apply geochemistry to improve environmental, societal and economic well-being through measurement, understanding and modelling. The G-BASE project has been ongoing for almost 50 years. Its focus has evolved from mineral exploration to answering questions related to the environment. G-BASE data helps us to understand processes occurring within the environment, and relate these processes to questions including those associated with contaminated land, sustainable development, human and agricultural health, and agricultural productivity. The data can help identify man-made modifications to the baselines or background geochemistry, and supports policy development and implementation in relation to several areas including land planning regulations, land use and its quality (Johnson et al., 2005).

Sampling commenced in the north of Scotland and progressed southwards, until 2013 when the south of England was surveyed and the systematic sampling phase of the project neared completion. Initially stream bottom sediments were sampled producing a sediment sample with a panned concentrate, and a water sample for the same location. This combination of sample types provides information on the geochemistry of the land upstream of the sample point and highlights the key relationship with the underlying geology (Johnson et al., 2005; Johnson and Flight, 2011).

As progress southwards continued soils were added to the types of sample collected, as soil is at the interface between the zone of human interaction and the environment, meaning these geochemical data have the potential to answer the changing needs and challenges of the population. Over time, the number of analytes included as part of the routine analysis has increased from 16 in the early years to 58 in 2013-14. With the increased range of elements that may be of interest, improvements in analytical chemistry techniques have allowed the detection of elements at lower concentrations (Johnson et al., 2005).

When sampling rural areas, streams are sampled at a density of approximately one every 1.5 km^2, and soils are sampled every 2 square km. In urban environments only soils have been collected, because of the limited availability of streams unaffected by man. The collection density is increased in the urban environment to one sample per 500 square meters to allow for identification of localised variation (Johnson, 2005). The BGS G-BASE project has collected samples from over 100,000 stream water and sediment sampling locations and over 42,000 soil sampling locations in both rural and urban environments (Figure 1). Despite changes in the focus of the project the G-BASE methodology has been consistent throughout its entire history. The resulting dataset is a robust, valuable national resource. The main outputs of G-BASE data are a series of atlases presenting interpolated maps, and providing interpretation. Figure 2 shows an example of an interpolated map created from G-BASE surface soil data around the city of Leicester.

The project has always used Earth Science undergraduate student volunteers to carry out the sampling. Each year new students are trained in the sampling methods, which in turn are transferred to universities and the volunteers' future employers, building UK capability. In addition the technology and methodologies have been exported worldwide to countries such as Ireland, Nigeria, Madagascar, and Morocco (Johnson et al., 2005).

Examples of where members of the Environmental Modelling Group have used G-BASE data to address environmentally relevant questions include:

- Estimating what UK normal background concentrations of potentially harmful elements in soil are, and defining boundaries between natural and human inputs to the soil. This has become increasingly important as contaminated land and planning regulations have been updated over recent years, information on elemental concentrations in UK soils has become increasingly relevant. A project commissioned by DEFRA, using the G-BASE soil data has shown that areas of the UK thought of as contaminated are not necessarily so, which could reduce unnecessary remediation costs, relieve the burden on landfill sites and associated landfill tax costs, and preserve soils as a natural resource (Ander et al., 2013).

- Developing the field of bioaccessibility on both a domestic and international basis which is associated with the developments in contaminated land legislation. This scientific research has focussed on developing robust methodologies to assess the amount of potentially harmful substances associated with soils than can be accidentally ingested and therefore cause harm. This information can be used as a line of evidence in human health risk assessments for contaminated land, as the team have shown by using G-BASE data that only a certain proportion of a contaminant may be available for uptake. Bioaccessibility maps developed using the team soil data have the potential to be used by local authorities as a decision making tool, helping to identify areas where there is a need for site specific risk assessments under contaminated land or under planning guidance (Cave et al., 2011; CIEH, 2009). Application of bioaccessibility at two former coal mining sites in the UK has enabled the reuse of existing site materials as part of the remediation process. This has led to reduced costs of £3.75 million, and saved 3,750 lorry journeys to landfill and 105 tonnes of carbon dioxide equivalent were saved. At another site the BGS assessment enabled savings of between £7 million and £30 million of remediation expenses. In addition local residents were reassured and the stalled housing market in the area was restarted (NERC, 2009).

- Application of the methodologies used on G-BASE to underpin similar projects such as the Tellus Border project (www.tellusborder.eu), which has included a geochemical survey in the Irish border counties. Data from this project has been used by members of the BGS Environmental Modelling Group to study the health of grazing animals. Cobalt is an essential element for grazing animals; uptake of this essential element via soil may be inhibited by the presence of manganese even when the cobalt content is large, exposing cattle to potential cobalt deficiency. Geochemical soil data from the Tellus border project has been used to identify areas of land that may require agricultural management for example by nutritional supplements (Lark et al., 2014)

The data have been used for a variety of other applications, such as: working with the medical profession to establish relationships with human health, undertaking research related to social deprivation and geochemical variation, contributing to policy for guidance associated with UK and EU related issues e.g. the water framework directive, and advising on research and identifying opportunities for mineral exploration. The data is considered by the team to be a national resource and designed to be used. It has the potential for large financial savings within the contaminated land community. The data is available under licence from BGS. Please contact digitaldata@bgs.ac.uk for more details

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Figure 1: G-BASE sample site locations. Map data, BGS © NERC. Contains Ordnance Survey data © Crown Copyright and database rights 2014

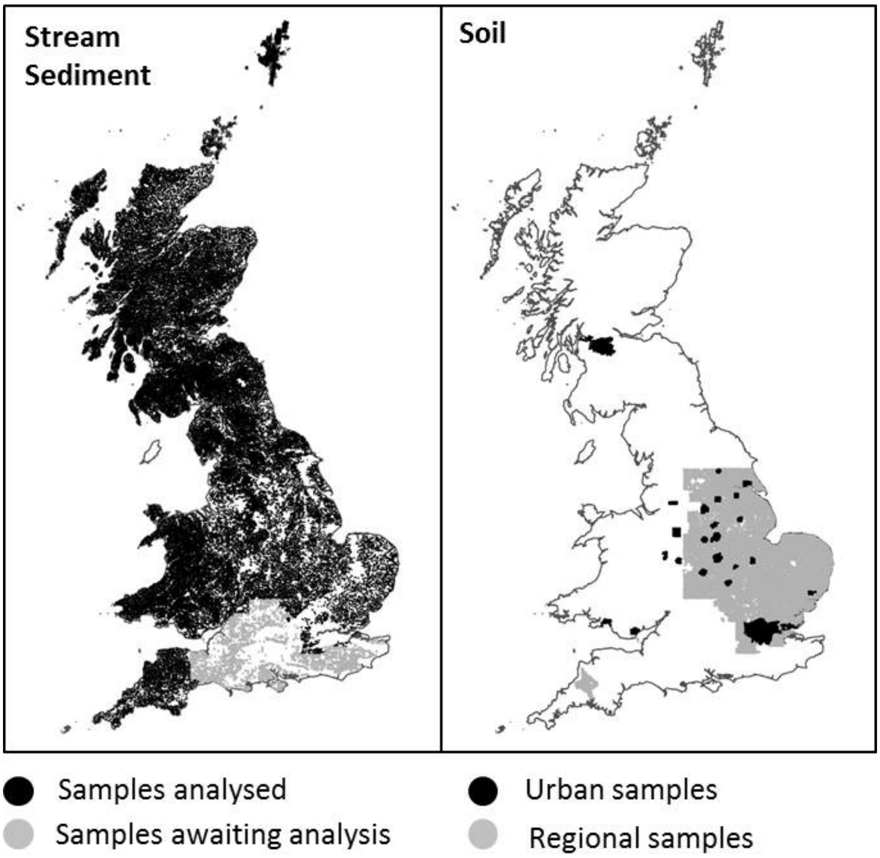

Figure 2: Example of interpolated map presenting G-BASE surface soil data. Map data, BGS © NERC. Contains Ordnance Survey data © Crown Copyright and database rights 2014