

We can only measure how far we have come if we know where we started. The **Geochemical Baselines and Medical Geology** team describe how they are setting a benchmark for environmental change.

Chemical elements in our environment

Humans are intimately linked to the Earth's surface environment; we are fundamentally dependent on it, yet we are responsible for many aspects of environmental change. This provides an urgent impetus to enhance our knowledge of the chemical status of our environment and improve our understanding of the processes and consequences of environmental change so that any hazards can be identified. The BGS delivers our National Capability in baseline geochemical mapping, providing a flexible observational framework for the chemistry of Britain's surface environment.

The core Geochemical Baseline Survey of the Environment (G-BASE) dataset comprises a high-quality, detailed multi-element analysis of stream waters, stream sediments and surface soils collected across the British landmass. Information is made accessible from our website, and provides a direct evidence-base for researchers and policy-makers in environment and health in addition to supporting a diverse portfolio of other studies with a wide range of partners. Through the collection of these new data we can help to assess our resilience to the chemical changes arising directly from human activities such as urbanisation, industrial activity, agricultural and other landuse changes. We can also start to understand more fully the consequences of climate-change scenarios such as increasingly frequent flooding events that result in chemical remobilisation and physical redistribution (e.g. wind-blown dust) of natural or man-made contamination.

The Geochemical Baselines and Medical Geology Team has developed strong skills and research expertise to continually improve, adapt and exploit the G-BASE resource. Recent and ongoing research addresses highest priority challenges

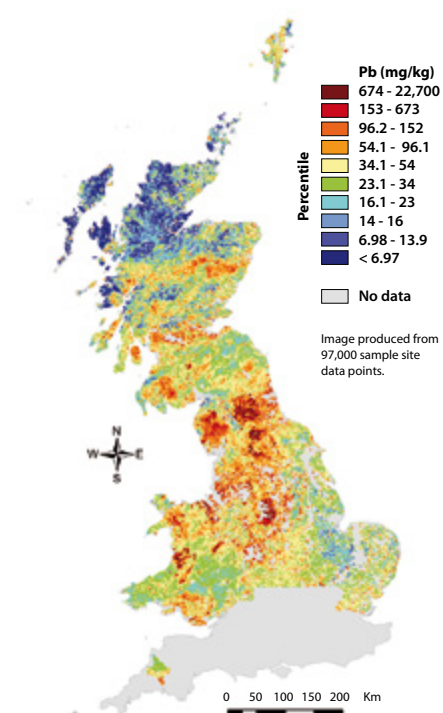
identified by British science and government bodies:

- Ecosystem assessments — defining geochemical variations in natural and altered stream environments, and providing information to ecologists.
- Sustainable use of natural resources — particularly water, sediment and soil quality in relation to regulations, also assessing soil carbon stocks and erosion potential.
- Human health and nutrition — distribution and bioaccessibility of elements, interdisciplinary research with health experts, assessment of micronutrients in agricultural systems.

Inadvertent soil ingestion through daily activities, such as gardening or children playing, can transfer toxic elements into the body. The G-BASE soil data demonstrates that large areas exceed the government guideline value for arsenic, indicating the possible widespread presence of a natural hazard. Novel research techniques developed at the BGS show, however, that in many instances the risk to health through soil ingestion is low; only a small fraction of the total arsenic is 'bioaccessible', or able to be absorbed

by the body. Bioaccessibility is controlled by the chemical form and mineralogy of the arsenic in the soil. A single aspect of this research was recently independently calculated to have an ongoing potential benefit of saving £4–13M a year to the UK economy. Recent developments include prediction of where arsenic bioaccessibility may be of concern, and further assessment of human biomarkers of exposure.

As our climate changes, we can expect soil properties to change. Exposure



The concentration of lead (Pb) in British stream sediments.



BGS staff training Nigerian Geological Survey staff on stream sediment sampling, Nigeria, 2009.

to geogenic dusts could increase if Mediterranean-style climates extend northwards across Europe as forecast. There is strong evidence that increased dust inhalation causes a broad range of health problems, so we are researching how mineral dusts dissolve in lung fluids and whether this may release toxic elements into the body. The physical properties of soils have been examined in detail using the G-BASE soil sample archive, and demonstrate an increased risk of wind erosion of soils in the east of England, one of the UK's most important agricultural areas. Our team has shown that 45 per cent of airborne particulates in one urban area were attributable to soil sources, thus reinforcing the importance of understanding how chemicals in these natural dusts affect the human body.

The G-BASE project also provides a unique resource in measuring the impact of urbanisation on our soil environment. The consistent and rigorous protocols allow us to make confident assessments of the relative impact of natural and diffuse contamination loadings within an urban centre, by comparison with the rural hinterland's soils. The most striking example of this is lead, which was widely released by industrial activities and was a significant component of petrol. It is almost ubiquitously at systematically higher concentrations across the urban environments studied, and is an element of ongoing concern to public health.

Researching toxic elements, however, is only one aspect of our work. A deficiency of essential elements can also have an important impact on health. We have studied nutrients such as iodine and selenium in the environment, which are considered to be in short supply in some soil-plant systems and therefore, potentially, in humans, even in a nation as diverse and wealthy as the UK. There is evidence that the average UK selenium intake has declined through increased use of European, rather than high-selenium North American, wheat. Recent research has shown that there are significant areas of the UK which have soils with low levels of selenium, for example in Scotland. Our multi-element soil data also explain why wheat grown in higher selenium soils in parts of East Anglia still have low selenium concentrations: take-up is probably restricted by high levels of organic carbon in the soil. The trend towards consuming more local foodstuffs provides a focus for understanding these geochemical cycles, to provide robust baseline information to agronomists and public health experts.

Soils form a vital store for carbon. UK soils contain around 10 billion tonnes of carbon, half of which is found in peat habitats. However, accurate calculations rely on field information which is often lacking. Were this stored carbon released to the atmosphere, emissions would be equivalent to more than 50 times the UK's current annual greenhouse gas emissions. As the climate warms and rainfall patterns

change, there is a growing risk that emissions to the atmosphere from soil will increase — causing further climate change and reducing the soil's productive capacity. Certain carbon deposits are more sensitive to seasonal variation, human interactions and, ultimately, to a changing climate — particularly where organic soils or peats are thin and subject to drying-out, overgrazing and erosion. Our 2010 sampling in the Clyde catchment has added the measurement of peat depth to our routine protocols, to be used as baseline data for 3D modelling of organic soils and to validate remote-sensing techniques designed to assess peat resources and vulnerability.

Our skills are also used to support capacity building in geochemical mapping for mineral deposits in emerging nations, where wealth creation is a priority. In the past five years projects in Madagascar, Mauritania, Tanzania, and Nigeria, have been funded by the World Bank.

Researching and contributing to societal needs has always been central to our existence as a geological survey. The application of geochemistry to map the distribution, and understand the behaviour of elements demonstrates how knowledge of the surface environment can be used to improve health, create wealth, and address the challenges posed by our present-day and future environmental changes.

For further information, visit:
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Exposed, vulnerable thin peat in Scotland, surveyed in 2010 by the G-BASE team.