

Measurement of heavy metals

Bioavailability and distribution in contaminated soils

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Impending legislation will require local authorities to take responsibility for contaminated land within their boundary (Part IIA of the Environmental Protection Act 1990 and Section 57 of the Environment Act 1995). Local authorities will be required to implement a strategy for the management of contaminated land to include assessment of the risks associated with the contamination.

Risk assessments are currently based on the total concentration of toxic substances present in contaminated land as presented in the Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL) guidelines. However, many soils in the UK contain natural levels of metals that are higher than those set out in these guidelines and, even in contaminated soils, high concentrations of heavy metals may not present a hazard, as their chemical form is unlikely to be available for animal or plant uptake. There is, therefore, a need to define a different parameter which can be used to judge the toxicity of a soil sample.

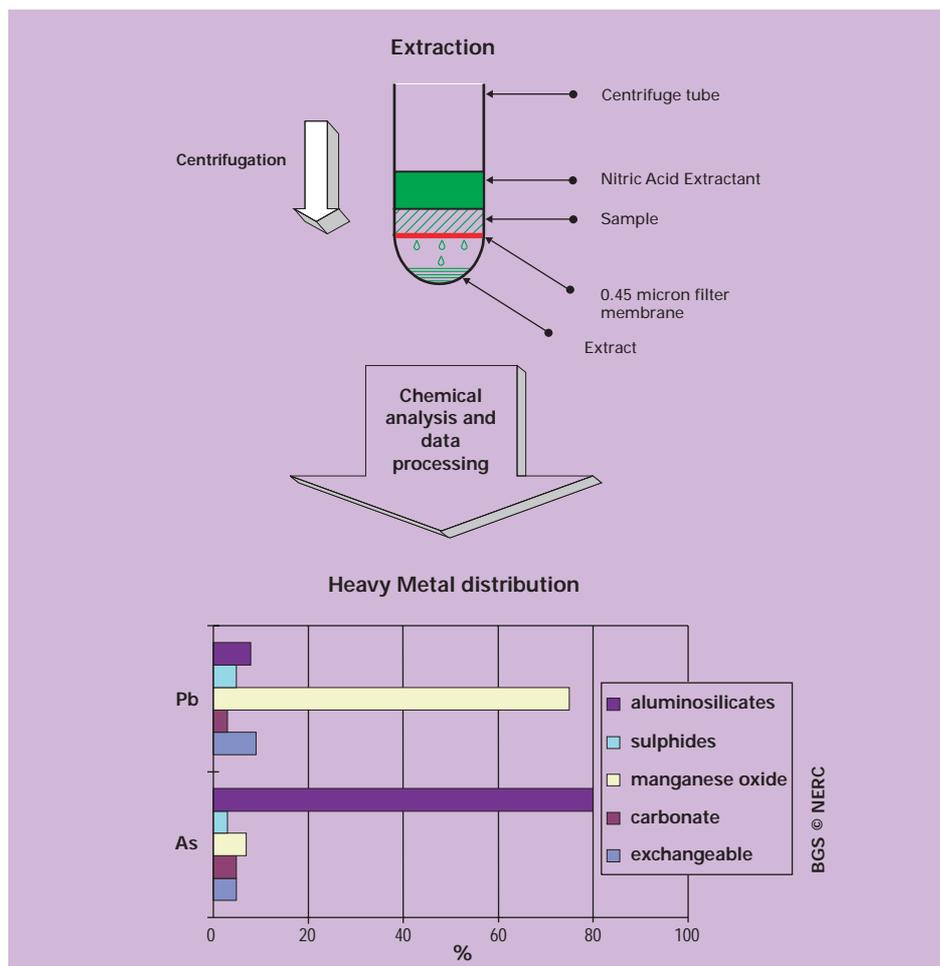
Bioavailability is the fraction of a contaminant present in a soil which is available for absorption by a biological organism *via* a specific exposure route. Many different approaches to the assessment of bioavailability have been suggested. The US Environmental Protection Agency (EPA) is considering using risk assessment models for contaminated sites partly based on the uptake of contaminants (such as lead and arsenic) *via* the human gut, from ingestion of soils and dust. Preliminary extraction test methodologies for mimicking bioavailable uptake in the human gut have been validated for lead.

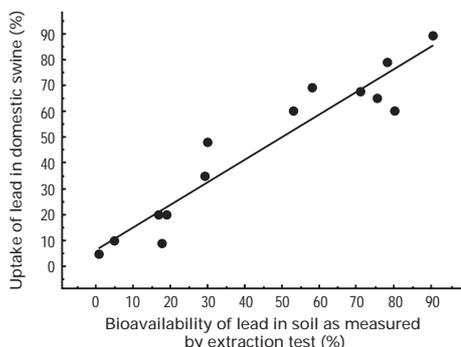
Rapid chemical extraction procedure developed by the BGS to identify the reactive physico-chemical substrates in soil samples.

The BGS has now set up a physiologically based extraction test (PBET) and a simplified form of this test (Simple Bioavailability Extraction Test, SBET) in which the contamination in a soil which is available for uptake can be determined using an extraction test. The test

This is illustrated in the graph (facing page) which shows the correlation between the bioavailability of lead in soils as measured by the extraction test and the uptake in domestic swine. Current work on other heavy metals is also being undertaken.

“... many soils in the UK contain natural levels of metals higher than those set out in guidelines...”





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Correlation between the measured bioavailability of lead in soils and uptake in domestic swine.

uses simulated stomach conditions (a synthetic stomach solution at 37°C). These tests have been successfully applied to a number of potentially contaminated soils with arsenic concentrations above the ICRCL limit of 10 milligrams per kilogram and have shown, in some instances, that less than 1% of arsenic in the soil is bioavailable.

In addition to bioavailability measurements, information on the distribution of heavy metals in the physico-chemical substrates within the soil are also required in order to make assessments of risk. These help to determine the reactivity of potentially toxic metals and form the basis for guidance on remediation and future land use.

Historically, the identification and measurement of the trace element distributions in soils has been carried out using sequential extraction tests and these suffer from various limitations. For instance, the methodological definition of the distribution of the trace elements between the solid phases may not be indicative of those in the test sample, and extraction is not necessarily specific to a single mineral phase, thus it is difficult to attribute the elements extracted to the respective phase. There are additional practical problems, such as that the extraction reagents are not easily analysed.

The BGS has recently developed a rapid chemical extraction procedure which overcomes problems associated with these conventional leaching methods and identifies the reactive physico-chemical substrates within the soil giving quantitative values for the distributions of heavy metals in the soil sub-

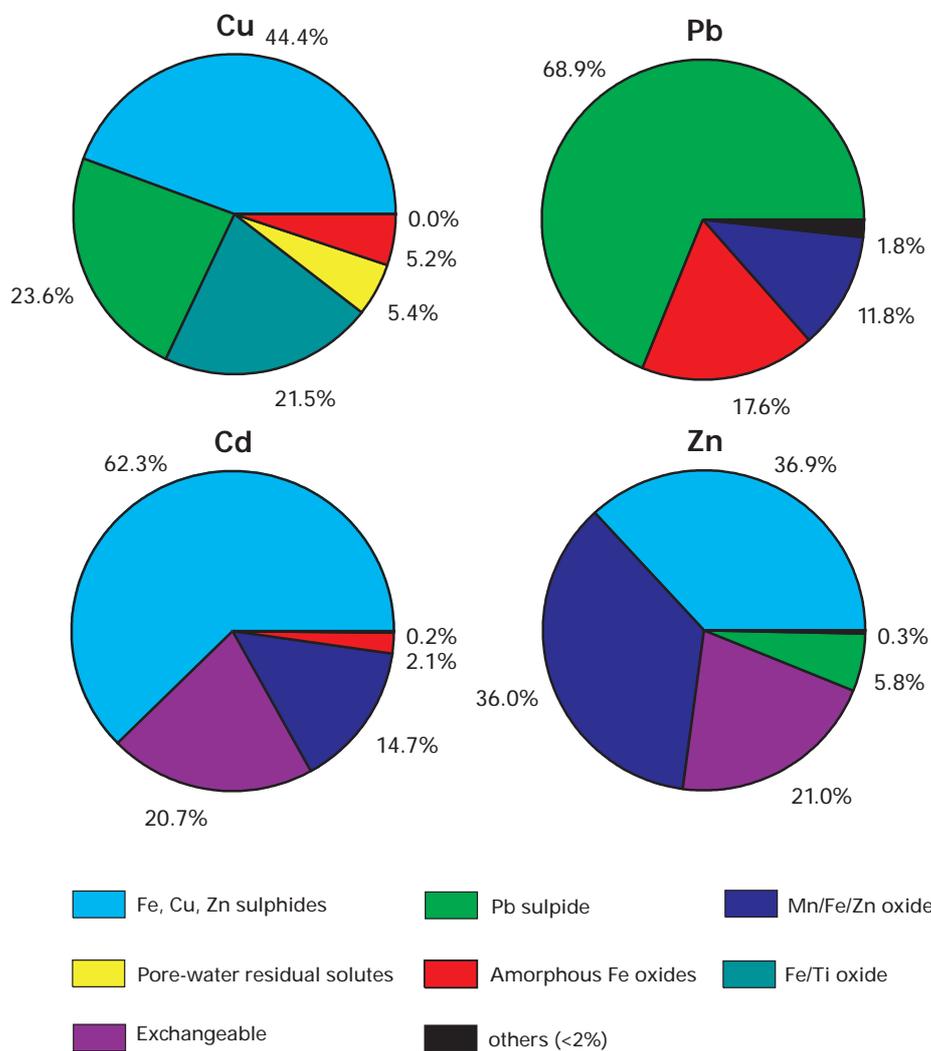
strates. A pictorial outline of the procedure is given opposite.

An example of the results produced by the new heavy metal extraction procedure are shown below for highly contaminated soil from pasture land along Silver Bow Creek in the Butte, Montana area, USA. The soil contains high concentrations of heavy metals, in particular copper, manganese, lead and zinc. The results clearly show the major physico-chemical substrates identified in the soil and how the heavy metals are distributed between them.

Testing can be applied to samples from typical contaminated sites like this tar pit in Derbyshire (right), to assess the potential for human bioavailability of heavy metals by ingestion.



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Distribution of heavy metals between different physico-chemical substrates identified in heavily contaminated soil samples from Silver Bow Creek, Butte, Montana.