Heavy metal plants

Heavy metals occur naturally in small quantities in soil, but human activity has raised these to exceptionally high levels at many polluted land and water sites. A collaborative project between the Interface Analysis Centre and researchers at Rothamsted Research has found a novel solution to the problem.

The decontamination of polluted sites is an expensive and often technically difficult task. However, one rapidly developing bio-technology is that of phytoremediation – the use of plants to remove contaminants from the soil. While many plants have developed mechanisms to either tolerate or exclude these potentially toxic contaminants, there are several species which can take up extraordinary quantities of such elements and concentrate them in their leaves and stems above ground. These plants are known as hyperaccumulators and are a promising method of cheap, environmentally sound remediation of contaminated soils.

Where *does* the plant store the arsenic?

One such plant is the brake fern (*Pteris vittata*). When growing on contaminated soils, this plant can accumulate arsenic to concentrations as high as 22,600 milligrams of arsenic per kilogram in the fronds – typical levels in non-hyperaccumulating plants are below 10 milligrams per kilogram. But knowing where, exactly, the plant eventually stores the arsenic is of great importance when trying to understand the mechanisms facilitating its remarkable ability to accumulate an element renowned for its toxicity. Surface analysis of the plant has been conducted to gain information about the sub-cellular distribution of arsenic in these ferns. The technique – secondary ion mass spectrometry – uses a beam of gallium ions to bombard the sample, causing a variety of secondary particles to be emitted from the surface layer. These secondary ions can then be identified by passing them through a mass spectrometer. This provides compositional information about the sample, showing the spatial distribution of any arsenic present.

As is typical of many surface analytical techniques, the system must be housed under high vacuum conditions, which in turn determines the type of sample that can be analysed, permitting only clean, dry, non-volatile samples with a flat surface – everything a piece of plant tissue is not! So a unique modification to the equipment has taken place to facilitate the analysis of fresh samples which are frozen in liquid nitrogen. This method of cryo-preparation is similar to that which is often employed on scanning electron microscopes, but the analysis maintains advantages such as higher sensitivity, the ability to detect all element and isotopes, and better spatial resolution.

In an alternative approach, an exciting collaboration with Dr Neville Bainbridge at the Atomic Weapons Establishment, Aldermaston has been established utilising the Versatile Intermediate Pulsed Experimental Reactor (VIPER) to perform neutron activation analysis. Pulsed reactors differ from conventional ones in their ability to produce short pulses of intense radiation. Fronds from arsenic-treated ferns are irradiated in a neutron beam which excites the stable arsenic isotope (^{75}As) to an unstable radioisotope (^{76}As). During this process, termed 'decay', gamma radiation of characteristic energy is emitted, detected and quantified, confirming the presence, or otherwise, of arsenic. Work is now under way to map its distribution along the frond. It is anticipated that future experiments may be conducted to apply these experimental techniques to other hyperaccumulator plants that accumulate elements such as cadmium, zinc and nickel. ■

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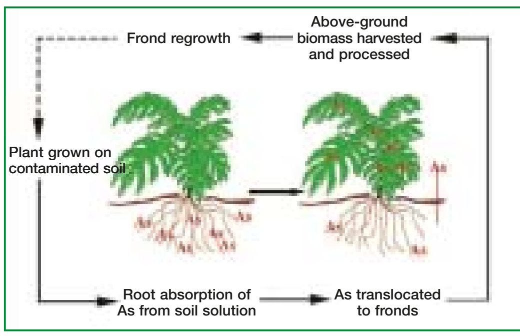

The brake fern can accumulate extraordinary concentrations of arsenic (As)