Uranium in groundwater

Impacts on health, geochemical exploration and radwaste disposal

by Barry Smith

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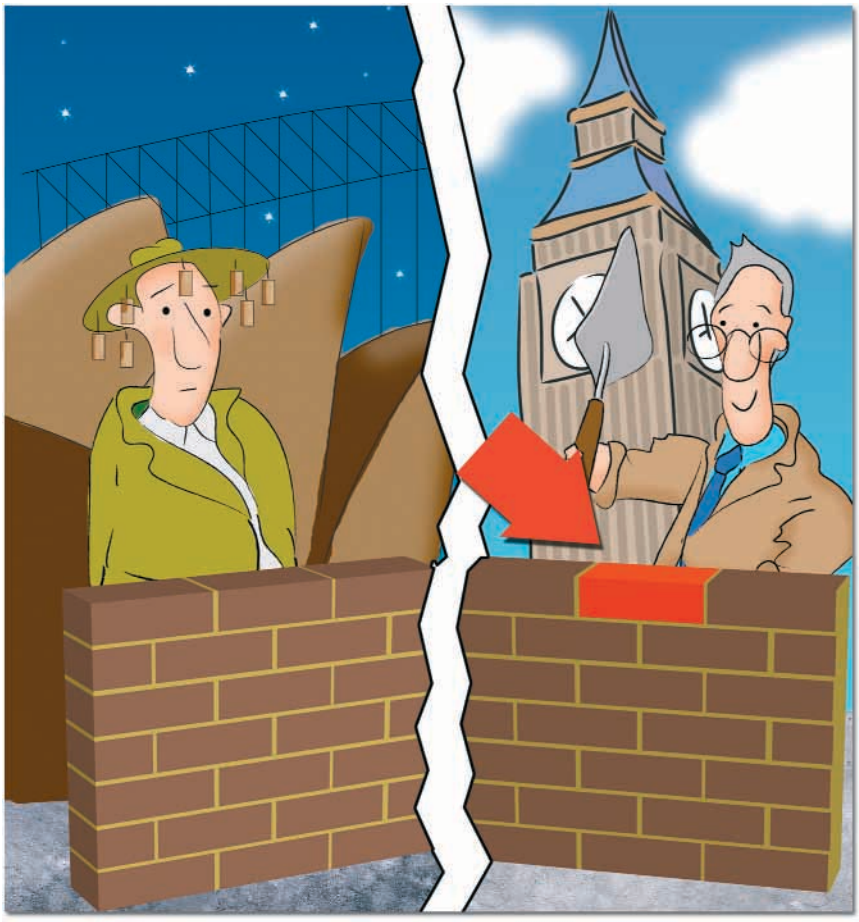
Uranium is a naturally occurring radioactive element, which is present throughout our environment. Atmospheric dust, food, soil, rocks and natural waters all contain uranium. However, in most cases it is uranium in water that controls our daily exposure to this element. This is particularly the case where drinking water is obtained directly from groundwater.

Despite its radioactive nature, the health impacts associated with exposure to elevated levels of naturally occurring uranium in drinking water are considered to result mainly from its chemical, rather than any long-term radiological, toxicity. At elevated levels, the chemical toxicity may result in impaired kidney function. The current recommended WHO guideline value in drinking water is 0.015 milligrams of uranium per litre of water. This is cited as being a provisional guideline value, as the available information on health effects is limited and because the calculated guideline value is below the level that can be achieved through practical treatment methods and source protection (WHO, 2004).



Most groundwaters have concentrations much lower than the guideline value given above; however, in some geological environments, concentrations in groundwater can approach or exceed it. This does not imply a threat to human health, but it does indicate that the abundance of uranium in affected resources requires a more detailed investigation. For these reasons we have undertaken a variety of investigations of uranium in groundwater used as a source of drinking water. For example, we carried out the first major study of the presence of uranium in groundwaters from Jordan and Cyprus. More recently we studied the presence of uranium and its association with arsenic-rich groundwaters from sedimentary aquifers in Bangladesh, China and Argentina. Closer to home, we have been undertaking a systematic

The concentration of uranium in natural waters is typically less than 0.001 milligram per litre. For comparison purposes this represents one brick in a one metre high wall stretching from Nottingham to Australia. Current analytical capabilities allow the reliable detection of less than a thousandth of this amount in typical groundwaters.

study of uranium in groundwater from England and Wales as part of our programme on baseline groundwater quality in collaboration with the Environment Agency. Studies of private water supplies have also been undertaken on behalf of the UK Department for the Environment, Food and Rural Affairs. Within Europe, such studies have made significant contributions to international investigations that are attempting to understand the health consequences of this element in groundwater and the typical variations in baseline values. In undertaking these, we have also identified a number of previously unknown occurrences of uranium mineralisation, underlining the need for systematic surveys of uranium in groundwater resources.

In addition to being of potential concern in respect to human health, uranium in groundwater can be used for a wide variety of other purposes. These include geochemical exploration, groundwater dating and improving our understanding of fundamental geochemical processes. The latter is particularly important in the case of uranium as it is a major component of intermediate level nuclear waste and a by-product of nuclear fuel production. In this area the BGS has, over many years, continued to play an important role, by improving our understanding of the mobility of uranium in groundwater when complexed with naturally-occurring organic matter, carbonates, and under highly alkaline conditions. These studies have relied on exploiting geological analogue sites, as natural laboratories. At such sites the behaviour of uranium can be investigated over periods far in excess of those achievable in laboratory experiments — in some cases in excess of 1000 years. At Broubster in Caithness and Needles Eye in Dumfries and Galloway, we have investigated the migration of groundwater containing elevated concentrations of uranium into post-glacial deposits (less than 10 000 years old), such as peats. These studies have established a variety of key parameters defining the strength of interactions between uranium and humic matter, as well as the importance of microbiology and fungi in controlling the movement of uranium. In Jordan we have been actively involved in an international consortium using naturally occurring hyperalkaline groundwaters, emerging from springs in the valley of the Yarmouk River, to study the stability of uranium under highly alkaline conditions. These conditions, with a pH greater than 11, are predicted to be representative of those found surrounding intermediate-level nuclear waste where encapsulation in Portland cement has been chosen as part of the primary containment strategy.

Sampling waters from a range of groundwater sources during an EU funded project to evaluate the abundance of uranium and radon in groundwaters from a variety of North African countries. During this project two drinking water supply boreholes containing over one milligram per litre uranium were discovered and subsequently removed from public supply.

Underpinning all of these related activities, in which we continue to undertake core and commissioned research, is the lead role played by the BGS in the original and current development and application of inductively coupled plasma mass spectrometry (ICP-MS) for uranium analysis. In recognition of a continuing need for development in this area of analytical geoscience, the BGS and the NERC Isotope Geosciences Laboratory recently held the first international workshop dedicated to the analysis of uranium by techniques based on mass spectrometry. Over 40 delegates attended from the UK and Europe and a major outcome was to refocus attention on the need for environmentally relevant standards and the comparison of analytical methods between laboratories that measure uranium distributions in diverse media. ▮

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