

Arsenic in groundwater

The hidden threat

by **Pauline Smedley**, *Wallingford*

Groundwater constitutes a major source of good-quality drinking-water in many parts of the world. Rocks and soils through which groundwater passes provide a natural filter for the removal of many undesirable contaminants and can be of great benefit in water purification. Indeed, the development of groundwater for drinking-water supplies over the past few decades has been instrumental in decreasing the incidence of serious water-borne diarrhoeal disease in developing countries and has been a major benefit in improving public health as a result. However, despite these benefits, the quality of groundwater cannot always be guaranteed as geochemical reactions in the host aquifers can lead to the natural build up of trace elements derived from

the rocks and soils. Many of these trace elements can be toxic if present in sufficiently high quantities. One of the most serious natural contaminants in groundwaters is arsenic.

“... several disorders, including internal cancers, have been associated with chronic arsenic ingestion ...”

Arsenic is toxic and carcinogenic. Long-term use of drinking-water with high concentrations of arsenic can lead to a number of health problems. The most commonly manifested of these are skin

disorders, including pigmentation changes, keratosis, and skin cancer, but several other disorders, including a number of internal cancers, have also been associated with chronic arsenic ingestion. The World Health Organisation’s (1993) provisional guideline value for arsenic in drinking-water is 10 micrograms per litre, although many countries continue to use the pre-1993 guideline of 50 micrograms per litre as their national standard. Most groundwaters have concentrations less than these values, but a number of aquifers contain groundwaters with unacceptably high arsenic concentrations. In extreme cases, concentrations in the milligram-per-litre range can occur.

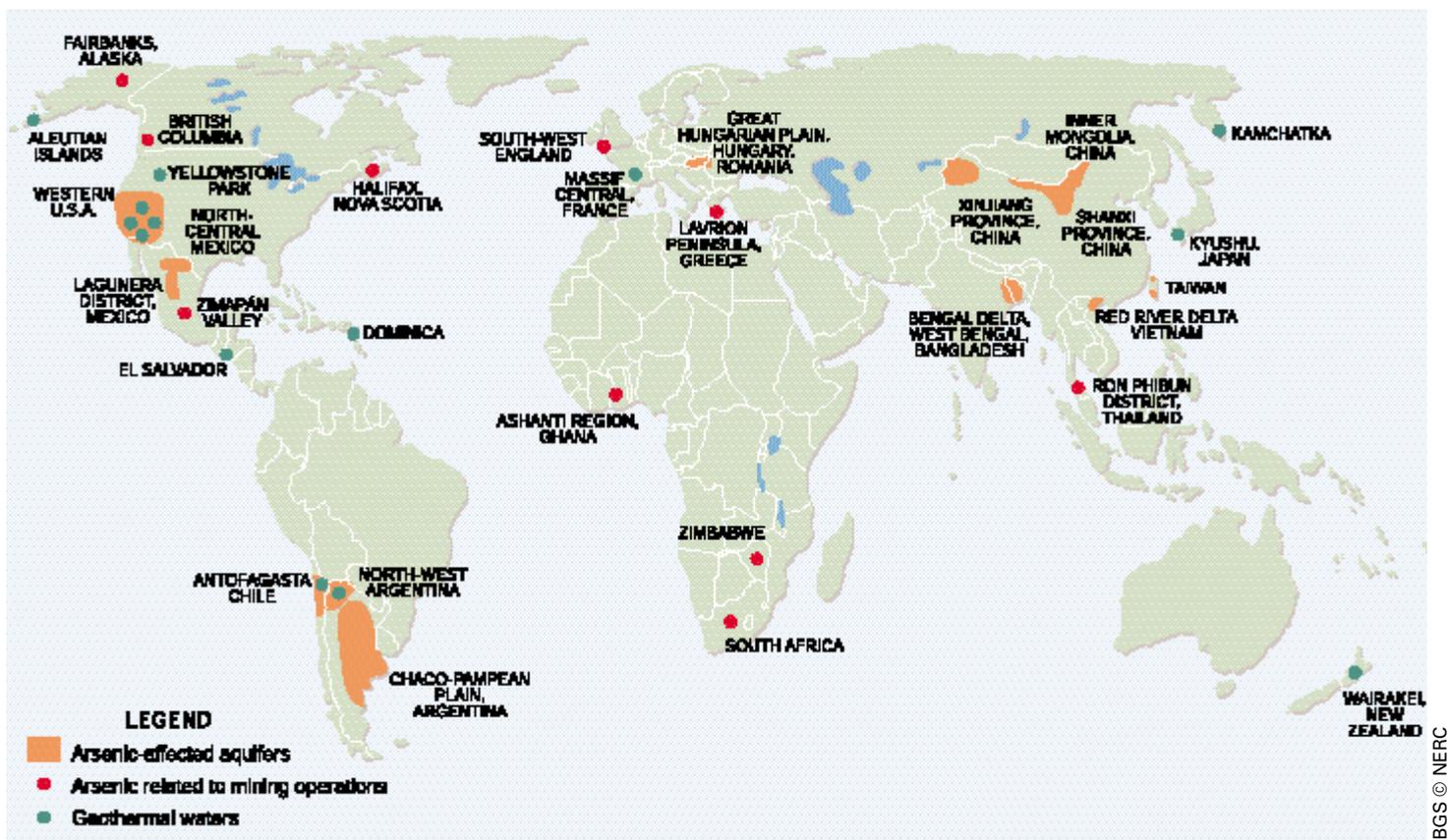
Arsenic-rich groundwaters generally occur in four types of geological environments:

- sulphide-rich mineralised zones, especially mining areas where weathering of sulphide minerals has been accelerated by the mining activity
- geothermal areas
- anaerobic groundwaters from young aquifers (a few thousand years old)
- aerobic groundwaters with high pH values from young aquifers, mainly in arid and semiarid regions

Arsenic problems in mineralised and geothermal areas occur in many parts of the world. While these occurrences can involve serious contamination with high concentrations of arsenic and other trace elements in water sources, the extent of contamination tends to be local to the source of contamination. Potentially much more extensive are the occurrences of arsenic in major aquifers. Documented cases include aquifers in Argentina, Chile, Mexico, India (West Bengal), Bangladesh, northern China, Taiwan, Vietnam, Hungary, and parts of the western USA. The BGS has been investigating the problems of arsenic contamination both in sulphide mining areas and major aquifers, largely with DFID support. Projects on mining-related contamination have been carried out in Ghana, Thailand, Brazil, and Argentina. Studies of major aquifers have been carried out in some of the worst affected aquifers in the world: Argentina, northern China (Inner Mongolia), and Bangladesh.



Keratosis on the hands of an arsenic patient, West Bengal.



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World distribution of documented cases of arsenic contamination in groundwater and the environment.

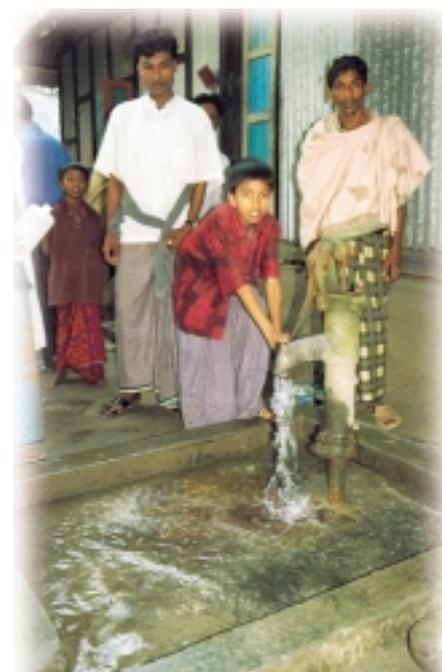
The worst case of groundwater contamination known is that of West Bengal (India) and Bangladesh. From our investigations we estimate that, in Bangladesh alone, some 35 million people are drinking groundwater with higher levels of arsenic than the national standard for drinking-water of 50 micrograms per litre. Furthermore, some 57 million people are drinking water with more than 10 micrograms of arsenic per litre. Many patients with arsenic-related skin disorders have already been identified. Affected groundwaters are from shallow tubewells (less than 150 metres in depth) in young alluvial and deltaic aquifers of the Bengal delta region. Shallow dug wells and groundwaters from older geological formations, including those at depths greater than 150 metres, have much lower arsenic concentrations, in most cases less than the WHO guideline value. The worst contamination occurs in the south and south-eastern parts of the country. However, even in the affected aquifers of Bangladesh, the distribution of arsenic concentrations is extremely

variable. This makes prediction of concentrations in a given well very difficult and requires that every well to be used for drinking-water be tested for arsenic.

The large scale of contamination of groundwaters in Bangladesh, together with socio-economic factors, makes the task of mitigation an extremely difficult one. An emergency programme, co-ordinated by the World Bank, is presently under way. Potential long-term solutions include development of dug well waters or deep groundwaters, treatment of available surface waters, rainwater harvesting, or treatment of arsenic-contaminated groundwaters. Several of these options are being tried locally, but provision of adequate mitigation measures for all the communities at risk is still some way off. One clear fact is that no single simple solution will be universally applicable across the whole of the Bengal Basin.

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A typical Bangladesh handpump in the village of Mandari, Kakshnipur, south-eastern Bangladesh.