Groundwater

Groundwater geochemistry

The impact of trace elements on community health

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The advent of tubewell drilling projects for groundwater supply in developing countries has seen major improvements in community health over the last few decades. Access to water from tubewells reduces the reliance on more traditional surface water sources, which are frequently polluted with bacteria, and hence reduces the spread of diarrhoeal and other waterborne diseases. Groundwater is also usually of good inorganic quality. Promotion of groundwater use rather than surface water is therefore generally a valid approach to promoting community health.

However, the wholesome quality of groundwater cannot always be guaranteed. Chemical reactions with the aquifers through which the groundwaters flow can lead to a build-up of harmful trace elements in the water. High iron concentrations are a common phenomenon and though not directly detrimental to health, lead to widespread acceptance problems and in the worst cases, to abandonment of groundwaters in favour of the very surface waters they were intended to replace. Many other trace elements are toxic if sufficiently concentrated, but the most significant and widespread are fluoride and arsenic. Health effects of exposure to these from drinking water are seen throughout large parts of the developing world.

Chronic exposure to high fluoride concentrations has given rise to the development of dental fluorosis, or in severe cases to the crippling bone disorder, skeletal fluorosis. Rural groundwater in large parts of India, Sri Lanka, Africa and China is severely impacted by high fluoride concentrations, often significantly above the World Health Organisation (WHO), recommended limit of 1.5 milligrams per litre. The fluoride derives from dissolution of minerals such as mica, apatite and fluorite and is found predominantly in low-calcium groundwaters. These occur in carbonate-poor silicate aquifers, particularly in hard-rock terrains.

Problems with arsenic in groundwater are less common globally but nonetheless severe where present. High arsenic concentrations (significantly above the provisional WHO recommended limit of 10 micrograms per litre) can lead to serious skin problems such as keratosis and pigmentation disorders, as well as skin cancer and numerous internal cancers. The problem of arsenic in groundwater has recently been highlighted especially in Bangladesh and West Bengal, where groundwaters from aquifers associated with the Ganges-Brahmaputra-Meghna river delta system are affected. The area at risk covers around 75 000 square kilometres and has a total population of around 80 million people, most of whom rely on groundwater for potable water supply. Arsenic in groundwater also severely affects parts of south America, Mexico and China. The arsenic most commonly derives from oxidation of sulphide minerals or reduction of iron oxide. Arsenic is therefore potentially mobile over a wide range of redox conditions in aquifers.

With Department for International Development (DFID) funding, the BGS is currently investigating problems of arsenic in groundwater in aquifers in Bangladesh, Argentina and China. These projects aim to identify the nature and source of the problem in each region, to determine the geochemical processes involved and to provide guidelines for groundwater remediation. Past projects have also been carried out on fluoride in Ghana and Sri Lanka.

Such investigations indicate that water quality is just as important a criterion to consider as water quantity during planning and instigation of groundwater supply projects in rural areas of developing countries. Groundwater is likely to provide the best available source of potable supply but trace elements such as fluoride and arsenic need to be measured in potentially vulnerable areas during tubewell drilling and completion. Continued monitoring of water quality is also vital to ensure the sustainability of the resource.

Hyperkeratosis on the hands of a Bangladeshi woman as a result of chronic exposure to high arsenic concentrations in drinking water.