Arsenic in Groundwater – A World Problem

Symposium organized by IAH's Dutch Chapter and the Netherlands' Hydrological Society, 29 November 2006, Utrecht, The Netherlands

Arsenic contamination of groundwater has occurred in various parts of the world – most notably the Ganges Delta of Bangladesh and West Bengal, India – causing serious arsenic poisoning amongst large numbers of people. In the Ganges Delta, a natural occurring high concentration of arsenic in deeper levels of groundwater became a high-profile problem in recent years due to the use of deep tube wells for water supply. Parts of Thailand, Taiwan, Argentina, Chile and China have also been affected. Approximately twenty incidents of groundwater arsenic contamination have been reported from all over the world, of which four major incidents have occurred in Asia.

Research on the occurrence and effects of arsenic in groundwater and drinking water is ongoing. Current research questions include the following:
– in what concentrations does arsenic become a health threat?
– how does arsenic behave in different environments?
– under what conditions will arsenic be mobilized?
– what are the threats of arsenic poisoning to humanity?

In The Netherlands, relatively small amounts of arsenic have been found, giving rise to research into its causes, occurrence and possible effects in the Dutch subsoil. As such, the symposium was divided between The Netherlands' situation (morning session) and the global dimension of arsenic in groundwater and drinking water.

Morning session

The 1st speaker and chair, Dr. Tony Appelo, introduced the other speakers and held a presentation about the concentration patterns of arsenic in groundwater in The Netherlands. He introduced a model for the release of arsenic for the Dutch case: that Pleistocene iron hydroxide was able to take up arsenic into its structure. During the Holocene transgressions sulphur from seawater was taken up to form pyrite (FeS_2) after which the deposits became covered by peat that formed near the outflow of the major river systems into the sea. During the cutting of the peat bogs since the Middle Ages, the pyrite became exposed to air, at which time arsenic was released.

The 2nd speaker, Sophie Vermooten, discussed a national project in which policy-makers are to be advised about the use of soil, sediments and groundwater in areas affected by relatively high arsenic concentration levels in The Netherlands. She explained that groundwater can take up arsenic while flowing from higher Pleistocene deposits in the east of the country towards the western seacoast, after which it might accumulate in the sand dunes that protect the coast (and which are used as major drinking water reservoirs). The outcome of the project would be the drawing up of risk maps and a soil management map.

Professor Pieter Stuyfzand explained the role of arsenic in the production of Dutch drinking water. At a few locations, the arsenic level is above the WHO norm of 10 µg/l, but the situation appears to be stable. While there is no large-scale problem, individual wells have been more closely examined, indicating that at the local level a few problematic cases might arise in the future, due to changes in the chemical composition of the infiltrating water (e.g., gases like CH_4 may give rise to mobilization of arsenic, which might lead to rather high arsenic levels locally [up to 1000 µg/l]).

In his presentation, Slavek Vasak (International Groundwater Resources Assessment Centre), explained the role of IGRAC in the production of an inventory of hazardous substances in groundwater at a global scale. For many countries adequate information is lacking, especially quantitative data. He called for more active sharing of information, as this may lead to better management of hazardous substances in groundwater.

Afternoon session

In the afternoon, Dr. Tony Appelo introduced the global dimensions of arsenic in groundwater and drinking water, thereby touching upon the problems of arsenic poisoning in Bangladesh and India.

Dr. Pauline Smedley (British Geological Survey, Wallingford, UK) discussed 'Arsenic in groundwater – natural sources and/or human interferences?' She explained that arsenic occurs in different minerals, and that it can be mobilized under different conditions. Countries with arsenic levels above 50 µg/l (that is, 5 times the WHO norm) are Argentina, Chile, Bangladesh and the Southwest of the US. Arsenic problems are mostly related to one of three situations: geothermal, mines (e.g. in Obuasi, Ghana, where by oxidation of sulphide minerals large amounts of arsenic come into the water), and large water reservoirs (e.g., La Pampa in Argentina, and California in the USA, where arsenic collects in topographically low reservoirs). The first two situations are sources of high arsenic concentrations, while in the latter case the problem is the mobilization of arsenic by changing geochemical conditions. Human impact has little to do with it.

'Arsenic in drinking water: threatening the health of millions?' was discussed by Professor Marie Vahter (Karolinska Institute, Stockholm, Sweden), whose answer was 'yes': measured concentrations of thousands of µg/l (WHO norm is 10 µg/l) at different places of the world, in combination with the effects on human health, make arsenic a global problem. More than 50 million people in Bangladesh are currently exposed to the risk of being poisoned. When consumed in very high doses, arsenic may lead to acute gastro-intestinal or paralytic symptoms.

The lethal dose is probably around a few mg per kg of body weight. Chronic effects are due to adverse effect on enzyme reactions. The most important chronic effect of arsenic poisoning is cancer (skin, lung, bladder, and kidney). Not all forms of arsenic are as dangerous, but it is clear that arsenic in drinking water is a serious threat to human health.

The last speaker treated the question 'Do we understand the origin of high arsenic concentrations in groundwater? Can we quantify it?'. Dr. Tony Appelo looked into three chemical theories to explain high concentrations of arsenic in groundwater. Even after experiments, no general conclusive answers can presently be given. Groundwater mixing often makes correlations vague. Possibly, there are different systems that give rise to mobilization of arsenic in groundwater in different situations. While superficial aquifers become poor in arsenic, the deeper aquifers remain rich in arsenic due to the compound with iron hydroxide that inhibits mobilization.

The symposium was well visited, despite the fact that arsenic in not a hot topic in Dutch water management or national policy. The charm of the chairperson helped to maintain a good atmosphere. In order to come up with more practical recommendations, similar symposiums should, in the future, also present possible solutions to arsenic problems.

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The presentations can be downloaded from the websites of the IAH (www.iah.org) and the NHV (www.nhv.info).

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